Research Article

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A Comparison of Acute Renal Dysfunction Following On-Pump Versus Off-Pump CABG

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ABSTRACT

Background: Coronary artery by-pass surgery (CABG) has traditionally been performed with the use of cardiopulmonary by-pass (on-pump CABG), with cardioplegic arrest. In the mid-90s surgeons began to perform the procedure on a beating heart, without the by-pass. This was an attempt to reduce a number of complications related to the cardiopulmonary bypass machine used for extracorporeal circulation during on-pump CABG.

Aim: To compare acute renal dysfunction after first isolated Off-pump versus On-pump coronary artery by-pass graft surgery (CABG) and to determine if there is a difference between the two groups.

Methodology: The study was carried out at the Heart Institute, Medanta Hospital, New Delhi India. The patients were randomized to undergo on-pump or off-pump coronary by-pass surgery and were prospectively followed. Preoperative and post-operative (24 hours, 48 hours and one week) serum creatinine and urea were recorded. Patients with preoperative serum creatinine greater than 1mg/dl and urea greater than 20mg/dl, as well as those having combined CABG and valve surgery were excluded.

Results: A total number of 288 patients had CABG surgery (154 had Off-pump CABG while 134 had On-pump CABG). Eighty seven percent were male while 12% were female. There was a rise in creatinine from the preoperative mean baseline for both groups. The average rise of preoperative creatinine for on-pump was 0.4mg/dl compared to 0.01mg/dl for off-pump and this was statistically significant. The serum creatinine however, dropped to 0.84mg/dl for the on-pump and 0.73mg/dl for the off-pump groups by one week. The urea level for both groups also rose steadily for the one-week period. This elevation in serum urea was, however, statistically significant for the on-pump group.

Conclusion: This study has shown that on-pump CABG causes significant acute renal dysfunction compared to off-pump coronary artery bypass surgery.

KEYWORDS: Acute renal dysfunction; On-pump CABG; Off-pump CABG

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INTRODUCTION

Coronary artery by-pass surgery (CABG) has traditionally been performed with the use of cardiopulmonary by-pass (on-pump CABG), with cardioplegic arrest [1-3]. In the mid-90s however, an increasing interest in performing CABG without the use of cardiopulmonary by-pass (off-pump CABG) sprang up among cardiothoracic surgeons [3,4]. This was an attempt to reduce a number of complications related to the Heart-lung machine used for extracorporeal circulation during on-pump CABG. Cardiopulmonary bypass is known to inflict injuries to organs including the kidney. In most patients these injuries are reversible. Despite improvement in surgical techniques, post-operative renal dysfunction remains a serious complication of coronary revascularization surgery and is associated with significant increase in morbidity and mortality in patients undergoing CABG2, [5,6]. Acute renal failure requiring dialysis develops in 2% to 7% of patients undergoing cardiac surgery. Although the cause of this renal failure is multifactorial and depends on the patients' clinical status, cardiopulmonary by-pass related events such as hypotension, renal hypoperfusion, hypothermia and non-pulsatile flow, may contribute significantly to renal dysfunction. Off-pump CABG does not involve the use of cardiopulmonary by-pass extracorporeal circulation and may help circumvent these complications of on-pump CABG. This prospective observational study evaluated acute renal dysfunction as a primary outcome in patients undergoing on-pump or off-pump CABG. We hypothesized that patients who had on-pump CABG would have significant acute renal dysfunction compared to those who had off-pump CABG.

METHODOLOGY

From June 2015 to June 2017 patients with coronary artery disease requiring surgery at the Heart Institute, Medanta Hospital, New Delhi, India were assigned to either on-pump or off-pump surgical techniques using simple random sampling technique. Inclusion criteria were patients requiring first CABG indicated by multivessel coronary artery disease. Patients with pre-operative creatinine greater than 1mg/dl and serum urea of more than 20mg/dl as well as those undergoing additional surgical procedures such as valve surgery were excluded from the study. The exclusion criteria included patients who had repeat CABG and patients who had combined CABG and valve surgery. The serum creatinine and urea concentration of each patient were recorded preoperatively and post-operatively. The preoperative values were the tests done within 48 hours before surgery while post-operatively; serum creatinine and urea were recorded at 24 hours, 48hours and one week after surgery. All surgeries were performed in the same hospital where surgeons and anaesthetists were of comparable skill and experience. Data was collected onto a spreadsheet and relevant statistical analysis was done.

RESULTS

Table 1: Showing the off-pump and on-pump creatinine (Cr) pattern.

