

## COMPARISON OF POST-OPERATIVE NEUROLOGICAL COMPLICATIONS BETWEEN ON-PUMP AND OFF-PUMP CORONARY ARTERY BYPASS SURGERY

Mohammad Hassan Naseri<sup>1</sup>, Bahram Pishgou<sup>2</sup>, Javad Ameli<sup>3</sup>,  
Esmail Babaei<sup>4</sup>, Hamid Reza Taghipour<sup>5</sup>

### ABSTRACT

**Objective:** To assess neurological impairment after the off-pump and on-pump techniques in patients with first-time isolated coronary artery bypass graft surgery.

**Methodology:** One hundred twenty patients undergoing first-time isolated coronary artery bypass graft surgery prospectively at Baqiatallah University Hospital, Tehran, Iran were randomised to the off-pump or on-pump technique.

Change in NIHSS score was measured at 30 days postoperatively.

**Results:** The on-pump group showed a significantly greater deterioration in scores than the off-pump group. The incidence of TIA at 30 days postoperatively was 15.3% (9 out of 60) in the on-pump group and 5% (3 out of 60) in the off-pump group. (P=0.05). The incidence of Stroke at 30 days postoperatively was 3.4% (2 out of 60) in the off-pump group, while no one from off-pump group suffered from stroke. (P=0.05)

**Conclusion:** Off-pump coronary artery bypass graft surgery results in less neurological impairment than the on-pump technique.

**KEYWORDS:** Cardiac surgery, Off-pump, On-pump, Neurological complications.

Pak J Med Sci January - March 2009 Vol. 25 No. 1 137-141

### How to cite this article:

Naseri MH, Pishgou B, Ameli J, Babaei E, Taghipour HR. Comparison of post-operative neurological complications between on-pump and off-pump coronary artery bypass surgery. Pak J Med Sci 2009;25(1):137-141.

1. Mohammad Hassan Naseri MD, Associate Professor of Cardiovascular Surgery,
  2. Bahram Pishgou MD, Assistant Professor of Cardiology,
  3. Javad Ameli, MD, Associate Professor of Neurology,
  4. Esmail Babaei, Medical Student,
  5. Hamid Reza Taghipour, MD, Cardiothoracic Surgeon,
- 1-5: Baqiyatallah Medical Sciences University, PO: 19945/581, Tehran, Iran.

### Correspondence

Mohammad Hassan Naseri,  
Email: m.h.naseri@gmail.com

- \* Received for Publication: September 19, 2008
- \* Revision Received: September 24, 2008
- \* Revision Accepted: November 5, 2008

## INTRODUCTION

Coronary artery bypass grafting (CABG) with cardiopulmonary bypass is still the gold standard for surgical myocardial revascularization. Despite advances in techniques and technologies, documented evidence indicates that cardiopulmonary bypass remains the major source of intra-operative brain injury.<sup>1</sup>

Neurological injury is an important complication after coronary artery bypass graft surgery. It comprises two types. Type-1 injury includes stroke, transient ischemic attack (TIA) and coma (incidence 3 to 6%). Type-2 injury is more subtle and includes impairment of

cognitive function. These are defects associated with attention, concentration, short term memory, fine motor function, and speed of mental and motor responses. The incidence of neurocognitive impairment after cardiac surgery varies from 20% to 80%.<sup>2</sup>

Although the pathogenesis of cerebral injury and cognitive dysfunction after cardiac surgery is multifactorial, there is increasing evidence that multiple microemboli arising from the ascending aorta, the heart chambers, or the bypass circuit are the primary pathophysiologic mechanisms producing diffuse ischemic cerebral injury.<sup>3</sup>

Cardiopulmonary bypass is associated with an intense inflammatory response because of conversion to laminar flow, blood contact with the artificial bypass surface, cold cardiac ischemia, and hypothermia. This inflammatory response produces an acute, massive defence reaction, induces mild-to-huge interstitial fluid shifts; generates a host of microemboli (<500µm); and causes temporary dysfunction of nearly every organ.<sup>3</sup>

By noting the fact that an important complication of CABG is post-op neurologic dysfunction, which is probably related to cardiopulmonary bypass circuit, it may be possible to reduce this complication by preventing of emboli formation during the operation. Therefore, one can hypothesize that results can be improved by eliminating the source of emboli, namely the extracorporeal circuit.<sup>4</sup>

This study aimed at comparing the neurologic complications between on-pump and off-pump cardiac surgery during the first month after the operation.

