Turkish Journal of Clinics and Laboratory

To cite this article: Beyazpinar DS, Erol ME. Risk factors for acute kidney injury in octogenari-ans undergoing open-heart surgery: Decreasing mortality and morbidity. Turk J Clin Lab 2024; 1: 104-109

Research Article

Risk factors for acute kidney injury in octogenarians undergoing open-heart surgery: Decrea-sing mortality and morbidity

Açık kalp ameliyatı geçiren ileri yaştaki hastalarda akut böbrek hasarı için risk faktörleri

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ABSTRACT

Aim: Our studys goal is, to determine the risk factors for acute kidney injury in octogenarians un-dergoing open-heart surgery to decrease mortality and morbidity by enhancing accurate patient selection in the preoperative period.

Material and Methods: Between January 2017-December 2022, 678 patients analyzed retros-pectively. The patient groups were divided as follows: < 70 years old = control group, 70–80 years old = septuagenarian group, and > 80 years old = octogenarian group. Age, sex, ethnicity, Eurosco-re, preoperative serum creatinine levels, postoperative first-month serum creatinine levels, dialy-sis requirements, and first-year mortality parameters were analyzed.

Results: 206 patients has included into study, with 94 patients in the control group (79 male), 29 patients in the septuagenarian group (22 male), and 83 patients in the octogenarian group (70 male). There was a statistically significant difference between the groups based on preoperative serum creatinine. Of the 26 patients requiring renal replacement therapy, 6 were in the control group, 3 were in the septuagenarian group, and 17 were in the octogenarian group. There was a statistically significant difference between groups based on requiring renal replacement therapy, and 11 of the patients requiring renal replacement therapy died. Of the 22 patients who died ove-rall, 4 were in the control group, 3 were in the septuagenarian group, and 15 were in the octoge-narian group.

Conclusion: In the senior patient group, the best approach for optimal patient selection is to ensu-re meticulous surgical technique and myocardial protection.

Keywords: cardiac surgical procedures, coronary artery bypass grafting, renal replacement the-rapy, acute kidney injury, octogenerian

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Recevied: 25.02.2024 accepted: 15.03.2024

ÖZ

Amaç: Bu çalışmadaki amacımız ileri yaştaki hasta grubunda açık kalp cerrahisi sonrasında akut böbrek yetmezliğinin risk faktörlerinin belirlenmesi ve doğru hasta seçimi yaparak bu hasta grubunda mortali-te ve morbiditeyi azalmaktır.

Gereç ve Yöntemler: Ocak 2017-aralık 2022, 678 hasta retrospektif olarak incelenmiştir. Hastalar yaşlarına göre < 70 yaş = kontrol grubu, 70–80 yaş = septuagenarian grubu, ve > 80 yaş = octogenarian grubu olarak ayrılmıştır. Yaş, cinsiyet, demografik özellikler, Euroskor, preoperatif serum kreatinin dü-zeyi, postoperatif 1. aydaki serum kreatinin düzeyleri, diyaliz ihtiyacı ve bir yıllık mortalite parametre-leri analiz edilmiştir.

Bulgular: Çalışmaya toplam 206 hasta dahi edilmiştir, bu hastalardan 94'u kontrol grubu (79 erkek), 29 hasta septuagenarian grubu (22 erkek), ve 83 hasta octogenarian grubu (70 erkek). Grupların preo-peratif serum kreatinin düzeylerinde istatistiksel olarak fark vardır. 26 hastanın renal replasman tedavi-si ihtiyacı olmuştur, bunların 6'si kontrol grubunda, 3'u septuagenarian grubunda, ve 17'si ise octoge-narian grubundadır. Renal replasman tedavisi açısından gruplar arasında istatistiksel fark vardır, ve re-nal replasman tedavisi alan hastaların 11 ölmüştür. Toplamda 22 hasta ölmüştür, bunların 4'u kontrol grubunda, 3'u septuagenarian grubunda, ve 15'i ise octogenarian grubundadır.

Sonuç: İleri yaştaki hasta grubunda doğru hasta seçimi, titiz bir cerrahi ve kusursuz miyokardiyal ko-ruma mortalite ve morbiditeyi ciddi azaltmaktadır.

