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KIDNEY FUNCTION AFTER OFF-PUMP OR ON-PUMP CORONARY ARTERY BYPASS GRAFTING IN THE HIGH-RISK SURGICAL PATIENTS

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ABSTRACT

Background and Aim

Theoretically, off-pump coronary artery bypass appears to have less impact on kidney function. We estimated the primary marker of renal dysfunction in patients with high surgical risk who underwent off-pump and on-pump coronary artery bypass.

Methods

We retrospectively analysed the 1339 patients with high surgical risk who underwent isolated coronary artery bypass grafting were. Patients were divided into two groups: Off-pump (n=672) and On-pump (n=667) coronary artery bypass. We measured kidney function tests for five days after surgery and before discharge and then compared the results with preoperative levels.

Results

In the On-pump group, a statistically significant increase in creatinine concentration was observed on the fifth day after surgery (p = 0.0001) and it persisted until the patient's discharge (p = 0,043). In the Off-pump group, a statistically significant difference was noted on the fifth day (p = 0,054); however, before discharge from hospital, the statistical significance was not revealed (p = 0,735). The patients with chronic kidney disease after on-pump CABG had a statistically significant increase in urea level (p = 0,0021) postoperatively, and more frequent need for hemodialysis Off-pump 2% (n=3), On-pump 7.3% (n=12), p=0.28.

Conclusion

Off-pump coronary artery bypass showed a less negative impact on kidney function than surgery with extracorporeal circulation and can be recommended for high-risk surgical patients.

Keywords: ischemic heart disease, Off-pump, CABG, Renal dysfunction, renal insufficiency, Creatinine, surgical complications, high risk.

Introduction

The coronary artery bypass grafting is one of the leading surgical methods for treating coronary heart disease. Despite improvements in surgical techniques, postoperative renal dysfunction remains a severe complication of coronary revascularisation surgery that is associated with significant increases in morbidity and mortality. The cause of renal dysfunction after surgery is multifactorial. Considerable contributors include the patient's clinical status, cardiopulmonary bypass (CPB)-related events, hypotension, renal hypoperfusion, hypothermia, microemboli in the renal vasculature, stimulation of the inflammatory response, and increased levels of circulating catecholamines, cytokines[1].

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Off-pump coronary artery bypass (OPCAB) eliminates the use of CPB and cardioplegia; therefore, a negative influence on a physiologic condition associated with CPB can be avoided.
During the last decades, several studies have shown that off-pump coronary revascularisation results had better outcomes for patients with high surgical risk than conventional, on-pump coronary revascularization.[23]
The use of off-pump coronary bypass grafting in high-risk surgical patients raises the necessity of assessing kidney function after surgery.
The purpose of this study was to assess the kidney function in patients with coronary artery disease from the high-risk group based on the analysis of the immediate results of myocardial revascularisation on the beating-heart technique (off-pump) or cardiopulmonary bypass (on-pump).

Materials and methods

The study is based on a retrospective analysis of surgical treatment results of consecutive 1339 patients with coronary artery disease and high surgical risk who underwent primary, isolated, non-emergency coronary revascularisation between January 2003 and December 2015. Patients were divided into two groups: the off-pump group (n=672, beating heart surgery) and the on-pump group (n=667, cardioplegic arrest and CPB). In both groups, complete coronary revascularisation was attempted. The off-pump group's average age was 69.6 ± 7.4 years; the on-pump group included patients with a mean age of 69.8 ± 7.7 years.
The average EuroSCORE for patients who underwent off-pump revascularisation was 7.0 ± 1.8; the EuroSCORE II was 4.32 ± 1.9%. For the on-pump group, EuroSCORE and EuroSCORE II were 7.15 ± 1.6 and 4.73 ± 1.2% respectively.
315 out of 1339 patients had chronic kidney disease (CKD) I - III degrees before surgery. In the off-pump group, CKD was observed in 151 (23%) patients, and in the on-pump group in 164 patients (25%).
To assess the effect of CPB and OPCAB on renal function and possible kidney damage, we observed the dynamics of such indicators as creatinine, cystatin C, urea, and we also calculated GFR.
The statistical analysis of the data was performed using the program STATISTICA[4].0 (StatSoft, USA). Comparative analysis was performed by nonparametric methods which do not require normal distribution. Descriptive characteristics were presented as mean±standard deviation for normally distributed data and median (first quartile; third quartile) for non-normally distributed numeric data. The study results were taken as statistically significant with a value of $p<0.05$ and percentage (95% confidence interval (CI) lower bound, 95% CI upper bound) for categorical data with CI calculation using the Wilson formula.

