CASE REPORT

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Successful prolonged intermittent renal replacement therapy in managing isolated coronary artery bypass graft surgery-associated acute kidney injury: A case report

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ABSTRACT

Introduction: Unstable angina pectoris is one of the most underappreciated conditions by emergency department doctors. Unfortunately, the UAP is a type of heart attack that is usually caused by the deadliest type of CAD, namely the left main disease and three-vessel diseases. Both types are excellent candidates for operative revascularization with a satisfying result. Not infrequently, the acute renal complications after CABG surgery often become catastrophic. This study aims to evaluate our experiences in managing our patients with AKI following a conventional CABG surgery as a postoperative complication.

Case description: A 69-year-old man was admitted to the ward to undergo a scheduled elective CABG surgery on the following day. The patient has a history of UAP, and a CAG study that was done three weeks earlier indicated that the culprit was a left main disease. The LIMA was anastomosed to the distal segment of the LAD, and one graft of GSV was anastomosed to the OM. Following the surgery, the patient experiences an unstable rapid response of AF and stage three AKI. Eventually, the patient must undergo two times of SLEDDs. After a second dialysis, the patient's serum creatinine was lowered and the stage of the AKI was downgraded. After close monitoring for fifteen days, the patient's serum creatinine gradually became normal. The dialysis access is removed, and the patient does not need a subsequent routine dialysis following discharge from our hospital.

Conclusion: The incidence of AKI following CABG surgery can be multifactorial. An alternative technique instead of using a CPB machine, judicious use of blood products, and prevention and treatments of a POAF should be considered. The PIRRT can be chosen as an alternative modality to CRRT with the same outcome quality for managing stage three AKI following CABG surgery.

Keywords: acute kidney injury, coronary artery bypass graft, renal replacement therapy, postoperative atrial fibrillation, unstable angina pectoris.

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INTRODUCTION

Coronary Heart Disease is the second leading cause of death in Indonesia after stroke. According to the data released by the World Health Organization in 2020, deaths caused by CHD in Indonesia are reaching 259,297 people or around 15.33% of the total deaths. So, that puts Indonesia's rank in 70th place worldwide.[1]

According to the riskesdas data in 2018, the prevalence of heart disease in Indonesia is around 1,5%.[2] However, this report is too general, does not specify the percentage of CHD prevalence, and does not divide CHD into groups based on the number of coronary artery segments affected. So, the data regarding the prevalence of coronary artery disease and its types in Indonesia are still not well known.

According to the research conducted by Khan MA et al., the prevalence of global CHD in 2017 was around 1.72%, or around 126 million of the world's population are affected by this disease.[3] This number is slightly higher than the prevalence of heart disease in Indonesia. However, this study did not divide the number of CHD patients into groups based on their types.

When referring to the research conducted by Carvalho JF et al. in 2018, it can be seen that the prevalence of types of CHD, namely left main disease (affecting the main branch segment of the left coronary artery) and three-vessel diseases (affecting three coronary arteries) is 26.5 % and 89.9%, respectively.[4] However, this data is based on the number of NSTEMI events in their hospital. So, it is not enough to describe the number of cases of left main disease and three-vessel diseases globally. Left main disease and three vessels disease are types of CAD that have the best revascularization response with the CABG surgery method.

Conventional CABG surgery is an open thoracic surgery technique in which

the left internal mammary artery and/ or great saphenous vein are grafted and anastomosed to the distal segment of the stenosed coronary artery. This operation creates a shunt between the aorta and the distal segments of the diseased coronary arteries, such as the right coronary artery, left anterior descending, and obtuse marginal. Generally, LIMA will be end-to-side anastomosed to the distal segment of the LAD, and one or two GSV grafts were end-to-side anastomosed to the distal segment of either RCA or OM as well.

Connection of grafted vessels, or anastomosis, can generally be done when the heart is motionless or in arrest. When performing an anastomosis, the patient's heart will be deliberately stopped within a certain period to provide comfort for the operator to perform the anastomosis. A cardiopulmonary bypass machine will temporarily replace the task of perfusion of the heart to the tissues.

Due to various factors, such as the quality of the patient's heart pump function, the amount of bleeding during surgery, the length of CPB machine time used, the length of aortic cross-clamping time, and many other factors, sometimes acute kidney injury with various stages can occur postoperatively. This event is often called cardiac surgery associated with acute kidney injury.

Cardiac surgery associated with acute kidney injury stage I, including CABG surgery, according to kidney disease improving global outcomes, is defined as a sudden decrease in kidney function within 48 hours after cardiac surgery. This includes one or more of the following: an increase in serum creatinine > 0.3 mg/dL or > 1.5 times of the pre-operative serum creatinine for more than 7 days or a urine output < 0.5 cc/kg/hour in 6 hours with greater staging indicates more severe the kidney injury.[5] Generally, this condition is followed by some associated symptoms, such as edema of the extremities or the whole body, to an acute pulmonary edema.

