# Acceptable short-term outcomes after open heart surgery in kidney transplant recipients: a case control study

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# Abstract

Background Cardiovascular disease is common in kidney transplant recipients. They are considered high risk surgery candidates due to comorbidity and immunosuppression. We assessed short-term results of open-heart surgery in kidney transplant recipients and matched controls between 1989 – 2016 at our center. Methods Ninety-five patients underwent open heart surgery (48 coronary artery bypass grafting, 27 valve replacements or repairs and 29 combined procedures) after kidney transplantation. Controls (n=95) were matched for age, sex, type and year of surgery. Mean follow-up was 5.6 (4.9) years. Independent two-sample t-test and chi-square test were used to compare continuous variables and frequencies, respectively. Logistic regression was used to identify preoperative risk factors for 30-day mortality. Results Included were 76 men and 19 women; mean age 60.3 (11.1) years, 7.1 (5.6) years after transplantation. Kidney transplants had lower renal function, more hypertension, but less pulmonary hypertension than matched controls. Intraoperative data was comparable between kidney transplants and controls. Kidney transplants experienced more frequent acute kidney injury (57% versus 21%, p<0.001), more bleeding (1288 (1081) mL versus 957 (548) mL, p=0.01) and more red cell transfusions (4.9 (5.6) versus 3.2 (5.4) units, p=0.04). Infections were borderline more frequent in kidney transplants (30% versus 20%, p=0.10). Thirty-day mortality was 6.3% in kidney transplants and 2.1% in controls (p=0.14). Independent risk factors for 30-day mortality were acute myocardial infarction last 90 days before surgery (OR 12.5, p=0.02) and current smoking (OR 17.3, p=0.02). Conclusions Kidney transplant recipients undergoing cardiac surgery have acceptable short-term results compared with matched controls; 30-day mortality rates were similar. Careful peri- and postoperative management is, however, warranted as kidney transplant recipients experience more bleeding and higher frequency of AKI.


# Background

Cardiovascular disease is common in patients with advanced chronic kidney disease (CKD) and in kidney transplant recipients (KTR) (1, 2). It is, amongst others, characterized by accelerated atherosclerosis and calcification resulting in stiff and dysfunctional arteries and left-sided valvular disease (3, 4). The number of KTR undergoing open heart surgery is steadily rising, as KTR live longer and have multiple risk factors for coronary heart and valve disease, including CKD, dialysis, post-transplant diabetes, arterial stiffness and immunosuppression (5). Even though surgical revascularization confers a high short-term risk, it is associated with favorable long-term outcome in the CKD population and probably also in KTR (6-11). Since the first report on coronary artery bypass grafting in KTR in 1974 (12), numerous studies have been published (13-24). These studies were, however, either small, uncontrolled or included unmatched controls. Recently, there have been several publications of higher quality (25-27) with somewhat diverging short- and long-term result. We present detailed short-term results of heart surgery in KTR and matched controls performed in Norway during a time period of almost three decades. The aim of our study was to assess the short-term risk of open-heart surgery in KTR and describe the influence of preoperative risk factors.

# Methods

Between January 1989 and July 2016 more than 12000 coronary artery bypass graft procedures (CABG) and/or heart valve replacements or repairs were performed on adults at the Department of Thoracic Surgery at Oslo University Hospital, Rikshospitalet. The departmental database, Datacor, was cross-checked with the Norwegian Renal Registry to identify KTR that underwent CABG, valve replacement or a combined procedure after kidney transplantation. The Norwegian Renal Registry is a nationwide quality registry with 100% coverage of all KTR in Norway. Study inclusion criteria were: adult KTR with functioning or non-functioning kidney graft, 18-85 years of age at time of heart surgery, cardiopulmonary bypass with CABG and/or aortic valve replacement/mitral valve replacement/mitral valve repair, both elective and emergency surgery (within 24-hours of diagnosis). Exclusion criteria were: minors (under 18 years old) and thoracic aortic aneurysm surgery. In total, we identified 95 KTR who underwent open heart surgery at Oslo University Hospital, Rikshospitalet. Three of the patients were simultaneous kidney-pancreas recipients. Controls were selected from the thoracic surgery database, Datacor, on a 1:1 basis, matched for age (+/- 2 years), sex, exact type of procedure, year of procedure (+/- 2 years). All 190 patient records were meticulously manually reviewed to double check the data from the registries, and supplement with relevant additional data such as accurate patient history, total peri- and postoperative blood product transfusions, all postoperative complications up to 30 days after surgery. For procedures performed between 1989-2003, paper records were reviewed, whereas electronic records were available after 2003.

