REVIEW ARTICLE

# Postoperative cognitive dysfunction after cardiac surgery

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## ABSTRACT

Postoperative cognitive dysfunction (POCD) remains a serious complication with increasing importance.

Cerebral dysfunction after surgery presents as stroke, delirium, or POCD. POCD is the post-operative disturbance of memory, and speed of information processing. The incidence of POCD is dependent on the type of procedure. The highest incidence of POCD occurs in patients undergoing cardiac surgery. CABG performed without CPB could reduce the incidence of postoperative neurological disturbance. However, there were no distinct differences in the incidence of POCD between off-pump and on-pump CABG. Many risk factors including aging and poor cognitive status about POCD have been reported. The recent reports suggest that low cerebral oxygenation, as evaluated by near-infrared spectroscopy, during the surgery is a good predictor of POCD. The careful monitoring of the central nervous system during cardiac surgery might predict POCD, and help in avoiding its occurrence.

**Key words:** Cardiac surgery; Cognitive function; Cerebral oxygenation

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## INTRODUCTION

Postoperative cognitive dysfunction (POCD) remains a serious complication with increasing importance.[1] POCD has been associated with longer hospital stay and increased mortality. Cardiac surgery is reported to lead to higher incidence of cerebral dysfunction compared to other operations. It ranges between 40% and 70% at the time of discharge from hospital and 20% to 40% after six months.[1] In this review, the recent findings of POCD after cardiac surgery have been described.

## DIAGNOSIS OF POCD

Cerebral dysfunction after surgery presents as stroke, delirium, or POCD.[2] POCD is characterized as post-operative deterioration in memory, attention, and speed of information processing. The diagnosis of POCD requires pre-operative and post-operative neuropsychological testing. Many elderly patients have a pre-existing undiagnosed mild cognitive impairment. There is no standard methodology to diagnose POCD. The choice of the neuropsychological tests and the timing of testing are varied.

## DELIRIUM

POCD is frequently mistaken to be delirium. POCD and delirium are two primary forms of postoperative central nervous system dysfunction. Postoperative delirium (POD) occurs 24–72 h after surgery. In contrast, POCD is observed weeks to months after surgery.[3]

POD is an acute disorder of cognition. It is diagnosed based on published criteria in the ICD-10 from the World Health Organization. The diagnosis of delirium is to detect the impairment of consciousness and attention. The patients often display disorientation of time as well as place and person. There may be psychomotor disturbances and disrupted sleep-wake cycle with anxiety and fear.

POD is not temporally associated with the anaesthesia during the emergence period. The patients may merge smoothly, and be lucid. However, after the lucid period, the patients develop the delirium in the intensive care unit, between postoperative days 1 and 3.

The mechanism of delirium has not been thoroughly understood. One hypothesis is that delirium occurs

as a result of the inflammatory response during the perioperative period. Age > 70, pre-existing cognitive dysfunction, alcohol abuse are known as the major risk factors for the development of POD. Vascular disorders have also associated with the development of POD.

## STROKE

Stroke following cardiac surgery is a critical complication that occurs in 1.4% to 3.8% of patients who received with coronary artery bypass grafting (CABG) and 8.7% of patients after aortic repair[1]. Age is a primary risk factor associated with stroke after CABG. The multi-centre study found that the factors predicting the risk of stroke were age > 70 years old, prior stroke, diabetes mellitus, hypertension, peripheral vascular disease, and renal failure.

Atherosclerosis of the ascending aorta is an important risk factor for cerebral embolism.[5.] Previous studies have suggested that clamping of the ascending aorta could be attributed to the development of stroke. Carotid stenosis is also a risk factor for stroke. In addition to intraoperative stroke, more than half of stroke cases occur post-operative period.[6] Intra-operative stroke is caused by cerebral emboli or hypoperfusion especially during cardiopulmonary bypass (CPB), while postoperative strokes might be associated with arterial fibrillation.

## POCD AND CARDIAC SURGERY

The incidence of POCD is dependent on the type of procedure. It is well known that the highest incidence of POCD occurs in patients undergoing cardiac surgery. Newman et al.[7] reported that the POCD incidence at hospital discharge was approximately 53%, 36% after six weeks, and 24% at six months post-operative period.[7] These results correspond to double the incidence compared with non-cardiac surgery.

Hypoperfusion, emboli, and inflammation related to the use of CPB have the association with the mechanisms of POCD. Therefore, in general, the incidence of POCD after cardiac surgery is higher than that after other non-cardiac surgeries.