Results

With the observation of plasma creatinine concentration in the early postoperative period in the on-pump group, the creatinine level was significantly higher than in the OPCAB group and varied within more comprehensive limits.
In the group of patients operated according to the standard technique with CPB, the maximum increase was noted on the fifth day after surgery and the mean value was 223.7 ± 52.7 mmol/ L; whereas, in the OPCAB group, the maximum increase was noted on the third day and the average value was 148 ± 36.5 mmol/ L (Fig. 1).

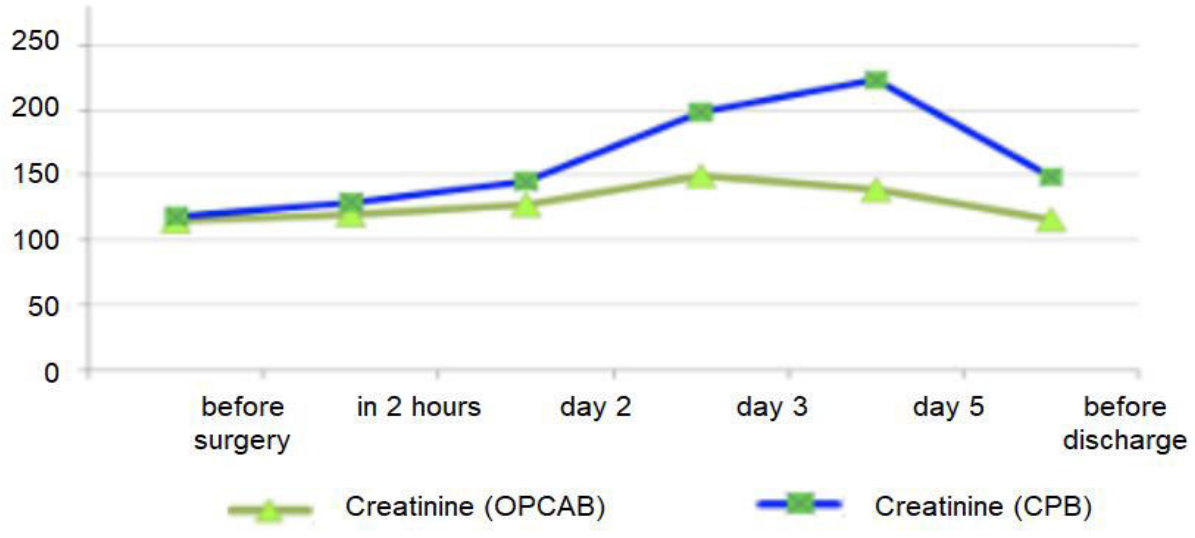

Figure 1.Dynamics of plasma creatinine concentration.

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A statistically significant increase in creatinine concentration was observed in the on-pump group on the third day after surgery (initial value was 117.9 ± 18.4 mmol/ L; on the third day 198 ± 42.6 mmol/ L; p = 0, 0013). The creatinine level reached its maximum values on the fifth day after the operation (initial value was 117.9 ± 48.4 mmol/ L; on the fifth day 223 ± 42.6 mmol/ L; p = 0.0001). The statistical significance remained until the patient was discharged (baseline mean creatinine level was 117.9 ± 18.4 mmol / L; before discharge from the hospital 148 ± 22.6 mmol/ L; p = 0.043).

In the off-pump group, a statistically significant difference was observed on day 3 after surgery (initial mean creatinine level was 115 ± 20.7 mmol / L; on day 3 149.4 ± 31.6 mmol / L; p = 0.036), on fifth day (p = 0.054) and no statistical significance was found before discharge from the hospital (p = 0.735).

Plasma cystatin C is another marker of kidney dysfunction. This marker's level was higher in patients undergoing CABG with cardiopulmonary bypass than patients operated on by the OPCAB technique at all stages of the early postoperative period. In the on-pump group of patients, there was a tendency for a gradual increase in plasma cystatin C level throughout the early postoperative period. The cystatin C level was significantly higher than the baseline values on day 3 and 5 after the surgery and before discharge compared with the baseline data, p <0.05 (Fig. 2).