Short-term mortality was defined as mortality within 30 days after heart surgery and is presented as Kaplan-Meier actuarial survival estimates. Log-rank test was used to compare survival rates. Analyses comparing continuous variables were based on independent two-sample t-test (except for age that was matched). Chi-square test was used to compare frequencies between two groups, whereas Fisher´s exact test was used if any observed count was less than 5. Binary logistic regression was used to calculate risk factors for 30-day mortality. The following preoperative risk factors were included in the univariable binary logistic regression models: age as a continuous variable, age as a dichotomous variable (under 70 years old vs 70 years old or older), chronic lung disease (COPD or asthma requiring treatment), pulmonary hypertension with estimated pulmonary arterial systolic pressure above 35 mmHg, diabetes mellitus requiring medications (type 1, type 2, post transplant diabetes), maintenance dialysis treatment at time of heart surgery (i.e. graft loss), estimated GFR (CKD EPI creatinine formula for patients with functioning graft), statin use (daily ingestion of any type of statin), left ventricular ejection fraction 35% or less estimated with Simpson´s biplane method, NYHA classification of heart failure class III and IV vs I and II, previous acute myocardial infarction (AMI), AMI 90 days before heart surgery, previous cerebrovascular event (transient ischemic attack, ischemic or hemorrhagic stroke), current smoking (daily), period of surgery (1989-2002 vs 2003-2016), previous heart surgery (any previous heart surgery requiring cardiopulmonary bypass), emergency surgery (i.e. heart surgery within 24-hours of diagnosis), valve surgery (any current valve surgery, including combined CAGB and valve surgery), kidney-pancreas transplant. The multivariable binary logistic regression models for preoperative risk factor for 30-day mortality were based on the backward stepwise (Wald) selection. These analyses included all variables from the univariable analyses, except for estimated GFR, as patients with both functioning and non-functioning kidney grafts were included. Multivariable analyses were performed on all KTR (n=95) as well as on KTR with functioning kidney grafts and dialysis duration of less than 90 days before surgery (n=86) to avoid potential excessive dialysis risk bias. In the multivariable models, age was chosen as a continuous variable. All statistical analyses were performed using SPSS for Windows, version 23 and 24 (IBM Corp, Armonk, NY) software or R, version 3.3.2 (The R Foundation for Statistical Computing).

## Results

Demographic data and baseline characteristics are presented in Table 1. Eighty percent were men and average age for all patients was 60.3 (11.1) years. The procedures were 51% CABG (n=48), 28% (n=27) isolated valve replacements or repairs and 21% (n=20) combined procedures, all performed on average 7.1 (5.6) years after transplantation. The most common valve procedure was aortic valve replacement (AVR). Twenty-four isolated AVRs and 18 combined CABG and AVR procedures were performed. Three KTR and seven controls had active endocarditis at time of surgery (p=0.33). Thirteen KTR had experienced graft loss and were established on chronic dialysis treatment at time of heart surgery. Four of these patients had been on dialysis for less than 90 days (median 60.5, range 38-65 days), whereas the remaining nine patients had undergone maintenance dialysis for more than 90 days (median 453, range 211-1382 days). In patients not on dialysis (n=82), the CKD-EPI creatinine based estimated GFR at time of surgery was lower compared with controls; 45 vs 77 mL/min/1.73m2 (p<0.001).