CABG performed without CPB (off-pump CABG) could reduce the incidence of postoperative neurological complications.[8] Off-pump CABG has been associated with reduced risk of stroke. However, there were no distinct differences in the incidence of POCD between off-pump and on-pump CABG.

In a randomized study, POCD was found in 21% of patients with off-pump and 29% in patients with on-pump three months after surgery (P = 0.15).[9]

All types of surgery have associated with inflammation and release of stress hormones such as cortisol and catecholamine. High levels of glucocorticoids impair cognitive function. The etiology of POCD after cardiac surgery is multifactorial.

## LONG TERM CONSEQUENCES

Several studies suggest that, in addition to the immediate effects on cognitive function, long-term outcomes are also affected.

Phillips-Bute at al.[10] evaluated the impact of POCD on the quality of life one year after CABG surgery. Although the most quality of life measures improved, 37% of the patients had POCD at one year after surgery. A substantial association has been found between changes in cognitive function and changes in quality of life over the course of 1 year. After non-cardiac surgery, a significantly higher mortality within one year of surgery has been reported in patients who had POCD at hospital discharge.[11] These data suggest that POCD has significant long-term consequences after surgery.

## RISK OF POCD AND MONITORING

Various risk factors for POCD were reported, including aging and poor preoperative cognitive status.

A recent report suggests that impaired cerebral oxygenation, as evaluated by near-infrared spectroscopy, during surgery is a predictor of POCD. Near-infrared spectroscopy allowa continuous non-invasive monitoring of cerebral oxygenation through the skin of forehead reflects the balance between brain oxygen supply and demand. We evaluated the relationship between cerebral oxygen saturation ($rSO_2$) and postoperative cognitive function in abdominal surgery.[12] Low pre-operative $rSO_2$ was an important risk factor for the development of POD. Although we could not find a significant relationship between $rSO_2$ and POCD, this study suggests that monitoring the $rSO_2$ might be a good indicator of perioperative cognitive function.

Similar results were observed by Casati et al. [13] They found that brain desaturation ($rSO_2$ decrease <75% of baseline) occurred in 40% of elderly patients after noncardiac surgery, and the cerebral desaturation was linked with a high incidence of

POCD. However, in cardiac surgery, Murkin et al.[14] reported that prolonged cerebral hypoperfusion detected by low $rSO_2$ was related with increased morbidity, but had no association with POCD. In contrast, Colak et al.[15] reported that prolonged $rSO_2$ desaturation is a predictor of cognitive decline after CABG surgery and should be avoided. A recent systematic review shows that reductions in $rSO_2$ during cardiac surgery may indicate CPB cannula malposition, particularly during aortic surgery.[16] However, only weak evidence links low $rSO_2$ during cardiac surgery to POCD.

If the cerebral oxygenation monitoring may predict the postoperative cognitive dysfunction, the management to improve the $sSO_2$ should improve the outcome. Palmbergen et al.[17] evaluated the efficiency of intervention to restore cerebral oxygenation when perioperative cerebral desaturations > 20% to the postoperative delirium rate. By this strategy, a reduction in the incidence of postoperative delirium in patients undergoing elective CABG surgery was observed in the study.

Bispectral index (BIS) is commonly used to maintain adequate anaesthesia depth during cardiac surgery. Because BIS values are calculated from electroencephalography (EEG), abnormal BIS value could show abnormal brain status including hypoperfusion.[18] A recent study suggests that intraoperative EEG suppression predicts POD and also POCD.[19] Further studies should be planned to evaluate the usefulness of cerebral oxygenation monitoring and EEG to maintain cerebral function during and after cardiac surgery.

## POSTOPERATIVE MANAGEMENT

Patients should be observed after surgery to detect early signs of neurological dysfunction in the intensive care unit. If cerebral infarction is detected, immediate therapy including pharmacological treatment should be considered.

Early intervention and treatment might reduce the severity and duration of delirium. A recent study suggests the perioperative neuroprotective strategies by some drugs including antiplatelet therapy, beta-blockers, and dexmedetomidine. Dexmedetomidine administered during the perioperative period was effective to reduce cardio-cerebral complications after cardiac surgery.[20] Further studies are needed to establish the postoperative management to maintain the cognitive function.

## CONCLUSIONS

Cerebral dysfunction after cardiac surgery is associated with complex interactions of emboli, hypoperfusion, inflammation, and patient's preoperative cerebral dysfunction. Recent studies suggest that careful monitoring of the central nervous system during cardiac surgery might predict POCD, and help in avoiding its occurrence.

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**Author's contribution:** YM is the sole responsible person for preparation of this manuscript.

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