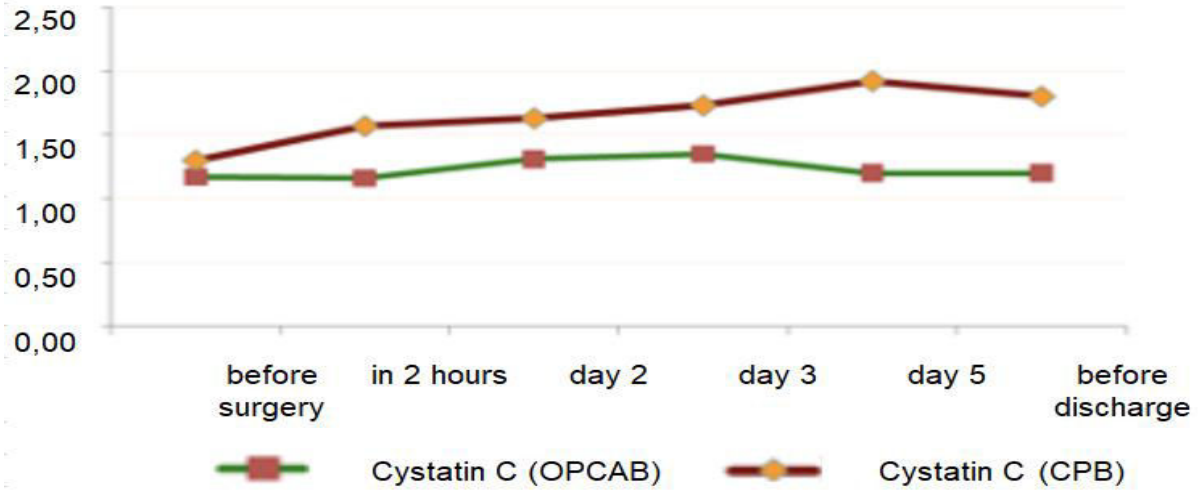

Figure 2.Dynamics of plasma cystatin C concentration.

In the off-pump group, there was no significant increase in the level of cystatin C in plasma compared to the baseline data, p> 0.05 for all periods of the postoperative period; while the maximum values were noted on the 3rd day after surgery. After three days of the postoperative period, the cystatin C level in the OPCAB group gradually decreased and returned to the initial values by discharge from the hospital.

In the group of high-risk patients with CKD who underwent coronary artery bypass grafting with cardiopulmonary bypass, there was also a statistically significant increase in urea level over time, p = 0.0021 (Fig 3).

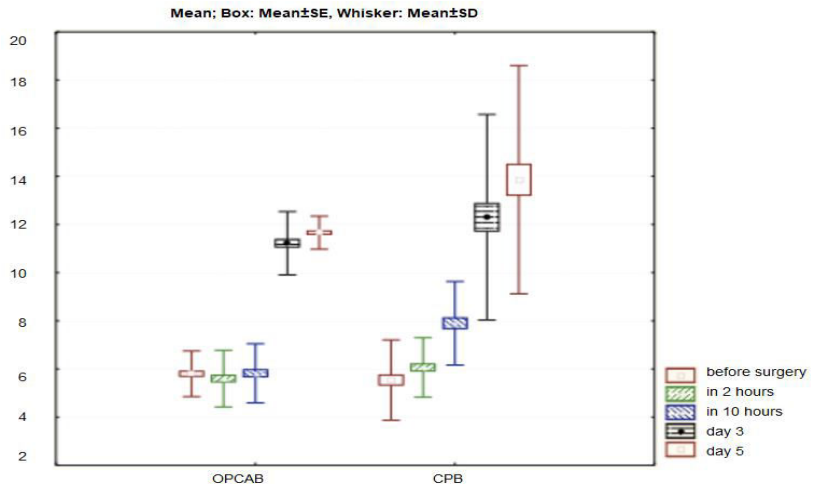

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Figure 3.Dynamics of plasma urea concentration.

