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Acute kidney injury after cardiac surgery in the North of Iran

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ABSTRACT

Introduction: Acute renal failure is a well-known complication in patients after cardiac surgery.
Objectives: The determination of disease-causing factors with the aim of identifying patients at high-risk and implementing preventive care pre- and postoperatively to reduce the incidence of acute kidney injury (AKI) in patients after cardiac surgery.
Patients and Methods: The present cross-sectional research was carried out on 512 adult patients who underwent cardiac surgery between 2015 and 2016 in our tertiary center. Demographic and laboratory data of patients were obtained using a checklist. AKI is defined as an increase of at least 0.3 mg/dL in creatinine (Cr) over 48 hours and one week after surgery according to acute kidney injury network (AKIN) and RIFLE (risk, injury, failure, loss of kidney function, and end-stage renal failure) criteria before surgery. All data were analyzed by SPSS version 1, and *P* value <0.05 was considered significant.
Results: In this study we found, AKI risk profiles including serum Cr level [OR = 3.24, 95% CI = 1.92 -12.48, *P* = 0.001], fasting blood glucose [OR = 1.22, 95% CI = 1.09 -1.92, *P* = 0.03] and hemoglobin (Hb) before surgery (OR = 0.59, 95% CI = 0.08 -0.87, *P* = 0.04) were significantly associated with increased risk of acute renal injury (logistic regression analysis).
Conclusion: The results indicated that changes in serum Cr level, fasting blood glucose and plasma Hb before cardiac surgery might be considered as the risk factors for AKI after cardiac surgery.

Implication for health policy/practice/research/medical education:
Identifying patients at high-risk and implementing preventive care pre- and postoperatively to reduce the incidence of acute kidney injury in patients after cardiac surgery, we conducted a study on 512 adult patients who underwent cardiac surgery. Our results indicated that changes in serum creatinine level, fasting blood glucose and hemoglobin levels before cardiac surgery may be considered as the risk factors for acute kidney injury after cardiac surgery.

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Original Article

Introduction

Acute kidney injury (AKI) (1) is a well-known complication in patients after major surgery (2-4). Incidence rates of AKI after surgery vary between 13% (5) to 50% (6), although AKI that requires renal replacement therapy is relatively rare (2.3%–6.8%) (7). Each year, more than two million cardiac operations are performed worldwide (8). In the setting of cardiac surgery, postoperative AKI (1) remains a common and a serious post-operative complication that affects 30% to 51% of patients, with up to 3% requiring renal replacement therapy (9-11).

Even though AKI may be modifiable, some patients suffer from a worse clinical outcome that can increase risk of kidney injury (12).

The physiopathology of postoperative AKI is complex and involves numerous factors including history of kidney injury, older age, diabetes mellitus, ischemia reperfusion injury and inflammatory responses (11,13-16). It has been shown that the survival rate is remarkably diminished if the injury progresses to acute renal failure (17), since the quality of life for patients is often meaningfully weak (18). Despite extensive research on mechanisms of cardiac

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surgery associated-AKI, the literature on specific treatment options for AKI is still scanty (19).

Recent studies show that longer AKI duration and greater AKI severity are independently associated with increased mortality (20,21). The International Community of Nephrology focuses on prevention of mortality associated with AKI by 2025, because the prevalence of AKI is increasing across the world (22). Nevertheless, long-term follow-up of coronary artery bypass grafting (CABG) patients demonstrates that AKI is accompanying by poor long-term clinical consequences. Therefore, there is a necessity to identify CABG patients at risk for long-term mortality by renal failure (21,23-26).

It has been shown that management for postoperative complication often requires great resource utilization, such as longer length of stay, make larger use of intensive care and finally the use of renal replacement therapy (27). To overcome the additional cost created by postoperative complications associated with AKI, more attention is needed (28).

As recently demonstrated, serum creatinine (Cr) is not a perfect criterion for detecting AKI, however it can be a valuable marker for chronic kidney disease, a disease with silent clinical signs and without any symptoms until later stages (12). Unfortunately, periodic serum Cr measurements are not common among all patients following CABG after discharge because it is neither an ideal biomarker clinically nor financially cost-effective.

Objectives

The determination of disease-causing factors with the aim of identifying patients at high-risk and implementing preventive care pre and postoperatively to reduce the incidence of AKI in patients after cardiac surgery.

