

Temporary Worsening of Kidney Function Following Aortic Reconstructive Surgery

Hafez Ghaheeri,¹ Gholam Hossein Kazem-Zadeh,² Beygi Broujeni²

¹Department of Surgery, Shahrekord University of Medical Sciences, Sharekord, Iran

²Department of Surgery, Mashhad University of Medical Sciences, Mashhad, Iran

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Introduction. Little is known about the incidence of temporary kidney dysfunction following major vascular surgeries. We aimed to assess the frequency of temporary decreased kidney function following aortic surgeries.

Materials and Methods. In a retrospective study, we assessed 108 hospital records of the patients who had undergone elective open abdominal surgery of aortic aneurysm. Preoperative and postoperative (days 1, 2, and 3) data on estimated glomerular filtration rate (GFR) were collected and evaluated in relation to the patients' clinical characteristics and outcomes. A decline greater than 10% in GFR on day 1 or 2, and then, an increase of GFR to a level of maximum 10% below the baseline value on the third postoperative day was considered as temporary worsening of kidney function. Postoperative alterations of GFR not greater than 10% in relation to the baseline were considered as improved or unchanged kidney function. Two patients with persistent decrease in GFR were excluded.

Results. Temporary worsening of kidney function was seen in 25 patients (23.6%). Short-term mortality rate was 44.0% in this group of patients, while it was 17.3% in those without decreased GFR ($P = .006$). According to the regression analysis, the only predictor of mortality was temporary worsening of kidney function, with a hazard ratio of 4.03 (95% confidence interval, 1.44 to 11.31; $P = .008$).

Conclusions. Nearly 1 out of 4 aortic surgeries results in kidney dysfunction. Albeit temporary in most cases, it seems to be associated with a higher short-term mortality rate.

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INTRODUCTION

Atherosclerosis, as a generalized disease with manifestations ranging from angina pectoris, myocardial infarction, and stroke to claudication, may cause aortic aneurysm, which is frequently associated with impaired organ function.¹ In this condition, kidney dysfunction with or without symptoms is often present and considered to be a marker for the presence and severity of an underlying vascular disease.²⁻⁴ Patients with such vascular diseases are also prone to another threat to their kidneys; decreased kidney

function is a well-known complication after major vascular surgeries, which is associated with increased long-term mortality.^{5,6} However, little is known about acute changes in kidney function during the postoperative period in patients undergoing major vascular surgeries. Particularly, data are scarce on temporary impairment of kidney function that revives within a few days after the operation. We designed a retrospective study to determine the frequency of temporary worsening of kidney function in patients with aortic surgeries.

MATERIALS AND METHODS

This retrospective study was carried out on 112 consecutive patients who had undergone elective aortic aneurysm repair with suprarenal clamping-declamping. They had been operated on between January 2004 and January 2007 at Shohada-e-Tajrish Hospital in Tehran, Iran. Patients who required additional renal revascularization were excluded. Men and women with a baseline serum creatinine level greater than 1.3 mg/dL and 1.1 mg/dL, respectively, and those with persistent postoperative impairment of kidney function were excluded as well.

Kidney Function Assessment

Kidney function was determined by estimation of glomerular filtration rate (GFR) using the Cockcroft-Gault formula.⁷ Data on serum creatinine levels measured preoperatively and on postoperative days 1, 2, and 3 were collected. The 3-day interval has been used previously by other researchers to assess the acute changes in kidney function after abdominal aortic aneurysm surgery and its impact on the patients' short-term and long-term survival.^{6,8} Baseline GFR was defined as the value estimated based on serum creatinine levels measured just before the operation or the hospitalization days preceding the operation. Alterations in the estimated GFR from baseline to day 1 or 2 and from day 1 or 2 to day 3 were determined.

Temporary worsening of kidney function was defined as a decline greater than 10% in GFR on day 1 or 2, and then, an increase of GFR to a level of maximum 10% below the baseline value on the third postoperative day. Postoperative alterations of GFR not greater than 10% in relation to the baseline were considered as improved or unchanged kidney function. Finally, persistent worsening in kidney function (an exclusion criterion) was defined as a decline greater than 10% in GFR that persisted until the third postoperative day.

