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Perioperative Management of Chronic Dialysis Patients Undergoing Cardiac Surgery

Kalp Cerrahisi Uygulanan Kronik Diyaliz Hastalarında Perioperatif İdare

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ABSTRACT

Introduction: *Chronic kidney disease is associated with significant cardiovascular morbidity and mortality. Cardiac surgery in patients undergoing dialysis is still challenging due to increased perioperative complication rates and mortality. The aim of this study is to document the outcomes of cardiac surgery in end stage renal disease patients and analyze the impact of perioperative management strategies.*

Patients and Methods: *Nineteen patients with end-stage renal disease undergoing hemodialysis (n= 17) or peritoneal dialysis (n= 2) operated between January 2011 and November 2012 were studied retrospectively. Isolated coronary bypass, coronary bypass concomitant with mitral valve procedures or mitral and/or tricuspid valve surgery were performed. Postoperative variables, mortality and survival rates were studied.*

Results: *The mean age of the patients was 56.32 ± 12.97 years. Male to female ratio was 10/9. The mean duration of preoperative hemodialysis was 4.07 ± 1.89 and peritoneal dialysis was 1.5 ± 0.7 years. Mean cross-clamp time was 57.63 ± 21.56 minutes and cardiopulmonary bypass time was 87.89 ± 24.66 minutes. Mean amount of ultrafiltration performed intraoperatively was 1610.53 ± 607.26 mL. Three (15.8%) in-hospital mortalities were noted. The median follow-up was 16 months and survival rate was 84.2%.*

Conclusion: *A well planned surgical strategy and perioperative medical management including the timing of pre and postoperative hemodialysis, use or avoidance of cardiopulmonary bypass and the use of intraoperative ultrafiltration should be documented to decrease perioperative morbidity and mortality.*

Key Words: *Renal dialysis; kidney failure, chronic; cardiac surgical procedures.*

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ÖZET

Giriş: *Kronik böbrek hastalığı belirgin kardiyovasküler morbidite ve mortaliteye sahiptir. Yüksek perioperatif komplikasyon oranları ve mortalite sebebiyle diyaliz yapılan hastalarda kalp cerrahisi oldukça zordur. Bu çalışmanın amacı kalp cerrahisi yapılan son dönem böbrek hastalarında tedavi sonuçlarının ortaya konması ve perioperatif hasta idare stratejilerinin etkisinin araştırılmasıdır.*

Hastalar ve Yöntem: *Ocak 2011-Kasım 2012 tarihleri arasında opere edilen hemodiyaliz (n= 17) ya da periton diyalizi (n= 2) uygulanan son dönem böbrek hastaları retrospektif olarak incelendi. İzole koroner baypas, koroner baypasla beraber mitral kapak prosedürleri ya da mitral ve/veya triküspid kapak cerrahisi uygulandı. Postoperatif değişkenler, mortalite ve sağkalım oranları çalışıldı.*

Bulgular: *Hastaların ortalama yaşı 56.32 ± 12.97 yıl idi. Erkek/kadın hasta oranı 10/9 idi. Ortalama hemodiyaliz süresi 4.07 ± 1.89 yıl, ortalama periton diyalizi süresi ise 1.5 ± 0.7 yıl idi. Ortalama kros-klemp süresi 57.63 ± 21.56 dakika, ortalama kardiyopulmoner baypas süresi ise 87.89 ± 24.66 dakika idi. İntraoperatif dönemde ortalama 1610.53 ± 607.26 mL ultrafiltrasyon yapıldı. Üç (%15.8) hasta hastane yatışı sırasında kaybedildi. Ortanca takip süresi 16 aydı ve sağkalım %84.2 idi.*

Sonuç: *Perioperatif morbidite ve mortalitenin düşürülmesi amaçlı preoperatif ve postoperatif hemodiyaliz planlaması, kardiyopulmoner baypasın kullanılması ya da kullanımından kaçınılması ve intraoperatif ultrafiltrasyon uygulaması gibi perioperatif hasta idaresiyle beraber iyi planlanmış bir cerrahi strateji belirlenmelidir.*

Anahtar Kelimeler: *Böbrek diyalizi; böbrek yetmezliği, kronik; kardiyak cerrahi girişimler.*

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INTRODUCTION

Chronic kidney disease (CKD) affects 390/1.000.000 people in Turkey and 355/1.000.000 people in United States[1,2]. It is a worldwide public health problem with increasing incidence and healthcare costs.