Anahtar kelimeler: Kalp cerrahisi prosedürleri, koroner arter bypass greftleme, böbrek replasman tedavisi, akut böbrek hasarı, ileri yaş

Introduction

The average lifespan of societies has increased over time due to enhancements in medical tech-nologies and therapies. Consequently, both the incidence of chronic diseases (e.g., coronary artery disease and degenerative heart valve disease) and the age of patients who undergo open-heart surgery because of these diseases have increased. A study conducted in Germany found that while the average age of patients who underwent open-heart surgery was 55.8 years in 1990, in 2007, this number increased to 68.6 years (1). In the USA, the number of octogenarians undergoing ope-rations increased 67% from 1987 to 1990 (1). Gummert et al. stated that, 50.8% of patients who underwent open-heart surgery were above 69 years old, while 11.85% of these patients were above the age of 80 (2). Alexander et al. stated that 6.7%–7.0% of patients undergoing heart sur-gery are above the age of 80 (3).

For patients undergoing open-heart surgery, acute kidney injury (AKI) is an important cause of mortality and morbidity in both the short and long terms (4). AKI development also increases the average time spent in the intensive care unit (ICU), the average number of admission days until discharge, and overall medical expenses (4). While the average risk for AKI development in pati-ents who undergo open-heart surgery is 3%–37%, a study conducted by the Mayo Clinic between 2003 and 2005 found this ratio to be 47% in octogenarians who underwent open-heart surgery (5).

In illumination of these data, it is evident that the average age of the patients we will be opera-ting on in the near future is going to increase. The mortality and morbidity of open-heart surgery conducted on senior patients is higher than that of younger patients for several reasons, such as increased fragility in older patients, deterioration in organ functions, and comorbidities (4). Cur-rent mortality and morbidity rates in open-heart surgery have dramatically decreased thanks to advancements in myocardial protection methods, surgical techniques, extracorporeal circulation equipment, and anesthesiology practices.

Certain changes occur in vascular morphology and function with aging. Decreased vascular wall thickness and dilation in great vessels, changes in the vascular wall matrix, and increased elas-tolytic and collagenolytic activity cause hardening of the vessels with age (6,7). While the contrac-tility of the heart decreases due to structural changes in myocardial cells, mural connective tissue, and heart valves, decreases in the number of myocytes with an accompanying increase in the di-mensions of the remaining ones increase the myocyte apoptosis rate (7,8). The objectives of our investigation encompassed elucidating the risk factors associated with AKI. Occurrence among undergoing open heart surgery, subsequently, ameliorating both mortality and morbidity rates in this demographic by refining the process of preoperative patients selection to ensure greater pre-cision.

Material and Methods

After ethics committee approval, in line with the 1975 Helsinki

Protocol, the data of 678 patients who underwent coronary artery bypass surgery with elective cardiopulmonary bypass (CPB) between January 2017 and December 2022 were analyzed retrospectively. Exclusion criteria were a history of previous open-heart surgery, preoperative intraaortic balloon pump requirement, pre-operative dialysis requirement, additional procedures in the same session, and emergency sur-gery. After the exclusion, 206 patients enrolled to the study. The patient groups were divided as follows: < 70 years old = control group (CG), 70–80 years old = septuagenarian group (SG), and > 80 years old = octogenarian group (OG). Age, sex, ethnicity, Euroscore, preoperative serum creati-nine levels (sCr), postoperative first-month sCr levels, requiring dialysis, and first-year mortality parameters were obtained and analyzed. The AKI classification and dialysis requirement assess-ments were performed according to Kidney Disease Improving Global Outcomes (KDIGO) criteria (Table 1).

Table 1: Kidney Disease Improving Global Outcomes criteria for Acute Kidney Injury

Stage	Serum Creatinine Level	Urine Output
1	1, 5–1, 9 times or ≥ 0.3 mg/dl increase in sCr	< 0.5 ml/kg/h in the last 6–12 hours
2	2–2, 9 times increase in sCr	< 0.5 ml/kg/h for ≥ 12 hours
3	3 times or more increase in basal sCr or sCr level above 4 mg/dl or Requiring RRT	< 0.3 ml/kg/h for ≥ 24 hours orscribendi anuria for ≥ 12 hours

The Euroscore classification system was used for preoperative risk assessment (Table 2).