Vascular Surgery

Repair of aortic aneurysm was done by thoracolaparotomy or midline laparotomy. An aortic clamp was placed above the renal arteries or above the celiac arteries, using the *clamp-and-sew* technique without protection of the kidneys from flushing of the renal arteries with heparin. The site of clamping (juxtarenal or suprarenal) was

dictated by aneurysm extent. Possible intraoperative confounders for renal outcome were noted: the operative time, clamping time, perioperative blood loss, episodes of hypotension (systolic blood pressure of less than 70 mm Hg lasting longer than 5 minutes), blood transfusion, body temperature; and the use of antibiotics.

Study Variables

Other than the GFR changes, data on sex, age, cardiac risk factors (history of hypertension, angina pectoris, myocardial infarction, diabetes mellitus, substance use, and smoking), and perioperative and early postoperative complications were also collected.

Surgical complications were grouped into the following categories: infections, pulmonary disorders, cardiac disorders, hypotension, lower limb ischemia (limb amputation or limb necrosis), graft thrombosis or occlusion, and other complications. Cardiac complications were defined as any coronary and noncoronary problems including myocardial infarction and cardiac arrhythmias (defined as the presence of a sustained cardiac rhythm disturbance that required urgent medical intervention). Pulmonary complications included both respiratory insufficiency and pulmonary edema.

All-cause mortality, defined as death of any cause occurring during the postoperative hospital stay,⁹ were also recorded. Causes of death were not included in this study, since it had not been ascertained in all medical records of the hospital database, and autopsy had not been done in all cases.

Statistical Analyses

Continuous data were described as mean \pm standard deviation or median (interquartile range), where appropriate, and dichotomous data were described as percentage frequencies. Independent sample *t* test was used for comparison of continuous variables, and the chi-square test and the Fisher exact test for categorical variables. Regression analysis was used to assess the predictive effect of temporary kidney dysfunction among other variables on the outcome. All of the analyses were performed using the SPSS software (Statistical Package for the Social Sciences, version 13.0, SPSS Inc, Chicago, Ill, USA). *P* values less than .05 were considered significant.

RESULTS

Of 108 patients who underwent aortic aneurysm surgery and their records on kidney function alterations were available, 2 (1.8%) were excluded because of persistent decrease of kidney function. The 106 eligible patients consisted of 94 men (88.7%) and 14 women (13.2%) with a mean age

of 63.5 ± 11.6 years (range, 38 to 87 years). The median hospital stay was 5 days (interquartile range, 4 to 9 days).

In 25 patients (23.6%), temporary impairment of kidney function was observed, while in 81 (76.4%), kidney function improved or remained unchanged. Temporary impairment of kidney function was not significantly associated with age, sex, history of hypertension, history of substance use, or smoking habits, but history of cardiac diseases (angina pectoris and myocardial infarction) were more frequent in patients with this condition (Table 1). Primary vascular disease, site of the aneurysm, operative parameters, and outcomes were not associated with temporary worsening of kidney function (Table 2).

Short-term mortality rate was 44.0% in the patients with temporary worsening of kidney function, and 17.3% in those without decreased GFR ($P = .006$). According to the regression analysis, the only predictor of mortality was temporary worsening of kidney function, and other variables did not remain in the model ($P = .06$ for age, $P = .99$ for sex, $P = .08$ for smoking). Hazard ratio for temporary worsening of kidney function was 4.03 (95% confidence interval [CI], 1.44 to 11.31; $P = .008$).