CKD is associated with increased cardiovascular morbidity and mortality independent of diabetes[3-5]. Accelerated atherosclerosis, inadequate control of blood pressure, lipid metabolism disorders, various cytokines and poor glycemic control contribute to the occurrence of cardiovascular events with increased incidence in CKD. Cardiovascular mortality makes up 45% of all-cause mortality in end-stage renal disease (ESRD). The annual rate of sudden cardiac death is 7% in patients with ESRD[6]. By the first time a patient is given hemodialysis, he already has significant degree of coronary stenosis with an incidence of 72.7% if symptomatic and 53.8% if asymptomatic[7]. These patients often require myocardial revascularization. Simultaneously, dialysis patients are associated with increased risk for calcified degeneration of cardiac valves and epiaortic vessels[8]. These cardiac pathologies have increased operative morbidity and mortality in ESRD patients compared to ones with normal renal functions. The effects of cardiopulmonary bypass (CPB) on coagulation and fluid-electrolyte balance further complicate the process.

The aim of this study is to document the outcomes of cardiac surgery in ESRD patients and analyze the impact of perioperative management strategies.

PATIENTS and METHODS

We retrospectively studied 19 patients undergoing hemodialysis who underwent cardiac surgery in a single center between January 2011 and November 2012. These patients belong to a consecutive series of 951 patients who were operated within this period. The Hospital Ethics Committee approved the study based on retrospective data retrieval, waiving for individual consent. The study followed the Declaration of Helsinki 2008 on medical protocol.

All patients underwent hemodialysis on the day prior to surgery and on the first postoperative day when stable hemodynamics were maintained except for the two cases on peritoneal dialysis. Peritoneal dialysis was performed on the night prior to surgery in peritoneal dialysis patients.

Intraoperative autologous priming together with intraoperative ultrafiltration was performed in every case. The CPB circuit was primed with Isolyte-S® (Eczacıbaşı-Baxter, Istanbul) which is a balanced electrolyte solution, and 5,000 units of heparin was added. After anticoagulation with heparin (300 U/kg), activated clotting time (ACT) was kept over 400 seconds. Cardiopulmonary bypass was established using a roller pump with a membrane oxygenator (DidecoCompactfloEvo, Sorin Group, Mirandola Modena, Italy). The average flow rate varied from 2.3 to 2.4 L/min/m^2. Surgery was performed under mild hypothermia (33°C). Mean arterial pressure was kept between 45 to 70 mmHg. Ultrafiltration was performed with Sorin SHI4 hemoconcentrator (Sorin Group, USA). All patients were rewarmed to 37°C (nasopharyngeal temperature) before weaning from CPB. Heparin was neutralized with 1:1 protamine sulfate.

Cold (4-8°C) blood cardioplegia,1000 mL (10 mEq/L potassium) was administered after aortic cross clamping (we use 25 mEq/L potassium in cases with normal renal functions), and 500 mL repeat doses were given every 15 to 20 minutes [antegrade and from venous bypass grafts in coronary artery bypass grafting (CABG); retrograde in patients with left main coronary disease]. Terminal warm blood cardioplegia (36-37°C) was given prior to aortic clamp release.

The operation room temperature was kept at 20-21°C.

In postoperative period, rate of fluid infusions were adjusted according to hemodynamic measurements. Central venous pressure was maintained between 8-12 mmHg.

Packed red blood cells (RBC) were given if the hematocrit level fell below 25%. Fresh frozen plasma (FFP) and platelet concentrates were administered in cases of documented postoperative coagulation abnormalities (international normalized ratio > 1.5, activated partial thromboblastin time > 60 s and platelet count < 80.000/mm^3), postoperative platelet dysfunction and factor deficiency.

The decision for re-exploration for hemorrhage was made when 200 mL/hour of drainage was documented on two consecutive hours despite measures taken or more than 300 mL/hour drainage.

Low cardiac output failure was defined as inability to maintain systolic blood pressure > 90 mmHg and urine output > 0.5 mL/kg/hour despite full dose inotropes and/or intraaortic balloon pump together with signs of tissue hypoperfusion.

On postoperative day 1, all patients were administered metoprolol (50 mg/day), nebivolol (5 mg/day) or carvedilol (3.125-6.25 mg/day) and N-acetylcysteine (IV) and continued. All patients were routinely administered low molecular weight heparin in doses adjusted to serum creatinine for deep venous thrombosis (DVT) and associated pulmonary thromboembolism (PTE) prophylaxis.

Primary outcome variables included mean time to extubation, intensive care unit (ICU) and postoperative hospital length of stay, postoperative stroke, postoperative total amount of blood loss, postoperative exploration for hemorrhage, number of used packed RBC, FFP and platelet concentrates, and inhospital mortality.