In the CABG + CPB group, the maximum increase in creatinine, cystatin C and urea was observed on the fifth day after revascularisation. The increase in these kidney function markers was statistically significant and may indirectly indicate the damaging effect of CPB on kidney function. As for GFR, which is one of the primary markers of renal function, its decrease in the OPCAB group did not have statistically significant values, while in the on-pump group there was a statistically significant decrease in comparison with the baseline, $p < 0.05$ (Fig. 4). The decreased GFR level was the most common cause of acute kidney injury (AKI), which required hemodialysis (Table 1).

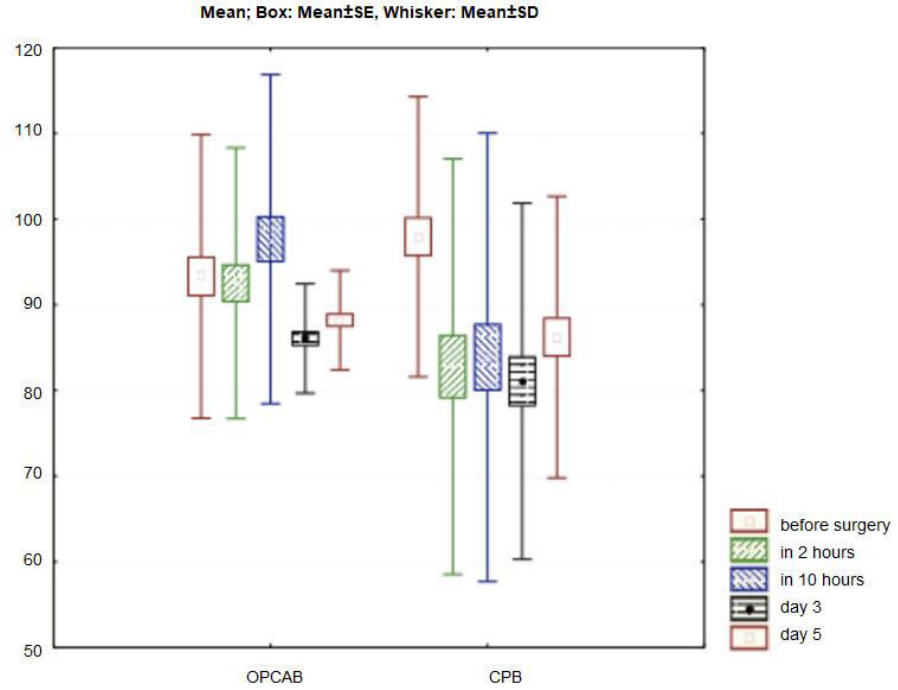

Figure 4.Glomerular filtration rate depending on the type of surgical intervention.

Table 1.Acute kidney injury requiring hemodialysis in patients with chronic kidney disease.

	off-pump (n-151)	**on-pump (n-164)**	**OR**	**95% CI**	***p***
AKI requiring hemodialysis	3 (2,0%)	12 (7,3%)	3,89	1,08-14,08	0,028

Discussion

After cardiac surgery, the incidence of acute renal failure can reach up to 30% of cases and 1.2–3% of which can require hemodialysis. The prognosis in patients requiring hemodialysis is poor because it increases the length of hospital stay and leads to an extremely high mortality rate of 43–63%[7].

The occurrence of acute kidney injury depends on many factors, such as the method of surgical intervention - with or without cardio-pulmonary bypass, preoperative and postoperative care, and whether the patient has CKD before surgery.

There is currently no clear evidence of the effectiveness of any prophylactic interventions or therapeutic approach to prevent AKI. Identifying patients at high risk for postoperative AKI before surgery can help surgeons provide much more detailed informed patient consent, improve clinical perioperative management, and optimise healthcare resource usage, all of which are clinically vital[58].

Our results confirmed other author's opinions on fewer complications from the kidneys in the group of patients who underwent minimally invasive myocardial revascularisation[769]. Our results were also consistent with other

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researchers' data on a smaller number of hemodialysis cases in patients who underwent off-pump coronary revascularization[10].

Conclusions

Based on the data, it can be concluded that off-pump coronary artery bypass has a much smaller negative effect on kidney function than on-pump surgery with cardiopulmonary bypass.

We recommend performing off-pump myocardial revascularisation in high-risk patients with coronary artery disease as it is associated with a significantly lower number of postoperative renal complications than conventional coronary surgery with CPB.

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