Table 1. Demographics and baseline characteristics of 95 kidney transplant recipients (including three simultaneous kidney pancreas recipients) who underwent heart surgery (48 CABG, 27 valve replacements or repairs and 20 combined procedures) and 95 controls.

| | Transplant recipients (n=95) | Controls (n=95) | *P* value |
|---|---|---|---|
| Men | 76/19 (80%) | 76/19 (80%) | NA |
| Age, years | 60.3 (11.1) | 60.4 (11.1) | NA |
| Hypertension | 87 | 64 | <0.001 |
| Diabetes mellitus | 36 | 27 | 0.17 |
| Type 1 | 12 | 0 | <0.001 |
| Type 2 | 21 | 27 | 0.40 |
| Post-transplant | 3 | 0 | N.A. |
| Pulmonary disease | 6 | 13 | 0.09 |
| Cerebrovascular disease | 10 | 14 | 0.38 |
| Family history of CVD[a] | 20 | 32 | 0.05 |
| Atrial fibrillation | 24 | 19 | 0.39 |
| VF/VT | 6 | 8 | 0.58 |
| Earlier CABG/Valve | 5 | 5 | 1.0 |
| Angina | 66 | 64 | 0.76 |
| Dyspnea | 66 | 68 | 0.75 |
| NYHA class (average) | 2.85 | 2.84 | 0.93 |
| AMI last 90 days | 12 | 17 | 0.31 |
| Active endocarditis | 3 | 7 | 0.33 |
| Pulmonary hypertension[b] | 14 (n=93) | 43 | <0.001 |
| Ejection fraction % (SD) | 53.1 (13.3) (n=93) | 53.8 (18.4) (n=95) | 0.78 |
| Body surface ($m^2$) | 1.96 (0.24) (n=92) | 1.95 (0.29) (n=91) | 0.76 |
| Serum creatinine mg/dL[c] | 1.84 (0.81) (n=82) | 1.08 (0.47) (n=78) | <0.001 |
| Estimated GFR[3] | 45.4 (21.8) (n=82) | 76.8 (21.7) (n=78) | <0.001 |
| Chronic dialysis[d] | 13 | 0 | NA |
| Years since transplantation | 7.1 (5.6) | NA | NA |
| Range | 23 days – 22 years | | |
| Emergency oper.[e] | 17 | 14 | 0.70 |

[a]Acute myocardial infarction in first-degree male relative before age of 55 or in first-degree female relative before age of 65. [b]Pulmonary artery systolic pressure above 35 mmHg. Two

missing values in KTR.

[c]Estimated glomerular filtration rate based on CKD-EPI creatinine formula. Patients on maintenance dialysis treatment were excluded from the calculation, likewise the matching controls of these patients. Four matching controls had missing creatinine values.

[d] Established on maintenance hemodialysis or peritoneal dialysis at time of heart surgery.

[e] Heart surgery within 24-hours from diagnosis.

Thirty-day mortality was 6.3% in KTR and 2.1% in controls (p=0.14; Log rank test), see Figure 1.

Figure 1. Kaplan-Meier actuarial 30-day survival after heart surgery in 95 kidney transplant recipients versus controls. Overall comparison with long-rank (Mantel-Cox) test, chi-square 2.13, df=1, p=0.14.

There was no difference in mortality rates in the 13 KTR on chronic dialysis versus those with a functioning kidney graft; 7.7% (n=1) vs 6.1% (n=5) (p=1.00). Three of the six KTR who died within first 30-days underwent CABG, two had valve surgery and one had a combined procedure. The causes of death were identified in all but one KTR: cardiac arrest after bleeding, progressive heart failure after perioperative AMI, cerebral infarction, Enterococcus endocarditis and bacterial pneumonia. In the control patients two died within the first 30-days; one had CABG surgery and died of postoperative myocardial infarction and progressive heart failure and the other underwent a combined procedure and died of Pseudomonas septicemia.

The frequency of acute kidney injury (AKI) was significantly higher in KTR with a functioning graft (n=82), 57% vs. 21% (p<0.001), driven mainly by a higher incidence of AKI stage 1, i.e. an absolute increase in serum creatinine of ³0.3 mg/dL or 25%, see Table 2. The incidence of AKI requiring dialysis was similar between groups (7 vs. 4 patients, p=0.35). In two KTR the kidney function did not recover and maintenance dialysis was established. In a univariable logistic regression, likelihood ratio (LR) for AKI in KTR vs. controls was 5.20 (2.58-10.51, p<0.001). After adjustment for preoperative estimated GFR, there was still an increased risk of AKI in KTR, LR 2.98 (1.30-6.83, p=0.02).