Statistical Analysis

The data were analyzed using software SPSS version 17.0 (version 17.0, Statistical Package for the Social Sciences Inc, Chicago, IL, USA). Continuous variables were presented as “mean ± SD”, median (min, max) and categorical variables were presented as “numbers and percentages”.

RESULTS

The mean age of the patients was 56.32 ± 12.97 years. There were 10 (52.6%) male patients and 9 (47.4%) female patients. The mean duration of preoperative hemodialysis was 4.07 ± 1.89 (n= 17) and peritoneal dialysis was 1.5 ± 0.7 years (n= 2). The preoperative demographic characteristics of the patients are summarized in Table 1.

On-pump CABG was performed on 14 (73.6%) patients. One (5.2%) patient underwent CABG concomitant with mitral ring annuloplasty (MRA), 1 isolated MRA, 2 (10.5%) mitral valve replacement (MVR) and one MVR concomitant with tricuspid De-Vega annuloplasty. The operations performed on ESRD patients are outlined in Table 2.

When intraoperative variables were explored, mean number of bypass grafts was 3.53 ± 0.91. Mean cross-clamp time was 57.63 ± 21.56 minutes and CPB time was 87.89 ± 24.66 minutes (Table 3). Ultrafiltration was performed in each case, and the mean amount of ultrafiltrate was 1610.53 ± 607.26 mL.

Table 1. Preoperative characteristics of patients

	Mean ± SD
Age (years)	56.32 ± 12.97
BMI (kg/m^2)	26.57 ± 5.51
LVEF (%)	52.47 ± 12.89
Duration of hemodialysis (n= 17) (years)	4.07 ± 1.89
Duration of peritoneal dialysis (n= 2) (years)	1.5 ± 0.7
	n (%)
Sex	
Male	10 (52.6)
Female	9 (47.4)
Preoperative beta-blocker therapy	6 (31.6)
Current/Ex-smoker	5 (26.3)
Diabetes mellitus	11 (57.9)
Hypertension	14 (73.7)
Peripheral arterial disease*	-
Stroke	-
COPD/Asthma	2 (10.5)

* History of therapeutic vascular intervention, history of claudication, angiography/non-invasive proven peripheral arterial disease.

BMI: Body mass index, COPD: Chronic obstructive pulmonary disease, LVEF: Left ventricular ejection fraction.

Table 2. Operative procedures

	n (%)
On-pump CABG	14 (73.6)
On-pump CABG + MRA	1 (5.2)
MRA	1 (5.2)
MVR	2 (10.5)
MVR + Tricuspid de-vega annuloplasty	1 (5.2)
	19 (100)

CABG: Coronary artery bypass grafting, MVR: Mitral valve replacement, MRA: Mitral ring annuloplasty.

Table 3. Intraoperative characteristics of patients

	Mean ± SD
Number of grafts*	3.53 ± 0.91
Cross-clamp time (min)	57.63 ± 21.56
Cardiopulmonary bypass time (min)	87.89 ± 24.66
Ultrafiltration (mL)	1610.53 ± 607.26

* 15 patients with coronary bypass surgery.

The mean time to extubation was 15. 26 ± 8.97 (median: 13; min: 7, max: 46) hours. The mean intensive care unit stay time was 130.37 ± 340.78 (median: 47; min: 42, max: 1536) hours whereas mean postoperative hospital length of stay was 11.79 ± 14.05 (median: 8; min: 5, max: 68) days. Total amount of drainage was 838.89 ± 418.52 ml. There were 3 (15.8%) reoperations for bleeding. The postoperative variables of the patients are outlined in Table 4.

No postoperative stroke was encountered during the study period.

There was one case with sternal dehiscence, Robicsek weave was performed. Only one case developed superficial wound infection treated with surgical debridement. There were no cases with mediastenitis.

There were three deaths (15.8%) reported during the study period. Two patients (one CABG and one MVR) died due to low output failure. One CABG patient developed multiorgan failure, soon tracheostomy was performed. He stayed in ICU for 64 days and died due to sepsis.

After gathering data, the patient follow-up was performed by telephone interview or hospital admission to our center. The median follow-up was 16 months (mean: 13.69 ± 6.77; min: 2 max: 22). All survivors were alive during the follow-up period (survival rate: 84.2%).