		N	Mean	Std. Deviation	Std. Error	Minimum	Maximum	*P*-value
Cr-Pre-op	Off pump	153	0.850	0.1387	0.0112	0.3	1.2	0.617
	On pump	132	0.859	0.1568	0.0136	0.0	1.0	
	Total	285	0.854	0.1471	0.0087	0.0	1.2	
Cr-24hrs	Off pump	152	0.8158	0.18774	0.01523	0.40	1.60	0.013
	On pump	132	0.8742	0.20735	0.01805	0.50	1.70	
	Total	284	0.8430	0.19890	0.01180	0.40	1.70	
Cr-48hrs	Off pump	152	0.7974	0.18376	0.01490	0.30	1.40	0.001
	On pump	130	1.0192	0.79466	0.06970	0.40	9.00	
	Total	282	0.8996	0.56597	0.03370	0.30	9.00	
Cr-1week	Off pump	152	0.7875	0.16084	0.01305	0.50	1.40	0.000
	On pump	132	0.9114	0.24546	0.02136	0.50	1.90	
	Total	284	0.8451	0.21336	0.01266	0.50	1.90	

A total of 288 patients were recruited for the study during the study period; 154 of these patients had Off-pump CABG while 134 had On-pump CABG. Two hundred and fifty-two (87%) were male while 36 (12%) were female. There was a rise in creatinine level from the preoperative mean baseline of 0.8mg/dl for both groups (Table 1) starting from 24 hours postoperative period, peaking to 1.2mg/dl and 0.81mg/dl by 48 hours for the on-pump and off-pump groups respectively (Figure 1,2). The mean serum creatinine however, dropped to 0.84mg/dl for the on-pump and 0.73mg/dl for the off-pump groups by one week (Figure 1). It was observed that for patients who had off-pump CABG, the creatinine showed an average rise of 0.01mg/dl from base line compared to patients who had on-pump CABG in which there was an average rise in creatinine of 0.4mg/dl from preoperative values (Figure 2). Although, the serum creatinine of both groups of patients normalized by one week, that of patients who had on-pump CABG was still higher than the base line preoperative values (Figure 2).

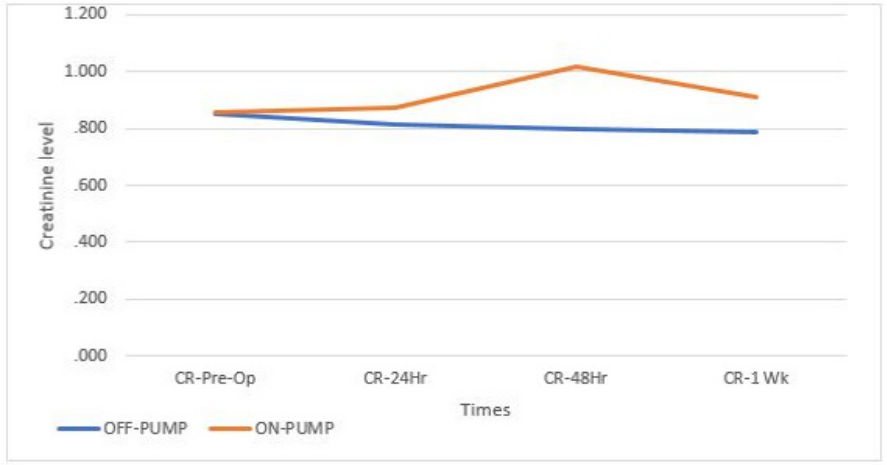

Figure 1: Creatinine pattern for each group.

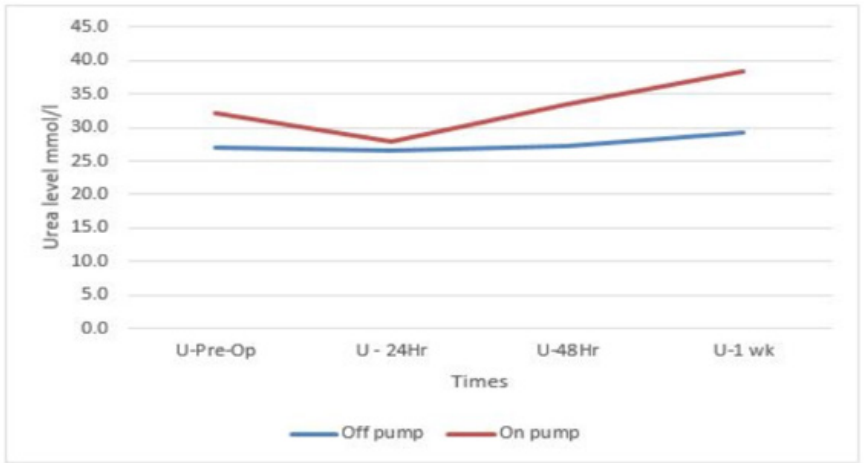

Figure 2: Urea pattern for each group.

Table 2: Urea pattern for off-pump and on-pump groups of patients.