Average serum creatinine at admission in the KTR group was 1.84 (0.81) mg/dL (n=82) and for controls 1.08 (0.47) mg/dL (n=78, 4 controls with missing creatinine values), see Table 1. The average peak in-hospital creatinine for KTR was 2.44 (1.22) mg/dL and for all controls 1.29 (0.80) mg/dL (p<0.001) while the mean discharge creatinine was 2.15 (1.17) mg/dL and 1.15 (0.78) mg/dL, respectively. The difference between creatinine at discharge versus admission of 0.3 mg/dL was significant for KTR (p<0.001) only.

KTR experienced also more postoperative bleeding, 1288 (1081) mL vs 957 (548) mL (p=0.01) and received a higher number of postoperative red cell transfusions than matched controls, 4.9 (5.6) vs 3.2 (5.4) (p=0.04). There was no difference in the use of acetylic salicylic acid, warfarin or low-molecular weight heparin among KTR vs. controls (72% vs 65%, p=0.35, 21% vs 18%, p=0.58 and 12% vs 12%, p=1.00, respectively). Although borderline significant, postoperative infections were more common in KTR, 29 (30.5%) vs. 19 (20.0%) patients (p=0.10), mainly driven by the increased frequency of wound infections (10 (10.5%) vs. 3 (3.2%), p=0.09). Postoperative data are presented in Table 2.

Table 2. Postoperative data in 95 kidney transplant recipients who underwent open heart surgery and 95 matched controls.

| **Postoperative data** | **Transplant recipients** (n=95) | **Controls** (n=95) | ***P* value** |
|---|---|---|---|
| 30-day mortality | 6 (6.3%) | 2 (2.1%) | 0.14 |
| Any AKI (AKIN[a] criteria) | 47/82 (57%) | 16/78 (21%) | <0.001 |
| Stage 1 | 37 | 11 | <0.001 |
| Stage 2 | 2 | 0 | 0.50 |
| Stage 3 | 8 (7 dialysis) | 5 (4 dialysis) | 0.44 |
| Readmission within 30 days | 13 (13.7%) | 9 (9.5%) | 0.36 |
| Hemorrhage (ml) | 1288 (1081) | 957 (548) | 0.01 |
| Red cells (units) | 4.9 (5.6) | 3.2 (5.4) | 0.04 |
| Plasma (units) | 3.9 (5.0) | 3.6 (8.3) | 0.77 |
| Platelets (units) | 0.9 (1.8) | 0.6 (2.0) | 0.29 |
| Whole blood | 0.1 (0.6) | 0.1 (0.4) | 0.41 |
| Any blood product | 9.7 (10.8) | 7.4 (15.4) | 0.23 |
| Reoperation for hemorrhage | 8 (8.4%) | 10 (10.5%) | 0.62 |
| Sepsis | 8 | 5 | 0.54 |
| Pneumonia | 15 | 16 | 0.84 |
| Wound infection | 10 | 3 | 0.09 |
| Mediastinitis | 2 | 1 | 1.00 |
| Any postoperative infection | 29 (30.5%) | 19 (20%) | 0.10 |
| Postoperative arrhythmia[b] | 42 | 38 | 0.56 |
| Ventilation support (hours) | 13.0 (29.1) | 15.5 (41.0) | 0.62 |
| ICU days | 2.0 (2.8) | 1.8 (2.4) | 0.51 |
| Length of stay (days) | 7.2 (7.5) | 6.0 (3.0) | 0.15 |

[a]Acute Kidney Injury Network. AKI calculated only in KTR with functioning kidney grafts (n=82) and corresponding matched controls (n=78, four controls had missing creatinine values) [b]New onset postoperative atrial fibrillation, atrial flutter, ventricular tachycardia, ventricular fibrillation

There was no statistical difference in intraoperative data and perioperative complications. However, perioperative stroke occurred in 6 KTR (6.3%) and in only 1 control patient (1.1%), p=0.12, see Table 3.