The prevalence of CSA-AKI itself is around 20-30%, where 1-4% of cases require renal replacement therapy.[6] The CSA-AKI mortality rate that requires RRT is quite high, which can reach 63%.[6] This number is very much different from the mortality rate of open-heart surgery without complications from AKI, which is only around 1-8%.[6]

Since 2020, The Hermina Depok Hospital, through its Integrated Heart Service, has performed open-heart surgery using a CPB machine. Ranging from congenital heart disease repair surgery to adult valve repair surgery has been performed at our hospital. The CABG operation itself started in late 2021 and continues to this day. More than 10 CABG procedures have been performed at our hospital. All were performed using a CPB machine. It is not uncommon to find AKI complications in our post-operative CABG patients.

In the following, we present one case of AKI after elective CABG surgery at our hospital, which we managed to treat well using the prolonged intermittent renal replacement therapy technique. The purpose of this case study is to evaluate our hospital's experience in treating patients with AKI that occurs as a complication after conventional CABG surgery.

CASE DESCRIPTION

A 69-year-old man was admitted to the ward on 17th December 2020 to undergo a scheduled elective CABG surgery on the following day. The patient at that time only complained of restlessness. Clinical complaints of ischemic chest pain and other associated symptoms were denied. Urine production was monitored within normal limits. Vital signs were reported within normal limits. Pre-operative laboratory parameters were within normal limits, especially creatinine and urea, which were 1.10 mg/dL and 35 mg/dL, respectively.

The patient had a history of being hospitalized for 8 days with a diagnosis of unstable angina pectoris on 23rd November 2022. Coronary angiography was performed on 24th November 2022 with results of coronary artery two vessels disease and left main disease with details: 50% stenosis in the osteal-proximal segment of LAD, 90% stenosis in the proximal left circumflex segment, 50% stenosis in the LCx osteal segment and 50% stenosis in the distal left main segment. The patient also had an echocardiography examination on 30th November 2022, with the results within normal limits with a known ejection fraction of 60.5%. There was no previous history of diabetes mellitus and AKI/ chronic kidney disease.

On 18th December 2022, a CABG operation was carried out. The operation lasted for 6 hours. There were complications during the operation, namely a laceration of the inferior vena cava, resulting in an arrest for two minutes when the aortic cross-clamping was performed. The CPB machine was temporarily stopped, the vena cava laceration was repaired, and the CPB machine was restarted. Intraoperative bleeding obtained 1000 cc. A LIMA anastomosis was performed on the distal segment of LAD, and a saphenous vein graft to the OM. Intra-operative packed red cell transfusion was given as much as 500cc. Cross clamp time under 25 minutes and CPB time under 120 minutes. Postoperative vital signs within normal limits. Urine output within normal limits. Then, the patient was transferred to the cardiac intensive care unit.

The patient was intubated for three consecutive days. On the first day of post-operative treatment at the CICU, there was a decrease in hemoglobin level from pre-operative Hb of 12.5 g/dL to 10.8 g/dL postoperatively. Then, the patient was transfused 750 cc of PRC, 3 units of thrombocyte concentrate, and 3 units of fresh frozen plasma. During post-operative treatment until patient discharge on 5th January 2023, the patient's hemoglobin was observed to be fluctuating but never exceeded 10.8 g/dL. Hemoglobin at discharge was found to be 10.1 g/dL.

On the second postoperative day of treatment, the monitor showed an irregular heart rhythm with an atrial fibrillation view accompanied by a rapid ventricular response. The heart rate observed on the monitor ranged from 150-160 beats per minute. Blood pressure measured 100/63 mmHg. Then, the patient is given Amiodarone drip according to the protocol. Four hours after the first Amiodarone drip administration, the patient's HR was observed to decrease at 120 beats per minute but still had an atrial fibrillation rhythm.

On the same day, 9 hours after the AF RVR event, the patient's urine production decreased below 0.5 cc/kg/hour, accompanied by swelling of

the extremities. However, he denied shortness of breath. The serum creatinine results showed an increase of 3.48 mg/dL and 112.9 mg/dL urea, respectively. However, electrolytes were monitored within normal limits. Then we consulted this condition to our nephrologist with advice to do a PIRRT with the sustained low-efficiency daily dialysis mode. The patient's condition now indicates a stage three prerenal AKI aggravated by acute pump failure. The patient was then placed by an anaesthesiologist with a double-lumen catheter in the right femoral vein as temporary dialysis access.

