Cardiovascular Topics

Effects of cardiopulmonary bypass on dialysis-dependent patients

Nursen Tanrıkuşlu, Baburhan Ozbek

Abstract

Background: End-stage renal disease is considered an independent risk factor for early and late survival after coronary artery bypass grafting.

Methods: We retrospectively analysed patients with dialysis-dependent renal insufficiency who had undergone coronary artery bypass surgery between 2010 and 2017. Patients who were operated with the assistance of cardiopulmonary bypass (ONCAB) were in group 1 and those operated with off-pump coronary artery bypass surgery (OPCAB) were in group 2. We compared peri-operative morbidity and mortality rates and short-term results of the two groups.

Results: There were 74 patients in group 1 and 36 in group 2. Blood transfusion requirement, drainage, need for intra-aortic balloon pump and duration of stay in intensive care unit was statistically significantly higher in group 1 (p < 0.05).

Also, postoperative creatine kinase (CK) and creatine kinase-muscle/brain (CKMB) values were statistically significantly higher in group 1 (p = 0.003).

Conclusion: Coronary artery bypass grafting under ONCAB was a potential risk for morbidity and mortality in patients with end-stage renal disease. Performing OPCAB surgery may improve postoperative outcomes and should be kept in mind as a surgical option.

Keywords: cardiac surgery, cardiopulmonary bypass, dialysis, renal insufficiency

Coronary artery disease is a common cause of mortality in patients requiring dialysis, with a rate higher than 40%. On the other hand, end-stage renal disease (ESRD) is considered an independent risk factor for early and late survival after coronary artery bypass grafting (CABG). Peri-operative mortality risk increases from five to 20% in ESRD patients, which is almost three-fold higher than in non-ESRD patients.

Off-pump coronary artery bypass grafting (OPCAB) is a well-established and feasible procedure with reduced morbidity and mortality rates in high-risk patients. By contrast, some authors reported that long-term survival rates after OPCAB were worse than those of on-pump coronary artery bypass grafting (ONCAB) because of lower rates of complete revascularisation. However, it was reported that OPCAB had better short-term outcomes than conventional CABG in ESRD patients.

There are limited data on myocardial revascularisation procedures in patients with ESRD. In this study, we retrospectively analysed peri-operative and short-term outcomes of dialysis-dependent patients after CABG and analysed the effect of cardiopulmonary bypass on the outcomes.

Methods

Patients who had undergone coronary artery surgery from 1 January 2010 to 31 December 2017 in our department were retrospectively analysed. We included patients with selective CABG surgery and dialysis-dependent ESRD. We excluded patients who had undergone a concomitant surgical procedure, had dialysis-independent renal disease and patients younger than 18 years old. All demographics and peri-operative variables were obtained from medical records.

Regarding the surgical procedure, patients were evaluated in two groups. Group 1 consisted of patients who had undergone ONCAB, and those who were operated with OPCAB were in group 2.

All operations were performed via a median sternotomy. Arterial conduits were harvested in a skeletonised fashion. In group 1, heparin was given to achieve an activated clotting time of 480 seconds. Standard cardiopulmonary bypass (CPB) was achieved via cannulating the ascending aorta and right atrium. Cold blood cardioplegia was delivered through the aortic root (antegrade flow) and through the coronary sinus (retrograde delivery). All patients were ultra-filtrated during CPB with a mean volume removal of 1 500 ml.

In group 2, heparin was given to achieve an activated clotting time greater than 300 seconds. Deep pericardial stitches were placed to manipulate the heart and expose the coronary arteries. An Octopus coronary stabiliser (Medtronic Inc, Minneapolis, MN) was used. Distal anastomoses were done first and the operation was ended after a proximal anastomosis. We compared pre-operative demographics and peri-operative and short-term outcomes between the two groups.
Statistical analysis

Statistical analyses were performed with the NCSS (Number Cruncher Statistical System) 2007 Statistical Software (Utah, USA) program for Windows. Besides standard descriptive statistical calculations, the Mann–Whitney U-test was used for comparison of the groups. The Wilcoxon test was employed in the assessment of pre- and postoperative values. Chi-squared and McNemar’s tests were performed during the evaluation of qualitative data. Multiple regression analyses were performed to explain the relationship between group 1 and group 2. The results were evaluated within a 95% confidence interval. Statistical significance level was established at \( p < 0.05 \).

Results

The study population consisted of 110 patients with dialysis-dependent ESRD among a total of 1886 patients who underwent CABG surgery between 2010 and 2017. There were 74 patients (26 female, 48 male) in group 1 with a mean age of 60 ± 7 years; 36 patients (12 female, 24 male) were in group 2 and the mean age was 61.5 ± 7.5 years.

There were no statistically significant differences between the two groups with regard to age, gender, old myocardial infarction and other demographic variables (Table 1). Drainage (800 ± 350 vs 600 ± 325 ml, \( p = 0.044 \)) and CK-MB elevation and lower rates of need for IABP when compared to ONCAB in dialysis-dependent patients. Although pre-operative levels of creatinine kinase (CK) and creatine kinase-muscle/brain (CK-MB) were similar, postoperative CK (1076.45 ± 2411.97 vs 208.45 ± 171.94 mg/dl, \( p = 0.003 \)) and CK-MB levels (102.32 ± 115.5 vs 53.15 ± 66.53 mg/dl, \( p = 0.044 \)) were statistically significantly higher in group 1. In the comparison of pre-operative and postoperative CK levels, it was observed that postoperative CK (111.94 ± 139.63 vs 1076.45 ± 2411.97 mg/dl, \( p = 0.0001 \)) and CK-MB levels (102.32 ± 115.5 vs 44.47 ± 124.9 mg/dl, \( p = 0.0001 \)) of group 1 were statistically significantly higher.