Table 3. Intraoperative data and perioperative complications in 95 kidney transplant recipients who underwent open heart surgery (48 CABG, 27 valve replacements or repairs and 20 combined procedures) and 95 controls.

| | **Transplant recipients** (n=95) | **Controls** (n=95) | ***P* value** |
|---|---|---|---|
| Perfusion time (min) | 91 (35) | 99 (50) | 0.22 |
| Ischemia time (min) | 59 (29) | 62.6 (39) | 0.48 |
| Perioperative myocardial infarction | 6 | 3 | 0.50 |
| Perioperative cerebrovascular accident | 6 | 1 | 0.12 |
| Number of distal coronary anastomoses[a] | 2.8 (1.15) | 2.9 (1.03) | 0.70 |
| Use of internal thoracic artery[a] | 91% (n=62) | 85% (n=58) | 0.29 |

[a]CABG only, n=68

Univariable binary logistic regression models for preoperative risk factors for 30-day mortality are presented in Table 4. The multivariable analysis for all KTR (n=95) is presented in Tables 5.

When excluding patients who had received dialysis for more than 90 days before heart surgery (n=9), multivariable binary logistic regression yielded the same risk factors of similar magnitude for 30-day mortality: current smoking OR 18.37, 95% CI 1.73-194.80, p=0.02 and AMI within 90 days before surgery OR 10.58, 95% CI 1.35-82.83, p=0.03.

Table 4. Univariable binary logistic regressions. Preoperative risk factors for 30-day mortality after heart surgery in 95 kidney transplant patients.

| Risk factor | Odds ratio (95% CI) | *P* value |
|---|---|---|
| Age per year | 1.05 (0.96-1.14) | 0.29 |
| Age (<70 vs =>70 years)[a] | 3.45 (0.65-18.44) | 0.15 |
| Chronic lung disease | 1. (0.00-.) | 1.00 |
| Pulmonary hypertension[b] | 1.17 (0.13-10.83) | 0.89 |
| Diabetes mellitus | 1.70 (0.32-8.90) | 0.53 |
| Dialysis | 1.28 (0.14 -11.95) | 0.83 |
| Estimated GFR[c] | 1.02 (0.98-1.06) | 0.29 |
| Statin use | 2.68 (0.30-23.90) | 0.38 |
| Ejection fraction £ 35% | 1. (0.00-.) | 1.00 |
| NYHA Class III/IV vs I/II | 2.18 (0.24-19.54) | 0.49 |
| Previous AMI | 2.45 (0.43-14.07) | 0.32 |
| AMI within 90 days before surgery | 8.89 (1.56-50.76) | 0.01 |
| Previous cerebrovascular event | 1.78 (0.19-16.95) | 0.62 |
| Current smoking | 12.12 (1.35-108.81) | 0.03 |
| Period of surgery[d] | 0.26 (0.03-2.29) | 0.22 |
| Previous heart surgery | 1. (0.00-.) | 1.00 |
| Emergency surgery | 2.47 (0.41-14.71) | 0.32 |
| Valve surgery | 1.02 (0.20-5.34) | 0.98 |
| Kidney-pancreas transplant | 1. (0.000-.) | 1.00 |

[a]n=23 versus n=72, respectively [b]Systolic pulmonary artery pressure > 35 mmHg [c]Estimated glomerular filtration rate based on CKD-EPI creatinine formula for patients with functioning kidney grafts (n=82) [d]1989-2002 versus 2003-2016

Table 5. Multivariable binary logistic regression[a]. Preoperative risk factors for 30-day mortality in 95 kidney transplant recipients.

| Risk factor | Odds ratio (95% CI) | *P* value |
|---|---|---|
| Current smoking | 17.32 (1.62-185.63) | 0.02 |
| AMI within 90 days before surgery | 12.49 (1.60-97.40) | 0.02 |

[a]Backward Wald selection procedure was used, including all variables from the univariable analyses (except estimated GFR) to identify the final multivariable model.