DISCUSSION

Patients with ESRD represent a subgroup of patients requiring special attention undergoing cardiac surgery. Cardiovascular diseases cause the majority of mortality in these patients[5,6]. Besides the basic impairment in renal functions, the long term adverse effects of the disease on multiple organ systems and the resultant fragile fluid-elec-

Table 4. Postoperative variables

	Mean ± SD	Median (min-max)
Intubation time (hours)	15. 26 ± 8.97	13 (7-46)
Length of stay		
Intensive care unit (hours)	130.37 ± 340.78	47 (42-1536)
Postoperative hospital (days)	11.79 ± 14.05	8 (5-68)
Drainage tubes removed (hours)	42.53 ± 15.92	36 (29-92)
Total amount of drainage (mL)	838.89 ± 418.52	725 (350-1750)
# of RBC suspension used	8.11 ± 12.48	5 (3-59)
# of FFP used	6.47 ± 6.72	5 (0-31)
# of PC used	2.89 ± 3.74	0 (0-11)
	n (%)	
Postoperative exploration for hemorrhage	3 (15.8)	
Atrial fibrillation*	2 (13.3)	
Postoperative stroke	-	
Mortality	3 (15.8)	

* 15 patients with coronary bypass surgery.
RBC: Red blood cell, FFP: Fresh frozen plasma, PC: Platelet concentrate.

trolyte imbalance may cause possible deteriorating scenarios following heart surgery. The burden of the disease is represented by a Z score of 2.08 on EuroSCORE II system after evaluation of final risk factors by multivariate regression for the model[9]. But, it is revealed that cardiac surgery can be performed with acceptable short and long-term outcomes in patients with ESRD[10]. Postoperative recovery is delayed one day most probably due to HD performed on postoperative first day[11].

In a series of 168 hemodialysis patients undergoing CABG and/or valve surgery, the mean age of the patients was 61.1 ± 9.7 years, whereas 56.32 ± 12.97 in our study[12]. Median time to extubation was 24 hours, median length of ICU stay was 4 days and median hospital length of stay was 10 days compared to 13 hours, 47 hours and 8 days in our study respectively. In-hospital mortality rates ranged between 6.8% and 18% in different studies compared to 15.7% in our study[8,10,12,13]. One of the largest series of hemodialysis patients is derived from Japan Adult Cardiovascular Surgery Database[13]. The mean age in that series was 65.4 ± 9.2, significantly older than ours. They also reported 23.1% mortality and major complication rates. They disclosed age, chronic obstructive pulmonary disease, EF < 30%, preoperative need for inotropes, concomitant mitral or aortic valve insufficiency and urgent/emergent surgery as risk factors for operative mortality[13]. Nicolini et al. reported 13.6% mortality in their series of 81 patients with CABG and/or valve surgery or major aortic surgery[14].They also reviewed 18 studies in literature for comparison and calculated 13.3% mortality in 1725 patients. The identified risk factors for perioperative mortality were previous MI, combined CABG and valve surgery, major aortic surgery, hemodialysis > 5 years and urgent/emergent surgery. There was only one emergent CABG case in our study and the patient survived.

The survival rates following cardiac surgery in ESRD patients are reported varyingly in different studies. Nicolini et al. reported 72.2% survival in 5 years period[14]. Tanaka et al. documented survival rates of 74.6% in 3 years, 55.7% in 5 years and 39.9% in 10 years period[8]. Kumar et al. compared survival rates of hemodialysis (66%) and peritoneal dialysis (69%) patients in two years time and observed no difference[12]. Jayasekara reported 78% and 40% survival at 1 and 5 years respectively[15]. Our median follow up time was 16 months. Three inhospital mortalities were noted (15.8%) and survivors were alive during the follow-up (84.2% survival).

The increased number of complications related to CKD is attributed to CPB due to its effects on immune mechanisms and volume homeostasis, and avoidance was revealed as a strategy by some authors[16,17]. Moreover, CPB leads to a state of hypercoagulation[18]. This hypercoagulable state may be detrimental in ESRD patients. Bruschi et al. reported lower incidence of atrial fibrillation (AF), fewer transfusions and shorter ICU stay in patients with off-pump CABG[16]. Zhang et al. documented improved in-hospital mortality by employing off-pump CABG[19]. Abud et al. compared off-pump and on-pump cases concluding that both are safe in CKD patients, but ICU and hospital length of stay were shorter in off-pump cases[20]. In our study, we employed CPB in every patient with ESRD. This is principally due to surgeon's preference for CABG surgery. But, even while employing CPB, the AF rate was 13.3% in CABG cases which is comparable to 16.3% AF documented in our series of 418 CABG cases[21]. The mean ICU and hospital stay was longer compared to 45.8 ± 11.67 hours and 5.63 ± 1.70 days compared to our previous results.