Table 1. Baseline Characteristics of Patients With and Without Postoperative Temporary Worsening of Kidney Function Following Surgical Repair of Aortic Aneurysm

Variable	Impaired Kidney Function		P
	Yes	No	
Number of patients	25 (23.6)	81 (76.4)	...
Sex			
Male	24 (96.0)	70 (86.4)	
Female	1 (4.0)	11 (13.6)	.29
Past medical history			
Coronary artery disease	8 (32.0)	11 (13.6)	.04
Hypertension	2 (8.0)	10 (12.3)	.55
Smoking	14 (56.0)	55 (67.9)	.28
Substance use	1 (4.0)	15 (18.5)	.11
Primary vascular disease			
Leak of aneurysm	7 (28.0)	11 (13.6)	.09
Aortic stenosis	5 (20.0)	31 (38.3)	.09
Abdominal aortic aneurysm	19 (76.0)	42 (51.9)	.33
Site of aneurysm			
Juxtarenal	17 (68.0)	51 (63.0)	
Suprarenal	8 (32.0)	30 (37.0)	.87

Table 2. Operative Parameters and Outcomes in Patients With and Without Postoperative Temporary Worsening of Kidney Function Following Surgical Repair of Aortic Aneurysm

Variable	Impaired Kidney Function		P
	Yes	No	
Type of Operation			
Aortobilliic	19 (76.0)	61 (75.3)	
Aortoiliofemoral	2 (8.0)	7 (8.6)	
Aortobifemoral	1 (4.0)	11 (13.6)	
Tubular	3 (12.0)	1 (1.2)	
Repair	0	1 (1.2)	.10
Intraoperative parameters			
Mean time of suprarenal clamping, min	49 ± 23	51 ± 20	.53
Mean duration of surgery, min	261 ± 70	250 ± 62	.34
Total blood loss, mL	3565 ± 2507	4120 ± 2779	.35
Units of homologues blood	3.0 ± 2.1	4.2 ± 4.7	.29
Hypotension	3 (11.0)	8 (10.0)	.99
Mean body temperature, °C	35.7 ± 0.9	35.6 ± 0.7	.51
Complications			
Hypotension	0	4 (4.9)	.09
Lower limb ischemia	3 (12.0)	9 (11.1)	.99
Graft thrombosis/occlusion	1 (4.0)	8 (9.9)	.32
Ischemic heart disease	3 (12.0)	11 (13.6)	.99
Short-term mortality	11 (44.0)	14 (17.3)	.006

DISCUSSION

We showed that nearly 1 out of 4 patients with aortic reconstructive surgery experienced temporary worsening of kidney function, which was associated with a poorer outcome (mortality rates 44.0% versus 17.3% in patients with and without temporary GFR decrease, respectively), with a hazard ratio of 4.03 (95% CI, 1.44 to 11.31; $P = .008$). The frequency of kidney function impairment that we reported in this study accords the incidence range between 2% and 45% previously reported.^{6,10-12} The wide discrepancies may be due to definition of the condition ranging from mild kidney dysfunction to end-stage renal disease.

In surgeries requiring suprarenal aortic clamping-declamping, renal hypoxia reperfusion injury has been mentioned as an inevitable consequence of the procedure; up to 20% to 30% of patients experience postoperative kidney dysfunction.¹³⁻¹⁵ This phenomenon is attributed to impaired renal perfusion, with subsequent reperfusion leading to acute inflammatory changes and loss of function. The cause of developing postoperative kidney failure after aortic surgery is multifactorial. Impaired kidney function before surgery, perioperative blood loss, use of nephrotoxic drugs, preexisting atherosclerosis, hypertension, prolonged suprarenal aortic cross-clamping, and ligation of the renal veins during the operation all negatively affect postoperative kidney function.¹⁶⁻¹⁸ Also, some factors play a role in the postoperative kidney function including preoperative assessment and postoperative care such as monitoring of volume status.¹⁹ The use of an experienced team that includes nephrologists during and after the procedure and a continuous coordination with the surgeon may improve the outcome.