Table 2: Euroscore Risk Assessment Classification Score

Parameters	Points
Age	60–64 1 65–69 2 ≥ 70 3
Sex	Male 0 Female 1
COPD	1
PVD	2
Previous cardiac surgery	3
Renal insufficiency (sCr > 2.26)	3
Dialysis dependency	5
Active endocarditis	3
İnsulin dependent diabetes mellitus	2
Critical preoperative state	LVEF 30–50: 1 > 30: 3
Pulmonary hypertension	> 40 mmHg2
Thoracic aortic surgery	5
Post MI VSD	5

Statistical Analysis

We performed our statistical analysis using IBM SPSS 22.0 software (IBM Corporation, Armonk, NY, USA). The Chi-square test, Mann–Whitney U test, and Kruskal–Wallis test were used to com-pare the groups. A probability value of $p < 0.05$ was considered significant. Data were expressed as mean values and standard deviations for continuous variables and as percentages for categori-cal variables.

Results

There were 94 patients in the CG (79 males, 84.04%), 29 patients in the SG (22 males, 75.86%), and 83 patients in the OG (70 males, 84.34%). The perioperative parameters are given in Table 3. There was no statistically significant difference between the groups based on sex. The preoperati-ve sCr levels were 0.971 ± 0.188 mg/dl in the CG, 0.943 ± 0.254 mg/dl in the SG, and 1.165 ± 0.263 mg/dl in the OG. There was a statistically significant difference between the groups based on preoperative sCr levels ($p = 0.001$). The average Euroscore points were 3.31 ± 2.16 points for the CG, 4.55 ± 2.68 points for the SG, and 5.45 ± 1.25 points for the OG. There was a statistically significant difference between the groups based on the preoperative Euroscore risk classification points ($p = 0.001$).

Table 3: Perioperative parameters

Group	CPB duration (mins)	Aortic Cross-clamp Duration (mins)	Number of By-passes Done
CG	64.40 ± 16.85	61.94 ± 13.89	4.37 ± 1.88
SG	77.86 ± 12.55	62.55 ± 14.59	4.58 ± 1.36
OG	87.62 ± 12.86	55.07 ± 16.29	4.14 ± 1.68

There was no statistically significant difference between the groups regarding aortic cross-clamp duration ($p = 0.157$) and numbers of bypasses done ($p = 0.751$), while there was a statistically significant difference regarding duration of CPB ($p = 0.002$).

Of the 26 (12.62%) patients requiring renal replacement therapy (RRT), 6 (6.38%) were in the CG, 3 (10.34%) were in the SG, and 17 (20.48%) were in the OG. There was a statistically significant difference between groups based on requiring RRT ($p = 0.01$), and 11 (42.3%) of the patients who required RRT died. Of the 22 (10.67%) patients who died overall, 4 (4.25%) were in the CG, 3 (10.34%) were in the SG, and 15 (18.07%) were in the OG. There was a statistically significant difference in terms of mortality between the groups.

Consequently, CPB duration ($p = 0.045$), preoperative sCr level ($p = 0.004$), Euroscore ($p = 0.001$), and age ($p = 0.002$) were

determined as risk factors for AKI development. Risk factors for morta-lity were determined to be AKI development (p = 0.001), the stage of AKI (p = 0.001), requiring RRT (p = 0.001), age (p = 0.026), CPB duration (p = 0.015), Euroscore (p = 0.002), and preoperative sCr level (p = 0.006).

Discussion

Coronary artery bypass grafting (CABG) surgery mortality rates depend on the patient group and comorbidities. Mortality and morbidity following CABG can be reduced if early precautions are taken in the preoperative and perioperative periods using accurate scoring and classification sys-tems. For this reason, our clinic uses the Euroscore risk classification system in the preoperative period and the KDIGO criteria to closely monitor the risk of AKI development in the postoperative period.