The perioperative dialysis strategy is one of the most important factors affecting outcomes. Nicolini et al. in their series of 81 patients employed routine hemodialysis the day prior to the operation and on first postoperative day when stable hemodynamics was maintained[14]. We also followed a similar strategy, but we also routinely performed intraoperative ultrafiltration together with autologous retrograde priming. We believe that accurate timing of hemodialysis positively affects perioperative course.Tanaka et al. used low potassium hemodialysis for 2 consecutive days prior to surgery except for emergencies. They also employed hemodialysis on first postoperative day when stable hemodynamics was maintained. Continuous hemofiltration was performed only when hemodynamic instability was present[8]. We performed continuous hemofiltration only in one patient who died after 68days in ICU.

We know that aortic vessels are more calcified in ESRD, which must be taken into consideration while determining operative strategy[8]. Preoperative routine use of epiaortic and aortic echocardiography is suggested in some reports[14]. More sophisticated imaging modalities like preoperative computerized tomography together with intraoperative echo scans are also employed[8].We do not routinely use epiaortic scanning and other imaging modalities, but we examine the aorta by palpation and decide the localization of cannulation and other manipulations. With these measures, we did not encounter any intraoperative complications and postoperative stroke throughout the study period.

The revascularization strategy is also special in CABG patients with ESRD. The calcification is more pronounced and widespread in coronary vessels, and this affects the operative strategy. It is advised to bypass calcification free branches rather than the calcific main artery, prefer a more distal artery than the calcific site and if possible choose a non-calcified artery. Getting more epicardial tissue than usual is suggested to attain hemostasis[22]. There are controversial reports regarding internal mammary artery use. In patients over 70 and emergent cases, to guarantee less invasiveness and easiness, saphenous vein grafts may be used rather than IMA[22]. Regarding the use of IMA in patients with ipsilateral fistula, steal from the IMA was documented[23,24]. Conversely, in cases of normal flow fistula, it was shown that patients do not suffer angina and there is no steal[25]. In our study, considering 15 CABG patients, left IMA was used in all cases. Five patients had ipsilateral fistula. Free left IMA was used only in one patient due to inadequate flow, he had contralateral fistula. We did not observe any steal or angina related to ipsilateral fistula in these patients.

In our study, only two patients were under peritoneal dialysis prior to the operation. One was hemodialyzed twice postoperatively followed by routine peritoneal dialysis whereas the other was begun peritoneal dialysis following extubation and stabilization of hemodynamics. It is believed that, in the early postoperative period, hemodialysis provides more adequate ultrafiltration and shorter intubation times. However, Kumar et al. documented that the incidence of postoperative complications were lower in peritoneal dialysis patients including intubation time, infection ratesand death; 28% in peritoneal dialysis vs. 50% in hemodialysis patients. They concluded that peritoneal dialysis patients dialysis do not experience blood pressure fluctuations as in hemodialysis, do not require anti- coagulation during the procedure and have lower risk of potential endocarditis especially in cases with valve surgery[12].

Reoperation rates for bleeding are increased in CKD patients due to platelet dysfunction and coagulation system defects caused by uremia. Anticoagulation needed for hemodialysis further causes a bleeding tendency[14]. Reoperation rate for bleeding was 15.8% in our study. This is high compared to rates reported by Nicolini et al[14]. Our group published 418 isolated CABG cases and reoperation rate for bleeding was 2.6% which is quite lower thanour ESRD patients[21]. Similarly, the amount of blood and blood products used were higher; 8.11 ± 12.48 vs. 1.75 ± 1.74 RBC suspension, 6.47 ± 6.72 vs. 1.41 ± 1.73 FFP and 2.89 ± 3.74 vs. 0.50 ± 1.75 PC[21]. We routinely employ low molecular weight heparin in all patients for dVT and associated PTE prophylaxis. Since prophylactic therapy is initiated after postoperative 24 hours, we do not think that low molecular weight heparin therapy affected the reoperation rates, however it may have influenced postoperative amount of drainage.

In addition to the discussion on perioperative management of ESRD patients undergoing cardiac surgery, there is still a controversy on the ideal treatment modality in coronary artery disease patients with ESRD. A very recent meta-analysis of 32.350 ESRD patients revealed that late mortality, myocardial infarction, repeat revascularization and cumulative adverse events were lower in CABG patients whereas only early mortality was lower in PCI group[5].

The limitations of the study should be noted. The study reflects the experience of a single center with a relatively low number of patients. It is a retrospective and observational study, thus the conclusions are limited in their application.

In conclusion, the operative morbidity and mortality of the ESRD patients are still high compared to patients with normal renal functions. A well planned surgical strategy and perioperative medical management should be documented. This includes the timing of pre and postoperative HD, use or avoidance of CPB and the use of intraoperative ultrafiltration.

CONFLICT of INTEREST

None declared.

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