Prolonged intermittent renal replacement therapy with SLEDD mode on this patient is done once a day with a 6-hour duration of dialysis. The blood and dialysate fluid flow was slowed by 125 cc/minute and 300 cc/minute, respectively. The temperature on the first to fifth hours is set at 35^{0}C while the temperature on the sixth hour is set at 36^{0}C. Sodium on the first to second hours is set at 143 mmol/L. The third to fourth hours are 142 mmol/L, and the fifth to sixth are 141 mmol/L. The dialysis procedure uses a standard dose of heparin, and the ultrafiltration is set at 500cc. After dialysis, the creatinine and urea were rechecked to assess the responsiveness of the renal replacement therapy.

The first dialysis was carried out on 21st December 2022 (the third day of postoperative care). During dialysis, the patient's vital signs appear stable. After the first dialysis attempt, the complaints of swelling began to resolve, and urine output increased to 0.9cc/kg/hour. However, the patient's serum creatinine and urea were increased to 3.81 mg/dL and 152.1 mg/dL, respectively. So, the second attempt of dialysis was carried out on 22nd December 2022 with the same dialysis settings but with increasing ultrafiltration to 1000 cc.

After the second attempt at dialysis, the patient's clinical condition became more stable. All previous complaints are eradicated. Urine output increases to 1.2 cc/kg/hour. The creatinine and urea follow-up results decreased significantly to 2.27 mg/dL and 97.4 mg/dL, respectively. So, the consecutive dialysis was postponed. From the fifth postoperative day to the sixteenth day of care, the serum creatinine and urea levels were constantly decreased without additional dialysis attempts. The clinical condition of the patient is improving every single day. All blood pressure supports were tapered off gradually until it was stopped, and diuretics were also tapered off.

On 5th January 2023, the patient was allowed to be discharged after the serum creatinine and urea levels reached normal values of 1.02 mg/dL and 64 mg/dL, respectively. The patient has also gone through a series of physiotherapy exercises. Vital sign parameters are within normal limits when the patient is discharged. The dialysis access, the femoral CDL, was removed before discharge. Patients discharged to his homes without dialysis access do not need a routine schedule of dialysis for the rest of his life.

DISCUSSION

In cases of left main disease, with stenosis of ≥ 50%, it is often associated with recurrent episodes of ischemic chest pain.[7] So, in this case, when there is a patient diagnosed with UAP, he has a higher chance of getting left main disease compared to other types of heart attack. One study involving 384 angiograms revealed that the majority of left main disease (40%) involved the distal segment or the bifurcation, which is also consistent with the results of CAG studies in these patients, that is, left main disease with 50% stenosis of the distal segment. Whereas 24% of cases affected the mid-shaft and 9% of cases involved the ostial segment.[7]

Because the distal segment of the left main is associated with complex multivessel disease, the best revascularization option for this case is CABG rather than percutaneous coronary intervention.[7] It is also supported by the SYNTAX study, where the rate of revascularization in cases of left main disease with PCI was higher than that of CABG, which was 28% in the PCI group and 12.9% in the CABG group.[7] So, the choice of the CABG revascularization method in this patient follows evidence-based medicine.

The exact mechanism by which CPB causes AKI after cardiac surgery is still not well known. However, a reasonably detailed explanation exists, whereas CPB triggers an ischemic reperfusion injury.[8] During CPB, catalytic free iron is released, which causes lipid peroxidation of the renal tubular cells. This reaction then triggers the event of ferroptosis in the kidney, an iron-dependent programming of cell death.[8] This IRI event triggers AKI after cardiac surgery using a CPB machine.

Then, this IRI event will be exacerbated by PRC transfusions. Because PRC contains a myeloid-related protein 14 substances.[9] In vitro, this MRP_14 protein increases the activity of neutrophilic trogocytosis against the renal tubular cells.[9] So, due to IRI, the already inflamed parenchyma of the kidney will be aggravated by the influx of neutrophils into the kidney parenchyma due to MRP_14 activity. Eventually, about 20% of patients will experience AKI after an on-pump heart surgery, and each administration of a PRC bag will increase the risk of AKI by 15%.[9] This theory is supported by a study by Khan UA et al., where AKI was more common in patients receiving more than 2-unit PRC. Patients who received more than 2 units of PRC had a 2.3-fold risk of having a double increase in serum creatinine level from its baseline level.[10]

In addressing this phenomenon, a 2011 blood conservation guideline by the Society of Thoracic Surgeons/ Society of Cardiovascular Anaesthesiologists recommends that transfusions should only be performed to maintain Hb above 7 g/dL while on CPB.[6] In the post-operative settings, the PRC transfusions are only to be done to maintain Hb > 8 g/dL.[6] The judicious use of PRC can reduce the risk of AKI in post-cardiac surgery patients who use the CPB machine.