Patients and Methods

Study design

This study is a cross-sectional analysis that was conducted on all adult patients who underwent CABG (2015 to 2016) at our tertiary center. The patients were selected by convenience sampling method, when completed the informed consent and had inclusion criteria. Inclusion criteria were included isolated cardiac bypass surgery, no-emergency surgery, no history of dialysis, no history of renal transplantation and no history of repeated cardiac surgery. Mortality and hospitalization of patients were recorded as exclusion criteria. Demographic and clinical data of all heart patients were collected by a co-researcher with using a checklist. Data were obtained through demographic (age and gender), clinical information (being smoker, having history of diabetes, hypertension and high cholesterol), having history of heart failure, percent of ejection fraction (EF), patient status for coronary artery disease and the preoperative laboratory data including fasting blood sugar (FBS), Cr, and hemoglobin (Hb), and also surgical information (including duration of surgery or blood transfusion during surgery). Plasma Cr was also measured routinely on 48 hours and one week after surgery for all patients. All tests were performed in a hospital laboratory. Disease records were reviewed based on patient response or medication use. Cardiac ejection fraction and angiographic information were extracted from echocardiography and angiography reports by a fellow cardiologist. The ejection fraction was reported as percentage and coronary artery involvement as single vessel disease (SVD), two vessel disease (2VD), and three vessel involvement (3VD). AKI is defined as an increase of at least 0.3 mg/dL in serum Cr 48 hours and one week after surgery according to acute kidney injury network (AKIN) and RIFLE (risk, injury, failure, loss of kidney function, and end-stage renal failure) criteria before surgery (29). All patients received routine preoperative care at the time of admission. Cardiac bypass surgery was performed by four hospital surgeons according to a specific protocol for cardiac surgery.

Statistical analysis

All data were analyzed in SPSS version 16. Normality of distribution was tested using a Kolmogorov-Smirnov test. Independent *t* test and chi-square test were used to compare qualitative and quantitative data, respectively. Then, using logistic regression analysis, odds ratios for each of the studied factors were calculated as independent and binary variables of AKI. In all cases, a *P* value of less than 0.05 was considered significant.

Results

The study performed on 512 subjects who were underwent cardiac surgery at Dr. Heshmat educational and therapeutic center. After excluding patients with having history of kidney transplantation (n = 10), and those who died within two days after operation (n = 2), 500 patients remained.

Table 1 shows the demographic, clinical, laboratory, and surgical characteristics of patients undergoing cardiac surgery. Out of the participants, 326 (65.2%) were male and the rest were female. The mean age of the patients was 60.94±9.2 years. Forty patients on the second day of open heart surgery and 48 patients (9.6%) on one week after surgery had acute renal injury according to AKIN criteria.

Among the studied factors, high FBS, low Hb level and high Cr level before surgery were significantly associated with acute renal injury after 48 hours and one week after surgery (Table 2). Other factors such as diabetes, hypertension, systolic hypertension and duration of surgery were not significantly correlated with AKI

Table 1. Demographic, Clinical, Laboratory Characteristics of Patients Undergoing Cardiac Bypass Surgery in 2015-2016

Variable	
Age, mean ± SD	60.94 ± 9.2
Sex (male), No. (%)	326 (65.2)
Diabetes, No. (%)	224 (44.8)
Hypertension, No. (%)	326 (65.2)
Cigarettes, No. (%)	106 (21.2)
Systolic blood pressure, mean ± SD (mm Hg)	122.5 ± 34.5
Diastolic blood pressure, mean ± SD (mm Hg)	74.8 ±10.9
EF, mean ± SD%	45.5 ± 10.5
Number of vessels with stenosis, No. (%)	
SVD	12 (2.4)
VD2	113 (22.6)
VD3	375 (75)
Duration of surgery (min), mean ± SD	216.4 ± 55.2
Hospital stay (days), mean ± SD	13.04 ± 3.4
Transfusion during surgery , No. (%)	331 (66.2)
FBS, mean ± SD	135.5 ± 61
Hb, mean ± SD	11.4 ± 1.8
Cr before surgery, mean ± SD	1.09 ± 0.53

EF, ejection fraction; SVD, single vessel disease; 2VD, two vessel disease; 3VD, three vessel involvement; FBS, fasting blood sugar; Cr, creatinine; Hb, hemoglobin.

($P > 0.05$).

Based on logistic regression analysis, serum Cr before surgery [OR = 3.24, 95% CI = 1.92-12.48, $P = 0.001$], FBS before surgery [OR = 1.22, 95% CI = 1.09-1.92, $P = 0.03$], and plasma Hb before surgery (OR = 0.59, 95% CI = 0.08-0.87, $P = 0.04$) were significantly associated with high incidence of acute renal injury.

Discussion

According to the present study, the patients following CABG are at high risk for progression to AKI, because some of them rescue from AKI, but others develop renal failure that makes them at risk for progressing to kidney failure (30). The recognition of patients who developing progressive renal injury is important, notably in CABG because these people frequently require other cardiac surgery or catheterization methods that may elevate the risk for developing recurrent AKI. Although numerous innovative markers are recognizing as a preferable procedure of diagnosing AKI, serum Cr is still the demonstrated technique for disease progression (12).

These findings of the present study were in contrast to the results of the study by Pickering et al (31). Besides, Karkouti et al examined the early identification of patients with AKI (32). In their study, 350 individuals who underwent elective valve surgery or CABG were selected, then serum Cr was assessed within 6 hours after operation, and the change in Cr was categorized into three levels including; >10% decrease from baseline, within 10% of baseline, and >10% increase from baseline. Statistical analysis of this study indicated that an early rise in serum Cr and other predictors of AKI were in accordance with our results study. In contrast, the strengths of our study were larger sample size, earlier measurement of serum Cr after surgery, including all types of cardiac surgeries requiring cardiopulmonary bypass.