## Discussion

Our study demonstrates acceptable short-term results of coronary artery bypass and valve surgery in KTR compared with matched controls. The 30-day mortality was 6.3% in KTR versus 2.1% in controls (p=0.15). There was no difference in perioperative data between KTR and controls, but KTR experienced more postoperative bleeding and a higher frequency of AKI stage 1. Postoperative infections tended to be more frequent in the KTR group (p=0.10). These are acceptable outcomes, bearing in mind that only 50% of patients underwent isolated CABG procedures and 21% underwent combined CABG and valve procedures. Additionally, 15% underwent emergency surgery, i.e. within 24-hour of diagnosis. We also demonstrate that independent risk factors for short-term mortality were current smoking and AMI within 90-days before surgery.

The 6.3% 30-day mortality compares well with previous studies. In the largest registry study published to date, Vargo et al report 7% in-house mortality for 2,712 KTR versus 4% for non-transplanted controls, extracted from the US Nationwide Inpatient Sample in the period 2004-2008 (28). This study is not only interesting due to the significant sample size, but also due to a similar distribution of cardiac procedures performed compared with our study. Others report a varying range of short-term mortality rates (11, 13-20, 22-25, 27, 29, 30), ranging from 1.4% (17) to 14% (30) depending on type of procedures and patient population.

Perioperative stroke was more frequent among KTR than controls, 6.3% vs 1.1% (n=6 vs n=1, p=0.12) although not statistically significant. Kohmoto et al (25) showed a significantly higher frequency of perioperative stroke among transplant recipients (kidney, kidney-pancreas and liver transplant recipients) than in matched controls, 4.3% vs 0.6% (p=0.005). Interestingly, both the actual number and percentage of KTR with perioperative stroke was very similar in our cohort (6 out of 95) compared to KTR in the Kohmoto study (5 out of 97) (25). Worth noting, all five strokes in the Kohmoto study were in KTR only. No strokes were observed in the 18 liver transplant or 15 kidney-pancreas transplant recipients also included in their study. The possible reasons for stroke not being significantly more frequent in our KTR versus controls is the lower number of controls (1:1 vs 1:3 matching) and possibly the high preoperative prevalence of stroke in our control patients (15% of our controls had a history of cerebrovascular event), i.e. signifying a high risk for repeat stroke. Other studies have not shown any difference in perioperative stroke frequency in KTR vs matched control patients.

As many as 57% of the our KTR experienced AKI, as compared to 21% of the controls. These high numbers were driven by the high incidence of AKI stage 1 in both patient groups, and especially in the former. This can be explained by the readily attainable 0.3 mg/dL increase in creatinine in KTR whose average preoperative creatinine was 1.8 mg/dL. Only 8.5% percent of KTR required acute dialysis and only 2% became dependent on chronic dialysis postoperatively. The perioperative ischemia time and perfusion time did not differ between KTR requiring acute dialysis postoperatively versus those who did not (data not shown). Farag et al reported AKI resulting in postoperative dialysis in as many as 16% of KTR, with an average preoperative creatinine of 2.2 mg/dL. The frequency was 5.7% for the matched controls in that study (preoperative creatinine 1.2 mg/dL). Vargo et al (28) reported 37.5% AKI in KTR versus 11.5% in controls. Another study with a control group published by John et al (17), showed 33% incidence of kidney dysfunction (acute dialysis in 11% and s-creatinine increase > 2 mg/dL in 22%) in KTR versus 6% in controls. Other studies report varying frequency of acute dialysis after cardiac surgery in KTR, 6-21% (13, 15, 18, 19). Interestingly, Rocha et al (13) reported 21% dialysis postoperatively, but only 3% permanent dialysis, a finding similar to ours.

