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Original Article

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Renal Problems Following Open-Heart Surgery: A Cardiovascular Surgeon's Perspective

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ABSTRACT

Objective: The presence of preoperative kidney disease or the development of postoperative renal failure (RF) is an undesirable condition and complication in patients who have undergone open-heart surgery (OHS). The purpose of this study is to assess the strategies and practical clinical interventions for patients with preoperative renal function impairment or newly developed postoperative renal function impairment subsequent to OHS.

Methods: We retrospectively analyzed 1115 patients who underwent OHS from 2010 to 2018 and collected data from 184 patients (71 patients had end-stage renal disease with dialysis routine, whereas 113 patients had preoperative compensated RF without dialysis requirement).

Results: The mortality rate of 141 patients with end-stage RF who underwent OHS and who needed renal replacement due to RF at the postoperative period was 11.34%. Three patients could be withdrawn from cardiopulmonary bypass with the help of an intra-aortic balloon pump. Five patients underwent revision due to bleeding. Mean intensive care unit length of stay and mean hospitalization duration were 4.3 ± 1.1 and 11.4 ± 1.8, respectively.

Conclusion: Multidisciplinary collaboration for the management of patients with preoperative or postoperative renal dysfunction may provide better results in the long term.

Keywords: Cardiac surgery, renal failure, dialysis, renal replacement therapies

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INTRODUCTION

The presence of preoperative kidney disease and postoperative development of acute kidney injury (AKI) is an undesirable condition and complication in patients who have undergone open-heart surgery (OHS).[1,2] All of the forms of renal failure (RF) have high mortality and morbidity despite all performed treatment methods including dialysis and high dose inotrope support.[3-5]

The incidence of renal function loss after cardiovascular surgery varies between 7% and 40% in various series depending on the surgical technique and procedure. Only 5% of these cases require renal replacement treatment.[6-10]

Kidney diseases are recognized as acute kidney disease (AKD), chronic kidney disease (CKD), and acute on CKD according to the duration of decreased renal functions. Three definitions of AKI based on serum creatinine (Scr) and urine output have been recommended and approved. The Kidney Disease: Improving Global Outcomes (KDIGO) grading was designed based on the Risk, Injury, Failure, Loss of Kidney Function, and End-stage Kidney Disease (RIFLE) and the Acute Kidney Injury Network (AKIN) classifications. According to KDIGO criteria, Scr increase of ≥0.3 mg/dL within 48 h or ≥50% within 7 days and urine output of <0.5 mL/kg/h for >6 h are defined as stage 1.[11-13]

The need for dialysis usually occurs in patients with stage 3 AKD when refractory fluid overload, severe hyperkalemia, signs of uremia, and severe metabolic acidosis are noticed. Patients who need postoperative dialysis have a significantly increased mortality rate compared to patients who do not need dialysis.[6,7] Besides, the transient elevation of the Scr level after OHS which does not require hemodialysis has been reported in 21% of patients.[14]

In our study, we discuss the strategies and practical interventions of patients with renal function impairment who have undergone OHS at our department by evaluating patients with preoperative renal function impairment and newly developed postoperative renal function impairment.

MATERIALS AND METHODS

Open-heart surgery cases performed between 2010 and 2018 years at the Department of Cardiovascular Surgery, KTU School of Medicine were evaluated by retrospective study after obtaining ethics committee approval. OHS had been performed in 1115 patients at our clinic during this period. Isolated coronary bypass surgery was performed in 825 patients. Valve replacement was performed in 160 patients, isolated thoracic aortic surgery in 58 patients, and combined surgery in 72 patients. The overall male/female ratio was 2.17. The mean age of patients was 64.06 ± 14.21. In this study, 51.36%, 35.57%, and 13.07% of patients had low, moderate, and high EuroSCORE points, respectively. The overall mortality rate was 2.41%. Seventy-one patients had end-stage renal disease with dialysis routine, whereas 113 patients had stage 4-5 CKD (predialysis).

Pre-, intra-, and postoperative follow-up and treatments of these patients with AKI were performed multidisciplinaryly. Patients undergoing elective operation were operated on at least 1 week after coronary angiography for renal recovery. A hemodialysis catheter was preoperatively inserted in patients who were in chronic peritoneal dialysis and chronic hemodialysis, and those with stage 4-5 CKD. Dialysis was performed in all routine dialysis patients 1 day before the operation. Intraoperative hemodiafiltration was performed before exiting cardiopulmonary bypass (CPB) in patients with low intraoperative urine output and patients with routine dialysis. Continuous venovenous hemodialysis was performed on most of the patients with the need for renal replacement due to hemodynamic instability at the early postoperative period. Dialysis of patients with previous arteriovenous fistula (AVF) was performed on a catheter instead of their fistula for effective dialysis and protection of fistula function. Monitoring and treatment planning of these patients were always done by consulting with the nephrology department.