Post-operative atrial fibrillation is a complication that often occurs after cardiac surgery. The incidence of POAF ranges from 20-55% in cardiac surgery cases.[11] Typically, POAF occurs within the first 6 days after cardiac surgery.[11] The mechanism for the occurrence of POAF is still not well known. The primary therapy for POAF is administration of Amiodarone. Amiodarone belongs to the class of antiarrhythmic agents and can be a peripheral and coronary artery vasodilator. American and European guidelines recommend this agent with a class IIA recommendation level.[11] Making it one of the most effective treatments of POAF.

Table 1. The kidney disease is improving global outcomes criteria and staging of acute kidney injury.

Stage	Serum creatinine criteria	Urine output criteria
1	Serum creatinine increases 1,5-1,9 times from the baseline, OR increase serum creatinine > 0,3 mg/dL.	< 0,5 cc/Kg/hours within 6-12 hours
2	Serum creatinine increases 2-2,9 times from the baseline	< 0,5 cc/Kg/hours within > 12 hours
3	Serum creatinine increase > 3 times from the baseline, OR increase serum creatinine > 4 mg/dL, OR dialysis initiation	< 0,3 cc/Kg/hours within > 24 hours, OR Anuria > 12 hours

Atrial fibrillation can worsen AKI through several mechanisms, such as causing acute tubular necrosis due to hemodynamic instability and renal ischemia due to a post-AF embolism event.[12] So, it can also be considered that AF that occurs in these patients is also increasing the risk of AKI or even worsening it.

Acute Kidney Injury is divided into three stages based on KDIGO criteria, as seen in the following table.[5]

In this patient, serum creatinine increased more than 3 times the initial serum creatinine. So, the patient eventually falls into stage III AKI. The best option for treating AKI in these patients is renal replacement therapy. Data from a meta-analysis of 847 patients, including 2 randomized controlled trials and 9 observational cohorts, showed a reduction in mortality at 28 days associated with early use of RRT in a post-cardiac surgery AKI.[6] The KDIGO guidelines recommend the use of CRRT or PIRRT in hemodynamically unstable patients with a class IIB recommendation level.[6]

Currently, our hospital does not have a specialized hemodialysis machine for continuous renal replacement therapy, so a modification to an intermittent renal replacement therapy was carried out so that it does not disturb the patient's hemodynamically unstable condition due to the POAF event. This modification is called prolonged intermittent renal replacement therapy.

Principally, the PIRRT technique is the same as the IRRT technique, but the difference is in the duration of the hemodialysis. In PIRRT, it will be carried out for 6-12 hours; in IRRT, it generally lasts 4-5 hours. In addition, IRRT is generally done 2-3 times per week, while PIRRT can be done every day, also called SLEDD. So, blood and dialysate fluid flow will be slowed down to 100-200 cc /minute and 100-300 cc/ minute, respectively.[13]

We performed PIRRT in SLEDD mode on this patient as much as needed. Total SLEDD was carried out were 2 times because after the second SLEDD had been done, the patient's serum creatinine fell into 2.27 mg/dL. After that, the patient's condition improved, and the AKI stage was downgraded to stage 2.[5] At this stage, the next management is close monitoring, such as stopping nephrotoxic drugs, vasodilators, NSAIDs, tapering off diuretics, and managing infections. In addition, fluid administration is also given sufficiently to maintain good hemodynamics.[14] So, the patient remained in the CICU until he was discharged on 5th January 2022 due to the need for close monitoring. The patient's serum creatinine levels after the second SLEDD continued to decrease until they reached normal levels when he was going to be discharged.

A study that Andujar AM conducted, et al. shows that there is a 14.36% risk of a major adverse kidney event within 1 year at any stage of CSA-AKI. This includes 93% of participants in the make group who experienced a persistent renal function impairment (decrease in estimated Glomerular Filtration Rate > 25%), 3.5% experiencing a new onset of hemodialysis, and 3.5% were death.[15] So, routine control of these patients is needed to identify the occurrence of MAKE in the future.

CONCLUSION

The incidence of AKI after CABG surgery, in this case presentation, is multifactorial. Most likely, the occurrence of AKI is caused by IRI, triggered by the use of CPB machines, and aggravated by PRC transfusions and the occurrence of POAF, whose cause remained unknown. So, an alternative technique instead of using a CPB machine, judicious use of blood products, and prevention and treatments of a POAF can be considered to be carried out in the future as part of managing prevention and management of AKI after CABG surgery.

The choice of postoperative management of AKI after CABG surgery must follow the severity of the AKI itself. The PIRRT option can be applied as an alternative to CRRT with an output quality that is not much different from CRRT. Routine control at least two times in one year after CSA-AKI is needed to identify and manage a MAKE in the future.

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Conflict of Interest
All of the authors declare there is no conflict of interest regarding this study publication.

Author Contribution
In this article, all authors are involved and take part in making the article. The first author contributed to drafting and designing this manuscript. The second author provides concepting, designing, and supervising the manuscript.

Consent for publication
The patient gave written informed consent for the publication of this report and any related photos.

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