More postoperative bleeding was reported in KTR. Some of this difference could be attributable to the uremic dialysis patients in the KTR group (n=13), but results were almost identical after excluding these patients from the analyses. However, KTR with functioning kidney grafts were in CKD 3, whereas controls had an estimated GFR within normal range. The use of acetylic salicylic acid, warfarin and low-molecular heparin was similar in the two patient cohorts. These results are consistent with both Farag et al and Vargo et al (27, 28). The Farag study reported more postoperative bleeding, higher frequency of re-exploration and higher need of intraoperative transfusions of all types of blood products, whereas Vargo reported an odds ratio for RBC transfusion of 1.63 in KTR versus controls.

Postoperative infections were frequent in both KTR and control patients, 30.5% and 20%, respectively (p=0.10). Pneumonia comprised the majority of infections in both patient groups, whereas wound infection was the second most frequent infection type in KTR. Farag et al (27) reported also relatively high frequency of infections, 20% in KTR vs 13% in controls, not statistically significant. Pneumonia and septicemia were the most frequent type of infections. Two other controlled studies, Vargo et al and John et al (17, 28), report much lower frequencies of postoperative infections, approximately 7%, with no difference between groups. Others report rates of 9-21% (14, 15, 18). A possible explanation for the high frequency of reported infections in the present study was the meticulous manual review of all patient records, thus fewer infections were missed.

The only significant preoperative risk factors for 30-day mortality in our KTR were AMI within 90 days before surgery and active smoking. These risk factors were the same even when excluded patients who had received dialysis for more than 90 days before surgery (n=9). Although these risk factors are plausible, the interpretation requires caution as the mortality in our cohort was low. Rocha et al (13) reported age over 65, left ventricular ejection fraction below 35% and combined procedure (CABG and valve surgery) as preoperative risk factors for short-term mortality. Both Vargo et al and John et al (17, 28) report both pre- and perioperative risk factors, including age and AKI (28) and perfusion time, CHF symptoms, urgent surgery and left ventricular ejection fraction below 40% (17). However, the latter study included both transplant recipients (n=74) and all non-transplanted controls (n=895) in the risk analysis. The recent study of Farag et al (27) demonstrated perioperative risk factors to be other thoracic surgery (ASD and VSD closures, pulmonary embolectomy), intraoperative blood transfusions, new-onset dialysis and septicemia. We also evaluated potential perioperative risk factors in our KTR cohort. Like Farag et al we confirm that only AKI requiring dialysis postoperatively is an independent risk factor for mortality (data not shown).

# Conclusions

KTR undergoing cardiac surgery have acceptable short-term results compared with matched controls. Thirty-day mortality rates were 6.3% and 2.1%, respectively. Careful peri- and postoperative management is warranted as KTR do experience more bleeding and higher frequency of AKI.

# Abbreviations

**ACEI:** Angiotensin II converting enzyme inhibitor

**AKI:** Acute kidney injury

**AKIN:** Acute Kidney Injury Network

**AMI:** Acute myocardial infarction

**ARB:** Angiotensin II receptor blocker

**ASD:** Atrial septal defect

**AVR:** Aortic valve replacement

**CABG:** Coronary artery bypass grafting

**CHF:** Congestive heart failure

**CI:** Confidence interval

**CKD:** Chronic kidney disease

**CKD-EPI:** Chronic kidney disease epidemiology collaboration

**CVD:** Cardiovascular disease

**DM:** Diabetes mellitus

**ESRD:** End-stage renal disease

**GFR:** Glomerular filtration rate

**ICU:** Intensive care unit

**KTR:** Kidney transplant recipient(s)

**LR:** Likelihood ratio

**NYHA:** New York Heart Association classification

**OR:** Odds ratio

**SD:** Standard deviation

**VF:** Ventricular fibrillation

**VT:** Ventricular tachycardia

**VSD:** Ventricular septal defect

# Declarations

### Ethics approval and consent to participate

Consent for this study was obtained from the Data Protection Official at Oslo University Hospital, Rikshospitalet. All data from the departmental database Datacor and from the Norwegian Renal Registry is approved for research and publications.

### Consent for publications

Not applicable

### Availability of data and materials

The dataset used and analyzed during the current study, un-personified, is available from the corresponding author on reasonable request.

### Competing interests

The authors declare that they have no competing interests.