Open-heart surgery is the second most common etiology of AKI development in ICUs (9). Early recognition and prevention of AKI are crucial since it is an important risk factor for mortality and morbidity. KDIGO criteria are more sensitive compared to Acute Kidney Injury Network (AKIN) and the risk of renal failure, injury to the kidney, failure of kidney function, loss of kidney function, and end-stage renal failure (RIFLE) criteria in terms of predicting in-hospital mortality and AKI diagno-sis (10,11). Rosner et al. found female sex, impaired left ventricular functions, congestive heart failure, diabetes mellitus, peripheral artery disease, preoperative intraaortic balloon pump (IABP) requirement, chronic obstructive pulmonary disease (COPD), emergency surgery, and preoperative high sCr levels to be risk factors (12). We did not include emergency surgeries or patients in a cri-tical state during the preoperative period in our study. Additionally, we found sex to be a risk fac-tor for AKI development, requiring RRT, and mortality. Preoperative sCr levels and high Euroscore risk classification points were determined to be risk factors for AKI development, requiring RRT, and mortality. Reid et al.'s study reached similar results to ours (12).

A noted problem with the Euroscore risk classification system is that the risk point for age does not change after 70 years. There was a statistically significant difference in terms of the risk of AKI development, requiring RRT, and mortality between the SG and OG groups. For these reasons, clinics that use the Euroscore risk classification system in the preoperative period should consider this fact for patients over 70 years of age.

Our study found the risk for AKI development following CABG to be 36.89%. This rate is parallel to previous studies reporting rates between 10% and 47% for AKI development (1,3,8,12). As Spanish researchers and our study have similarly shown, the risk for AKI development increases as the average age of the patient group increases, and AKI development increases mortality. In our study, 23.28% of patients who developed AKI died. The mortality rate is around 30%–60% in pati-ents who require RRT (12,13). Similarly, we identified this rate as 42.3%. Palomba et al. found that mortality increased 7.9 times in patients who developed AKI with a requirement for dialysis following open-heart surgery (13). In our study, similar to Brown et al. and many other studies in the literature, age was an important risk factor for AKI development following open-heart surgery (5). Deschka et al. demonstrated that age and mortality are directly proportional, similar to our study (14). The main reason for this relationship is that senior patients have a more limited tissue and organ reserve compared to younger patients (15).

Prolonged CPB duration is an important predictor of AKI development (16). Similar to the literatu-re, our study showed a statistically significant, directly proportional relationship between prolon-ged CPB duration and AKI development, requiring RRT, and mortality.

The number of bypasses lengthens CPB time and aortic cross-clamp duration (2,5,14), but in our study, the number of bypasses done and aortic cross-clamp duration were found to have no statis-tically significant relationship with AKI development, requiring RRT, and mortality. Mao et al.'s findings were parallel to those in our study in that they also found no statistically significant rela-tionship between the number of bypasses done during CABG and AKI development/mortality (17). Similarly, a study by Wang et al. found no relationship between AKI development/mortality and prolonged aortic cross-clamp duration for octogenarians undergoing combined cardiac procedures with CABG (18).

Our study included patients who underwent open heart surgery with CPB. Many studies in the lite-rature have shown that beating heart surgery is superior to the conventional method in terms of mortality and morbidity (e.g., atrial fibrillation, neurological complications, delirium, AKI, requiring RRT) (5,14,19). This is mainly because systemic inflammatory responses, myocardial injuries, and cerebral injuries caused

by CPB are significantly decreased in older patients during beating heart surgery (20). However, many articles have stated that there is no statistically signi-ficant difference in terms of mortality between these two methods (20–22).

The most important factors in the reduction of AKI development in octogenarians during the pos-toperative period are surgical techniques, medical technological advancements, accurate preope-rative assessment, and correct anesthesiological management (23,24). Despite these advance-ments, the mortality rate in this patient group is higher than in non-AKI patients. A deeper unders-tanding of the pathogenesis of AKI, an accurate determination of risk factors in the preoperative period, and early recognition accompanied by early intervention/treatment can help protect these patients and make open-heart surgery on octogenarian patients safer.

In conclusion, in the senior patient group, the best approach for optimal patient selection is to ensure meticulous surgical technique, hemostasis and excellent anesthesiological management and myocardial preservation (24). Additionally, preoperative and postoperative success requires a personal treatment regime with the utmost cooperation between the cardiac surgeon, anesthesi-ologist, cardiologist, and geriatrician.

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