		N	Mean	Std. Deviation	Std. Error	Minimum	Maximum	*P*-value
Cr-Pre-op	Off pump	153	27.09	8.598	0.695	12	59	0.008
	On pump	132	32.15	21.608	1.881	11	220	
	Total	285	29.44	16.166	0.958	11	220	
Cr-24hrs	Off pump	153	26.59	10.540	0.852	11	108	0.274
	On pump	132	27.95	10.219	0.889	13	67	
	Total	285	27.22	10.397	0.616	11	108	
Cr-48hrs	Off pump	153	27.14	8.930	0.722	10	58	0.000
	On pump	132	33.54	11.319	0.985	13	71	
	Total	285	30.10	10.583	0.627	10	71	
Cr-1week	Off pump	153	29.22	11.443	0.925	10	86	0.000
	On pump	132	38.33	16.231	1.413	15	135	
	Total	285	33.44	14.571	0.863	10	135	

The mean urea level for both groups also rose steadily for the one-week period. This elevation in serum urea was, however, statistically significant for the on-pump group (Table 2). The serum urea for both groups of patients did not return to preoperative values by 1-week (Figure 2).

DISCUSSION

During the past 30 years CABG primarily was performed with the use of cardiopulmonary bypass with the heart arrested (on-pump CABG) and it was historically shown to improve ischaemic symptoms and in selected patients prolonged survival [7,8]. Despite improvement in surgical techniques however, post-operative renal dysfunction remained a serious complication of coronary revascularization surgery and was associated with significant morbidity and mortality in patients undergoing on-pump coronary revascularization [9,10]. In the mid-90s, interests emerged in carrying out coronary bypass surgery on a beating heart without the use of extracorporeal circulation with the heart lung machine [11-13]. This was an attempt to reduce complications associated with extracorporeal circulation, such as systemic inflammatory response, renal failure, cerebral dysfunction, myocardial depression and haemodynamic instability [14-16].

In this study comparing acute renal dysfunction in patients undergoing first isolated on-pump or off-pump CABG, it was found that on-pump coronary artery bypass surgery caused significant renal dysfunction in the immediate post-operative period compared to off-pump CABG. This was demonstrated by a statistically significant rise in both creatinine and urea in the immediate post-operative period, for patients who had on-pump CABG surgery. This may be due to cardiopulmonary by-pass related events such as hypotension, renal hypoperfusion, hypothermia, micro emboli in the renal vasculature, non-pulsatile flow, haemolysis, stimulation of the systemic inflammatory response, as well as increased levels of circulating catecholamines, cytokines and free haemoglobin which may contribute significantly to renal dysfunction [17,18]. Additionally, the use of aortic cross clamping and cardioplegic arrest during on-pump CABG could result in myocardial dysfunction that may lead to renal perfusion defects and subsequent renal impairment.

Even though the mean pre-operative serum creatinine in the on-pump group was higher compared to the off-pump group, this was not statistically significant. The serum creatinine of both groups of patients in this study normalized by one week, but that of patients who had on pump CABG remained higher than the preoperative base line value. While some studies have seen this as a renal protective advantage of off- pump CABG,2,3 others have questioned this by concluding that off-pump CABG offers no renal protective advantage over on-pump CABG. In a study by Arlan et al 3, the author concluded that off- pump CABG, offered a superior renal protection and has a significantly lower risk for renal dysfunction when compared to on-pump CABG. Shroyer et al 16, on the other hand, concluded in their study that there was no overall advantage to the use of the off-pump compared to the on-pump cardiac surgery approach for coronary bypass.

The association between CPB and acute renal injury (AKI) is however, plausible, especially among patients with preoperative limited renal reserve [19-21]. Generally, Off-pump CABG has been shown to be a safe and effective technique, when performed in a relatively heterogeneous patient population with coronary artery disease and is associated with a reduction in incidence of acute kidney injury (AKI), an observation also noted by other studies [22,23]. We admit that our study is limited by not considering the transfusion requirement of the patients. A longer follow up period may also be more revealing. We recommend adoption of reno-protective measures for patients undergoing on pump CABG. Further studies that take into consideration the need for renal replacement therapy are also recommended.

CONCLUSION

This study has shown that on-pump coronary artery bypass graft surgery causes significant renal dysfunction in the immediate post-operative period compared to off-pump coronary artery bypass surgery. This suggests that off-pump CABG offers superior renal protection and has a significantly lower risk for renal dysfunction in patients undergoing coronary revascularization.

ETHICAL APPROVAL AND CONSENT TO PARTICIPATE

Institutional clearance was obtained from the ethical committee of the hospital as well as informed consent from the patients

AUTHOR'S CONTRIBUTIONS

J M N - Designed the study, carried out data collection and analysis as well as wrote and approved the final copy of the manuscript.

ECP - Designed the study, carried out data collection and analysis as well as wrote and approved the final copy of the manuscript.

U D - Designed the study, carried out data collection and analysis as well as wrote and approved the final copy of the manuscript.

SJY - Designed the study, carried out data analysis as well as wrote and approved the final copy of the manuscript.

MMT- Designed the study carried out data analysis as well as wrote and approved the final copy of the manuscript.

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