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### Authors´ contributions

BJW: collected data, conducted data analyses, interpreted data and was a major contributor in writing the manuscript. JLS: collected data, conceptualized the ideas, research goals and aims and edited the paper. AH: interpreted data, was instrumental in research design and editing of the paper. AEF: collected data, research design. AÅ: conducted data analyses, conceptualized ideas, interpreted data and was indispensable in editing the paper. All authors read and approved the final manuscript.


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# Figures

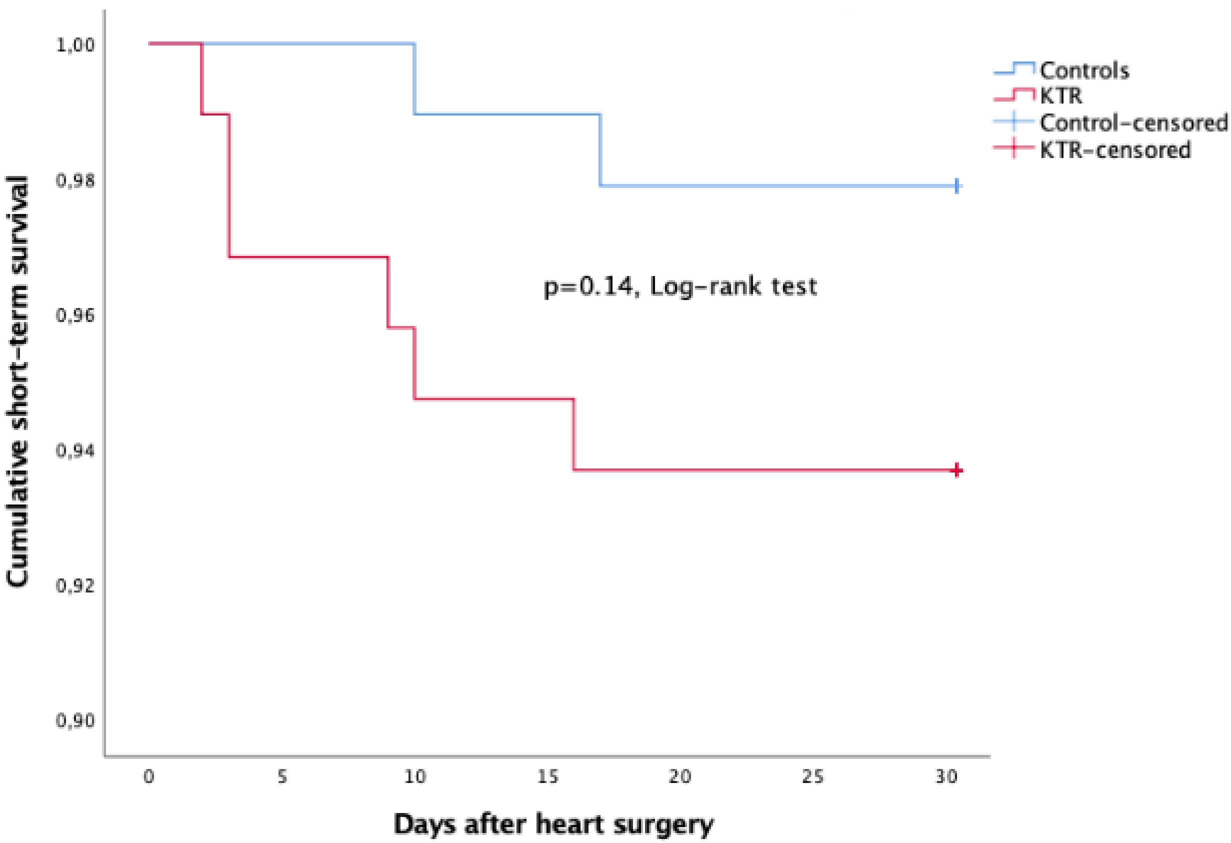


Figure 1

Kaplan-Meier actuarial 30-day survival after heart surgery in 95 kidney transplant recipients versus controls. Overall comparison with long-rank (Mantel-Cox) test, chi-square 2.13, df=1, p=0.14.