RESULTS

Preoperative demographic data of the patients are shown in Table 1. The number of patients who underwent postoperative renal replacement therapy was 141. The male/female ratio was 1.98. According to the EuroSCORE evaluation, 58 (41.1%) of all cases are in the low-risk group (average risk score 1.99 ± 0.84), 42 (29.8%) were in the medium-risk group (mean risk score 4.79 ± 0.79), and 41 (29,1%) were in the high-risk group (mean risk score 6.88 ± 0.93). Patients' rates of hypertension and diabetes mellitus were quite high. In the postoperative period, the mortality rate was 11.34% for 141 patients who underwent renal replacement therapy following OHS. Valve replacements in these patients were performed with mechanical valves. The mean duration of the cross-clamping period and CPB were 64 ± 18 and 96 ± 17 min, respectively (Table 2). Three patients were withdrawn from CPB with the help of an intra-aortic balloon pump. Five patients underwent revision due to bleeding. The mean duration of postoperative mechanical ventilator use was 10.2 ± 4.1 h. The mean drainage volume of these patients until the removal of the chest tube was 552 ± 124 mL. Mean intensive care unit length of stay and mean hospitalization duration were 4.3 ± 1.1 day and 11.4 ± 1.8 day, respectively.

Table 1. Preoperative Demographic Parameters of the Enrolled Patients

Preop Demographic Data	Overall ($n = 1115$)	Post-op Renal Replacement Therapy in ICU ($n = 141$)
Age (years)	64.06 ± 14.21	67.17 ± 13.43
Male/female ratio	217	1.98
Low EuroSCORE	51.36%	41.13%
Moderate EuroSCORE	35.57%	29.78%
High EuroSCORE	13.07%	29.09%
Hypertension	54.30%	58.15%
Diabetes mellitus	46.18%	56.02%
Three vessel disease	36%	41.13%
Previous coronary stent insertion	16%	9.92%
CVA	11.27%	10.63%
COPD	13.89%	25.53%

COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; ICU, intensive care unit.

Table 2. Intra- and Postoperative Clinical Characteristics of the Enrolled Patients

	Overall ($n = 115$)	Post-op Renal Replacement Therapy in ICU ($n = 141$)
Coronary artery bypass grafting	73.9%	76.6%
Valve replacement	14.4%	16.3%
Isolated aortic surgery	5.2%	2.2%
Combined surgery	6.5%	4.9%
Operation time (h)	3.1 ± 1.4	-3.8 ± 1.3
CPB time (min)	93.8 ± 7.8	96.6 ± 17
Aortic cross-clamp time (min)	61.1 ± 21.2	64 ± 18
MV time (h)	7,6 ± 1.2	10,2 ± 4.1
Chest tube drainage (mL)	482 ± 34	552 ± 124
Length of stay in ICU (day)	2.4 ± 1.6	4.3 ± 1.1
Mean hospitalization duration (day)	7.1 ± 1.8	11.4 ± 1.8

CPB, cardiopulmonary bypass; MV, mechanical ventilation; ICU, *intensive care unit.*

DISCUSSION

Nowadays, as a result of technological and scientific developments, heart operations are performed more successfully and more effectively. In light of recent studies, the number of OHS for patients with kidney problems is steadily increasing as medical treatment or Percutaneous transluminal coronary angioplasty (PTCA) is associated with worse long-term outcomes in these patients. So, it causes an increase in the number of more high-risk and comorbid cases.[15,16]

While the cause of mortality for 36% of hemodialysis patients is cardiovascular events, this rate of mortality 39% in peritoneal dialysis patients.[10] Due to its protective effects against cardiovascular complications, patients with CKD who underwent OHS have a better chance for transplantation, higher life expectancy, and better life quality.[17]

Approximately 25% increase in serum creatinine levels was observed after OHS in 17.2% of patients with normal preoperative creatinine levels.[18] Various factors promoting renal injury are responsible for this condition. Advanced age, obesity, hypertension, peripheral vascular disease, diabetes mellitus, metabolic syndrome, left ventricle dysfunction, COPD, history of revision surgery, aortic valve surgery, cardiac arrest during surgery, and prolonged cardiopulmonary pump duration are known as traditional risk factors.[17,18] Non-traditional risk factors for CKD patients such as uremic toxins, chronic inflammation, anemia, abnormal calcium, and phosphor metabolism may cause cardiovascular events, especially in dialysis-dependent patients.[19] The main cause of postoperative renal injury following OHS may be renal perfusion defect.[16] Despite the complex effects of low-flow, low-pressure, non-pulsatile perfusion with hemodilution and hypothermia on renal function, RF is most commonly the result of a low cardiac output state.[20]