## METHODOLOGY

We prospectively randomised 120 patients to conventional coronary artery bypass grafting surgery using cardiopulmonary bypass (n = 60) or to off-pump coronary artery bypass grafting surgery (n=60) at Baqiatallah hospital between September 2007 and March 2008.

*Inclusion criteria:*

1. All patients older than 65 years of age.
2. All patients with the history of stroke, TIA

or hemiparesis (regardless of age)

3. All patients with left main stem stenosis (regardless of age)

*Exclusion criteria:*

1. All patients who did not agree to be part of the study
2. All the patients who passed away during the first month after the operation
3. Emergency operations

Pre-op investigations included medical history (including cardiovascular risk factors), physical examination (especially neurologic), brain CT scan, carotid artery angiography, and echocardiography.

Pre-op neurologic data of the patients were gathered using NIHSS scale (The National Institutes of Health Stroke Scale) to calculate the pre-score. The same scale was used to gather information 30 days post-operatively (post-score). NIHSS is a systematic assessment tool that provides a quantitative measure of stroke-related neurologic deficit. The NIHSS is a 15-item neurologic examination stroke scale used to evaluate the effect of acute cerebral infarction on the levels of consciousness, language, neglect, visual-field loss, extraocular movement, motor strength, ataxia, dysarthria, and sensory loss. Ratings for each item are scored with 3 to 5 grades with 0 as normal. As a result, higher scores indicate more severe neurological problems.

Written consent was taken from all patients after explaining the whole procedure. Decisions regarding type of surgery (on-pump or off-pump) were made according to scientific indications by the cardiac surgeons themselves and neither any of the patients nor this survey had any role in making that decision. The survey was done double blinded, as the surgeons did not know which patients were in the survey, and the post-op examiners did not know the type of operation which was done for the patients.

Clinical decisions on patient management on the intensive therapy unit and the ward were taken by blinded staff and were based on local protocols and guidelines, including decisions on extubation, blood transfusion, & discharge.

## RESULTS

Each group consisted of 60 patients. In on-pump group, there were 46 males and 14 females with mean age of  $68 \pm 8.5$  years-old. Off-pump group also consisted of 60 patients (45 male and 15 female) with mean age of  $71 \pm 6.9$  years old. Age difference between two groups was not statistically significant.

Baseline characteristics were similar between patients in two groups (Table-I). Mean LDL level of on-pump and off-pump groups was  $147.2 \pm 28.2$  mg/dl and  $144.2 \pm 28$  mg/dl, and this difference was not statistically significant. Mean triglyceride level of on-pump and off-pump groups was  $239.7 \pm 50$ mg/dl and  $235.7 \pm 57.9$ mg/dl, which was not statistically significant.

Hypertension was defined as systolic pressure  $>140$  mmHg or diastolic pressure  $>90$ mmHg. Patients with normal blood pressure who were already on antihypertensive medication were also considered as being hypertensive. In on-pump group 59 had hypertension (five patients with uncontrolled hypertension). In off-pump group, 55 patients were hypertensive (seven patients with uncontrolled hypertension). However, this difference was not statistically significant.

Regarding diabetes mellitus, 30 patients from on-pump group and 19 patients from off-pump group were diabetic; however the difference was not statistically significant. Patients who were regular smokers for more than year before the operation were considered as smok-

ers. There was also no statistically significant difference between the prevalence of smoking in two groups.

Type-2 injuries (dizziness, blurred vision, and slight decline in level of consciousness) happened in eight patients from on-pump group and two in off-pump. However, this difference was not statistically significant ( $p=0.27$ ).

In case of serious psychological problems (including delirium, depression anxiety and insomnia, severe enough to necessitate psychiatric consultation) seven patients from on-pump group suffered such problems while no one from off-pump group had such problems, and this difference was significant.

Three patients from on-pump group and one patient from off-pump group had visual problems including blurred vision, visual-field loss, or impaired extraocular muscles movements. However, this difference was not significant ( $P=0.61$ ).

In case of serious neurological problems, in on-pump group 9 patients (15.3%) had TIA and two patients (3.4%) suffered from stroke. In off-pump group, three patients (5%) had TIA and no one suffered from stroke and this difference was statistically significant ( $P=0.05$ ). (Table-II).