We found higher serum Cr before surgery 3.24 times and higher FBS 1.2 times heightened the risk of acute renal injury. However, normal Hb before surgery had a protective effect by 41% on renal function. In the same way, reducing renal oxygen delivery, worsening oxidative stress, and impairing hemostasis can be emerged by anemia with contribution to kidney injury. Tissue oxygen delivery is directly related to arterial oxygen content, which is primarily dependent on the Hb concentration (33). The harmful outcomes of anemia are probably raised moreover during CABG for reasons outlined earlier, since the kidney is more prone to renal hypoperfusion (34).

Overall, we found, other factors such as diabetes mellitus, systolic hypertension and duration of surgery were not significantly correlated with AKI. In the study by Karkouti et al (27) diabetes mellitus and hypertension were the risk factors for AKI after cardiac surgery but duration of surgery was not strongly associated with AKI. However, this difference in results can be related to study type or sample size.

Conclusion

Our results indicated that changes in serum Cr, fasting blood glucose and plasma Hb before cardiac surgery can be the risk factors for AKI after coronary artery bypass surgery. The identification of factors that may increase the prevalence of complications is important for planning an effective treatment. Accordingly, more impressive and time-dependent methods to diagnosis AKI are mandatory to decrease treatment costs.

Study limitations

Our research limitation was the duration of follow-up which was restricted to the period of hospitalization.

Authors' contribution

Conception and design: JKH and TH, literature search and Data acquisition: ZA and HD drafting the manuscript: AS, SHM and HD, analysis and interpretation of data: HD and TH. Critical revision of the manuscript for important intellectual content; ZA, SHM and TH. All authors read and approved the final paper.

Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

Table 2. Comparison of the studied factors in two groups with and without acute kidney injury on the second and seventh days

Variables	AKI 2d day +	AKI 2d day -	P#	AKI 1st week +	AKI 1st week -	P#
	40 (8%)	460 (92%)		48 (9.6)	452 (90.4)	
Continues	**Mean (SD)**	**Mean (SD)**		**Mean (SD)**	**Mean (SD)**	
Age (y)	61.01 (9.2)	59.8 (9.1)	0.7	60.9 (9.3)	60.4 (8.2)	0.47
SBP (mm Hg)	122.5 (35.7)	122.6 (18.2)	0.99	123.1 (17.6)	122.5 (35.2)	0.90
DBP (mm Hg)*	74.9 (11.05)	73.8 (9.7)	0.56	75.9 (10.3)	74.7 (11.04)	0.15
EF (٪)	44.6 (13.5)	45.6 (10.2)	0.57	43.4 (12.7)	45.7 (10.2)	0.15
Duration of surgery (min)	217.46 (55.2)	205.3 (55.6)	0.19	217.9 (54.5)	131.3 (59.6)	0.6
FBS (mg/dL)	136.05 (61.9)	130.05 (52.03)	0.002	145.5 (73.2)	131.3 (59.6)	0.01
Hb mg/dL	11.32 (1.8)	13.6 (1.7)	0.03	11.02 (1.1)	12.5 (1.8)	0.02
Cr before surgery (mg/dL)	1.85 (1.53)	1.03 (0.23)	0.001	1.78 (1.41)	1.02 (0.23)	0.002
Categorical	**No. (%)**	**No. (%)**	***P****	**No. (%)**	**No. (%)**	***P****
Gender (male)	25 (62.5)	300 (65.4)	0.24	35 (72.9)	291 (64.5)	0.71
DM	18 (45)	206 (44.9)	0.65	20 (41.7)	203 (45)	0.98
HTN	27 (65.5)	209 (65.1)	0.76	33 (68.8)	292 (64.7)	0.57
Smoker	10 (25)	96 (20.9)	0.54	9 (18.8)	97 (21.5)	0.65
Number of vessels with stenosis			0.32			0.09
SVD	1 (2.6)	6 (1.3)		1 (2.2)	6 (1.4)	
2VD	12 (30.8)	96 (21.6)		10 (21.7)	98 (22.4)	
3VD	26 (66.7)	343 (77.1)		35 (76.1)	334 (76.3)	
Transfusion during surgery	21 (91.3)	309 (89)	0.73	26 (96.3)	304 (88.6)	0.21

AKI, acute kidney injury; DM, diabetes mellitus; HTN, hypertension; FBS, fasting blood sugar; Hb, hemoglobin; EF, ejection fraction; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Independent *t* test; * Chi-square test.

Ethics issues

This study was approved by the Ethics Committee of the Guilan University of Medical Sciences (IR.GUMS.REC.1394.282). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments. All participants provided written and informed consent. This study was extracted from a research proposal of Cardiovascular Diseases Research Center at Guilan University of Medical Sciences. Moreover, ethical issues (including plagiarism, data fabrication, double publication) have been completely observed by the authors.

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