Lassnigg and colleague²⁰ suggested that patients who survived the first 30 days after cardiothoracic surgery and had sufficient recovery of kidney function regained the same long-term prognosis as patients without temporary impaired kidney function. Some, however, believe that patients with temporary alterations in kidney function have an even worse long-term outcome than those with persistent worsening of kidney function.⁸ This might be because high-risk patients with persistent worsening of kidney function mainly die within the first 30 days; thus, the diluting effect of kidney dysfunction will be less for the long-term mortality

outcome. The risk of developing severe nonrenal complications that may lead to death increases furthermore by the kidney injury itself and can be explained by the extent and pattern of preexisting comorbidities.¹¹

The effect of acute changes (within the first 3 days) on kidney function after aortic surgery also was investigated by Ellenberger and colleagues.⁶ They reported the greatest mortality rate within 30 days in patients with an increase in serum creatinine levels greater than 0.5 mg/dL compared with baseline, indicating that alterations in kidney function within 3 days after surgery was a strong predictor of perioperative mortality.

In a historical cohort study of 1324 patients who underwent elective open abdominal aortic aneurysm surgery in a single center, adjusted for baseline characteristics and postoperative complications, 30-day mortality was the greatest in patients with persistent worsening of kidney function (hazard ratio, 7.3; 95% CI, 2.7 to 19.8), followed by those with temporary worsening (hazard ratio, 3.7; 95% CI, 1.4 to 9.9). The authors concluded that temporary worsening of kidney function was associated with greater long-term mortality.⁸

Suprarenal aortic cross-clamping which may be required in operations for aortic disease, will result in renal hypoxia reperfusion injury as an inevitable consequence. When limb ischemia is also present, muscle necrosis and myoglobinuria might also be present, all negatively affect kidney function.²¹ A safe renal ischemia time is reported to be 45 to 50 minutes.^{14,22} These effects should be taken seriously, especially in patients with abnormal kidney function at baseline, in whom postoperative chronic kidney dysfunction requiring renal replacement therapy is common. In order to prevent this devastating complication, it is recommended to take every possible measure to minimize the risk.^{5,23,24} It has been reported that subtle changes in postoperative kidney function might identify patients at risk.

A major limitation of our study was the retrospective analysis of data. In addition, not all perioperative data (duration of aortic cross-clamping, transfusion requirements, need for additional surgical interventions, time to extubation, admission in intensive care unit, and use of medication) were available to implement these parameters in our analysis. Furthermore,

changes in perioperative management have evolved markedly over time, which were not taken into account in our analysis. These include multiple factors ranging from preoperative management (such as drug therapy and anesthesiological and surgical techniques) to intensive postoperative care management. Furthermore, we did not evaluate long-term mortality, and the limited number of patients was another limitation. On the other hand, it is well known that a key impediment in the field of acute kidney failure is lack of a uniform definition of changes of kidney function. Current definitions that rely on changes in serum creatinine levels and urine output are neither sensitive nor specific. In a recent report²⁵ the investigators were able to describe 19 different definitions of acute kidney failure (for instance, 20% to 100% increases in serum creatinine levels or increases in serum creatinine levels ranging from ≥ 0.3 mg/dL to ≥ 1.0 mg/dL). Although we did not evaluate these cutoff values, comparing our arbitrary definition of alteration in kidney function with most other published definitions, we had an extremely conservative cutoff value. Since the main objective of this study was to evaluate the incidence of small changes in kidney function, we chose a cutoff value of 10% increase, as previous studies.^{6,8} Furthermore, kidney function estimating equations (eg, Cockcroft-Gault) are derived from patients in a steady state. Because we reported perioperative estimated creatinine clearance changes (within 3 days after surgery) by definition, such a steady state is difficult to establish, which might underestimate true changes in kidney function. Unfortunately, there are no practical ways to readily measure kidney function in an acute setting.

CONCLUSIONS

Based on our findings, 1 out of 4 patients who undergo aortic surgery will show temporary worsening of kidney function. These patients are at a high risk of poor short-term outcome. Temporary impaired kidney function within the first 3 days after aortic surgery was a predictor for perioperative mortality among our series, but it recovered completely in most cases.

CONFLICT OF INTEREST

None declared.

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Correspondence to:
Gholam Hossein Kazem-Zadeh, MD
Department of Surgery, Shahrekord University of Medical
Sciences, Sharekord, Iran
Tel: +98 21 8126 4150
Fax: +98 21 8126 4150
E-mail: cru_common@yahoo.com

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