NIHSS pre-scores were  $0.23 \pm 0.96$  and  $0.28 \pm 0.99$  in on-pump and off-pump groups respectively. Post-scores were  $1.28 \pm 2.78$  and  $0.50 \pm 1.75$  in on-pump and off-pump groups respectively and this difference was statistically significant (Table-III). In other words, the results of our survey show that the prevalence

Table-I: Baseline characteristics of the patients in two groups

	<i>On-pump group</i>	<i>Off-pump group</i>	<i>P-value</i>
Male patients	46	45	NS
Mean age	$68 \pm 8.5$ year-old	$71 \pm 6.9$ years-old	NS
Age $> 65$ year-old	45 patients	54 patients	NS
LDL cholesterol	$147.2 \pm 28.2$ mg/dl	$144.2 \pm 28$ mg/dl	NS
Triglyceride level	$239.7 \pm 50$ mg/dl	$235.7 \pm 57.9$ mg/dl	NS
Hypertension	59 patients	55 patients	NS
Diabetes mellitus	30 patients	27 patients	NS
Smoking	15 patients	15 patients	NS

NS: Not Significant

Table-II: Neurological problems

	<i>On-pump group</i>	<i>Off-pump group</i>	<i>P-value</i>
Psychological problems	7 patients	0 patients	0.001
TIA	9 patients	3 patients	0.05
Stroke	2 patients	0 patients	0.05

of neurological complications, which is showed by NIHSS score, is more in on-pump cardiac surgery comparing to off-pump surgery.

### DISCUSSION

Major neurological complications constitute a growing percentage of serious postoperative morbidity.<sup>5</sup> Changes in cognitive function may persist with an incidence of 25-30% at 8 weeks post cardiac surgery, with only slightly lower levels at one year.<sup>4</sup> A longitudinal assessment of neurocognitive function in patients after cardiopulmonary bypass surgery showed that the cognitive decline could still be present in 42% at five years after surgery.<sup>5</sup>

Major neurologic events, such as disabling strokes, are some of the most feared complications with a reported incidence of 0.8% to 5.2% in patients undergoing cardiac surgery and are mainly due to embolisation by atheromatous debris during manipulation of the diseased aorta. However, cognitive impairment, which is predominantly caused by microembolisation of gaseous and particulate matter is a more common form of neurological injury related to coronary artery bypass surgery but at the same time more difficult to assess or quantify than stroke.<sup>5</sup>

Recent randomised trials comparing the neurocognitive performance of patients after off-pump surgery or cardiopulmonary bypass surgery have reported contradictory results. One trial of 281 patients reported no difference in cognitive outcome at three and 12 months,<sup>6</sup>

but in a separate report on 219 patients the authors still concluded that early cognitive decline at four days after surgery predicted cognitive outcome at three months more prominently in patients after cardiopulmonary bypass surgery.<sup>7</sup> In contrast, two trials, recruiting fewer patients, reported significantly better neurocognitive performances in patients after off-pump surgery.<sup>8,9</sup>

The off-pump CABG technique has been shown to improve the outcome in high-risk patients,<sup>10-12</sup> whereas the use of cardiopulmonary bypass has been shown to be associated with some degree of neurocognitive and neurologic dysfunction.<sup>5</sup>

A recent large multivariate study in a general CABG population including 16,184 patients showed the off-pump CABG approach to be protective in terms of reducing the incidence of neurologic injury.<sup>13</sup> The frequency of major perioperative neurological sequelae in our patients undergoing primary isolated CABG was less than 2%, which is consistent with the reported frequency in the recent literature.<sup>14-16</sup> Patients who underwent off-pump coronary artery bypass grafting surgery had better preservation of neurocognitive function as can be concluded from NIHSS scores.

### CONCLUSION

There has been a growing interest in off-pump CABG especially during the last decade, and the advantages associated with the use of this technique have been repeatedly empha-

Table-III: Comparison of NIHSS scores between two groups

	<i>On-pump group</i>	<i>Off-pump group</i>	<i>P-value</i>
Pre-op NIHSS score	0.23±0.96	0.28±0.99	NS
30 days post-op NIHSS score	1.28±2.78	0.50±1.75	0.001

NS: Not Significant

sized. However, controversies still exist concerning the benefits of off-pump CABG in comparison to those of conventional CABG. An analysis of the best available existing evidence from RCTs clearly suggests that, compared to conventional CABG, off-pump CABG is associated with lower morbidity rates, similar graft patency, and substantially lower costs.

Our study also shows that patients who underwent Off-pump CABG, did better than the patients who underwent on-pump CABG in the first month post-op period. As neurocognitive sequelae are among the most prevalent and important complications of CABG, off-pump CABG so far has shown promising results in lowering the rate of such complications. It must be emphasised however, that despite early reports of good results, more long-term studies are needed to firmly encourage the use of this technique.

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