OHS in uremic patients is still a particular challenge in terms of perioperative management as it may lead to alterations of the body fluid volume. Besides, these patients have several conditions that predispose them to postoperative complications, such as susceptibility to infection, chronic anemia, clotting disorders, and platelet dysfunction.[16]

Renal protection strategies of patients undergoing OHS should start at the preoperative period and continue through intraoperative and postoperative periods. Recognition criteria and risk assessments are very important for the perioperative management of patients with CKD.[21] The main factor of monitoring and treatment is the cooperative work of the team (cardiovascular surgeon, cardiovascular anesthetist, cardiologist, nephrologist, and staff). Except for cases requiring urgent operation, a certain amount of time before operative should pass for elective cases to renal function recovery induced by recent coronary angiography. We recommend hydration and N-acetylcysteine treatment for high-risk patients (for AKI) during the recovery period before the operation. In this period, risk levels in terms of renal function can be identified according to the EuroSCORE risk evaluation which includes creatinine clearance.[22] Patients with creatinine clearance >85 mL/min, between 50-85 mL/min, and <50 mL/min are considered as normal, moderate renal function impairment, and advanced renal function impairment, respectively.[23]

At our clinic, we insert a temporary hemodialysis catheter into one of the jugular veins during the anesthetic preparation period in the operating room for patients with stage 4–5 CKD (predialysis) (creatinine clearance, <50 mL/min) and for end-stage renal disease patients (hemodialysis dependent). The mechanical valve must be preferred in chronic RF patients undergoing valve replacement due to accelerated bioprosthesis calcification in this group of patients. However, it requires

additional attention due to increased thromboembolism and bleeding complications.[15]

Maximal attention must be paid by both surgical and anesthetic teams for the preservation of renal function. These groups of patients must be first evaluated for whether they are suitable for off-pump or minimally invasive techniques. At our clinic, cardiopulmonary bypass (CPB) with the pulsatile flow is used in patients with high risk, patients with low ejection fraction, and patients undergoing combined surgery with relatively longer operation duration. CPB duration should be kept at optimum levels as short as possible, along with careful surgery. Hemodiafiltration should be applied in the operating room while exiting from CPB in patients with low intraoperative urine output and patients with low renal function.

After transferring patients to the intensive care unit, close hemodynamic and drainage monitoring along with hourly urine output monitoring should be performed. Even though functional AVF is present, dialysis in end-stage renal disease patients should be performed as continuous venovenous hemodiafiltration via a temporary catheter, which is preoperatively inserted until hemodynamic instability improves. However, urine output should be kept at the optimum level by forced diuresis application when urine output starts to decrease in non-dialysis patients. Hemodiafiltration treatment is usually performed in consultation with the nephrology department for cases with uremic symptoms or patients with refractory medical treatment for hypervolemia or hyperkalemia or acidosis. Infections and bleeding in RF patients are factors increasing mortality and morbidity after OHS.[1-4] We gave N-acetylcysteine and hydration therapy to patients with high risk of AKI in the preoperative period.[5,6]

Solute removal during renal replacement treatment is done in two different ways: passive diffusion and ultrafiltration (convective transport). In passive diffusion, the solute passage is done according to the concentration gradient from plasma to dialysate fluid. The solute passage is done through ultrafiltration (convective transport). Dialysis is done with passive diffusion and convective transport principle in hemodialysis and hemofiltration, respectively.[17,18]

There are advantages and disadvantages between continuous renal replacement treatment and the intermittent hemodialysis approach. Being more physiological, having better hemodynamic tolerance, more controlled fluid removal, and inflammatory mediator removal are among the advantages of continuous renal replacement treatment. Applicability in every center, being more effective in time, and ease of patient mobilization are among the advantages of hemodialysis. Disadvantages of continuous renal replacement treatment are low effectiveness, prolonged immobilization, increased bleeding risk, increased thrombosis risk, hypothermia, and hypophosphatemia, whereas limited hemodynamic adaptation, limited fluid removal, and limited physiological processes are disadvantages of hemodialysis.[17,18]

CONCLUSION

In conclusion, the cooperative work of cardiology, nephrology, cardiovascular surgery, and anesthesiology teams for the management of patients with preoperative or postoperative renal dysfunction may provide better results in the long term. The presence of experienced personnel and fully equipped dialysis units in centers performing cardiac surgery may result in better outcomes.

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