Similarly, postoperative troponin values of group 1 were statistically significantly higher than those in the pre-operative period (0.07 ± 0.09 vs 9.15 ± 22.54 mg/dl, \( p = 0.043 \)). Postoperative requirement for inotropic agents (22.2 vs 29.70%, \( p = 0.557 \)) and intra-aortic balloon pump (IABP) (16.7 vs 21.6%, \( p = 0.666 \)) were similar in both groups (Table 3).

Univariate tests were significantly higher in group 1 in terms of blood transfusion, drainage, length of stay in ICU, and postoperative CK and CK-MB values. In the logistic regression analysis, only post-operative CK levels remained statistically significantly higher (\( p = 0.038 \)) (Table 4).

Discussion

This study demonstrates that OPCAB had the advantage of decreased incidence of bleeding, lower rates of requirement for transfusion, shorter length of stay in ICU, decreased CK and CK-MB elevation and lower rates of need for IABP when compared to ONCAB in dialysis-dependent patients.
Patients with ESRD have significantly higher risk for cardiovascular morbidity and mortality. Most patients with ESRD have left ventricular hypertrophy secondary to systemic arterial hypertension, hyperparathyroidism secondary to chronic renal disease, and several systemic co-morbidities such as cerebrovascular disease or diabetes mellitus. All these factors can lead to accelerated atherosclerosis of the coronary arteries.

Based on the present study and our clinical experience, coronary lesions of dialysis-dependent patients are mostly characterised by extensive, long, diffuse disease with calcification. Peri-operative mortality rate may be increased in patients with diffuse arterial disease. Also, long-term survival may be decreased with the OPCAB procedure due to incomplete revascularisation in these patients.

According to our clinical observation, dialysis-dependent patients may present with two different patterns of coronary artery disease. Some present with typical proximal obstructions and relatively good distal vessels. However a second group presents with severe distal disease in addition to proximal obstruction. The second group has increased surgical risk and decreased chance of benefiting from the operation. In most cases, receiving medical therapy or angioplasty may produce better results in these patients.

Contemporary treatment models for renal replacement have improved survival rates in ESRD patients. This condition, considering the high number of elderly patients on dialysis, increases the incidence of coronary artery disease (CAD) and the need for myocardial revascularisation in such patients. Recent reports have shown that patients with ESRD have improved long-term outcomes when treated surgically compared to percutaneous procedures. Cardiac surgery can be performed with acceptable results in dialysis-dependent patients. In our study, the in-hospital mortality rate was 24.5%, and it was acceptable for patients with a high EuroSCORE.

After CABG, complications develop more often in patients with ESRD. Sternal wound infection and pneumonia are common complications that increase the risk of mortality. In ESRD patients, the in-hospital mortality rate of cardiac surgery varies from zero to 36.7%. In chronic renal disease, Herzog et al. declared an in-hospital mortality rate of 8.6% and two-year mortality rate of 44% after surgery.

Interestingly, postoperative pneumonia was higher in OPCAB patients in our study. This may have been because of our patient selection, since we performed the OPCAB procedure particularly in patients with severe lung disease. Although patients had severe pulmonary disease in group 2, the in-hospital mortality rate was lower. In this regard, we highlight that, from the randomised-groups statistical analysis, the OPCAB procedure may be more favourable.

Several studies have shown that an increased risk of complications were associated with the use of CPB, decreased leukocyte chemotaxis and leukopenia, and difficulty in maintaining fluid-electrolyte balance. OPCAB is an alternative method that could improve surgical morbidity and mortality rates in dialysis-dependent patients with CAD. The OPCAB procedure prevents the inflammatory and destructive effects of CPB and improves short-term cardiac haemodynamics.

Improvements in technology for cardiac stabilisation and increased experience with heart positioning have allowed surgeons to perform routine complete off-pump revascularisation in three-vessel coronary artery disease, especially in patients with multiple co-morbidities. OPCAB surgery improves short-term mortality rates in patients with ESRD. While the in-hospital mortality rate of OPCAB was between zero and 1.7% in some studies, the rate for the ONCAB procedure was reported as 14.7–17.2%. Potential benefits of off-pump surgery include less postoperative cognitive impairment, lower incidence of renal failure, decreased blood loss, shorter mechanical ventilation, shorter length of ICU and hospital stay, and lower mortality rates in high-risk groups.

Re-operation for bleeding is also a common problem in ESRD patients. Homeostasis disturbances, platelet dysfunction, coagulation defects depending on uraemia, and the mechanical stress of dialysis may be reasons for increased postoperative bleeding. In our study, the rate of re-operation due to bleeding was 10.5% and this may have been caused by dialysis and its complications. In our study, 12 (10.5%) patients needed re-operation caused by bleeding, which was higher than in patients without renal disease.

A limitation of this study includes the disadvantages of retrospective studies, therefore any conclusions are limited in applicability. In this study we report on a single-centre experience with a relatively small number of patients and short follow-up period. Additionally, we have no definitive data for the cause of death after hospital discharge.

Conclusion

In dialysis-dependent patients, CPB has additional risk factors such as inflammatory effects and longer surgical times. The inflammatory response and increased surgery and ventilation times may cause systemic problems, particularly pulmonary dysfunction in high-risk patients. These systemic problems lengthen the hospitalisation period and increase mortality and morbidity rates. The OPCAB procedure is a safe alternative with acceptable outcomes and avoids the side effects of CPB. After detailed investigation with coronary angiography, complete revascularisation with the OPCAB procedure is possible in centres with experienced surgeons. It may be the treatment of choice in high-risk patients, using skilled surgeons.

References

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