



OUTCOMES OF OFF-PUMP VERSUS ON-PUMP CORONARY ARTERY BYPASS GRAFTING

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ABSTRACT

The aim of this study was to analyse if off-pumpcoronary artery bypass surgery (CABG) is associated with better treatment outcomes than on-pump CABG.

Method: We reviewed 10 recent articles on pub-med off-pump and on-pump CABG revascularization.

Discussions: OPCAB was in theory superior ONCAB in many ways as it spared patients the burden of CPB with the inevitable increase in transfusion demands and inflammatory response and therefore lowering the surgical load. Since the popularization OPCAB two decades ago it has become the most common CABG variant performed in countries like Japan and India while in Europe and the USA ONCAB is the most common and OPCAB is performed in 8 to 25 % of cases. Large observational studies like ROOBY, CORONARY and DOORS, especially in recent follow-up studies, have tended to favor ONCBG.

Conclusion: In a well selected patient in a high-risk subgroup with a surgeon skilled in OPCAB there are potential benefits compared to ONCAB but the overall trend in recent large RCTs and follow-up studies point to the average CABG patient being better served by ONCAB due to better graft patency and fewer complications.

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INTRODUCTION

An Austrian-German physiologist Maximilian von Frey constructed an early prototype of a heart-lung machine in 1885 at Carl Ludwig's Physiological Institute of the University of Leipzig (McCullough, 2004). However, such machines were not feasible before the discovery of heparin in 1916 which prevents blood coagulation. The first successful open heart procedure on a human utilizing the heart lung machine was performed by John Gibbon on May 6, 1953 at Thomas Jefferson University Hospital in Philadelphia. He repaired an atrial septal defect in an 18-year-old woman (Cohn, 2003). Gibbon's machine was further developed into a reliable instrument by a surgical team led by John W. Kirklin at the

Mayo Clinic in Rochester, Minnesota in the mid-1950s paving the way for modern cardio-thoracic surgery (McCullough, 2004 and Cohn, 2003). Gibbon's machine became the cornerstone of modern Cardiopulmonary bypass (CPB), a technique that temporarily takes over the function of the heart and lungs during surgery, maintaining the circulation of blood and the oxygen content of the patient's body. By allowing the heart and lungs to be "bypassed" and the heart stopped new possibilities opened up for the surgeon performing operations on the heart. Whereas previously operations had been closed or minimally invasive to avoid fatally compromising circulation in the patient the surgeon now had both more time to operate and a good operating field when operating on and in the heart.

DISCUSSIONS

While allowing lifesaving procedures to be performed CPB is not benign and there are a few associated problems.

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Table 1.

Article:	Patients Nr=?	ONCAB Nr=?	OPCAB Nr=?	Graft patency Months=?	Conclusions:
Comparison of Mid-Term Graft Patency between On-Pump and Off-Pump Coronary Artery Bypass Grafting. <i>Seki T, Yoshida et al.</i>	365 consecutive patients	67	67	35 ± 37	A retrospective study with a propensity score matched cohort. Showed no difference in ONCAB vs OPCAB graft patency (P = 0.42 and 0.76, respectively).
Myocardial revascularization without extracorporeal circulation; Why hasn't it convinced yet? <i>Apostolakis E., Papakonstantinou NA et al.</i>	Review				Argues for ONCAB in normal patients' due to better graft patency, OPCAB may have role in high risk subgroups
Current outcomes of off-pump versus on-pump coronary artery bypass grafting: evidence from randomized controlled trials. <i>Fudulu D, Benedetto U, et al.</i>	Review				The high-risk patient groups seem to benefit from off-pump coronary surgery post operatively. OPCAB shows poorer graft patency but pooled patient data suggests lower rate of post-operative stroke.
Five-Year Outcomes after On-Pump and Off-Pump Coronary-Artery Bypass. <i>Shroyer AL, Hattler B, et al.</i>	2203 patients/18 medical centres	death at 5 years was 11.9% in the On-pump group	death at 5 years was 15.2% in the off-pump group		off-pump CABG led to lower rates of 5-year survival and event-free survival than on-pump CABG.
Clampless versus clamped coronary bypass grafting: does it make a difference? <i>Kawajiri H, Yaku H.</i>	Review				Suggests OPCAB as place a specialty technique specially to avoid stroke in sensitive patients
6. Operative strategies to reduce cerebral embolic events during on- and off-pump coronary artery bypass surgery: A stratified, prospective randomized trial. <i>Halkos MEI, Anderson A, et al.</i>	142 patients	(n = 34)	(n = 36)		There were no differences in neurocognitive outcomes across the groups.
7. Off-pump versus on-pump coronary surgery in patients with chronic kidney disease: a meta-analysis. <i>Wang Y, Zhu S, et al.</i>	meta-analysis includes 17 studies 201,889 patients with CKD	ONCAB was associated with decreased risk of atrial fibrillation	OPCAB was associated with significantly lower early mortality		No difference was found regarding long-term survival (HR 1.08; 95% CI 0.86-1.36; p = 0.51) or myocardial infarction (OR 0.65; 95% CI 0.30-1.38; p = 0.26).
8. Long-term survival after off-pump versus on-pump coronary artery bypass graft surgery. Does completeness of revascularization play a role? <i>Benedetto U, Caputo M, et al.</i>	From 1996 to 2015, 14555 patients	7,427 ONCAB	7,427 OPCAB. OPCAB was associated with higher rate of incomplete revascularization 13.3% versus 6.7%; P<0.0001).		At 12 years OPCAB was associated with a marginal but significant +3% increase in overall mortality. This translated into a marginal but significant reduction in late survival rates after OPCAB when compared to ONCAB.
9. Single-Centre Experience of Off-Pump Multi-Vessel Coronary Artery Bypass Grafting Using Proximal Suture Device. <i>Ohira S, Doi K</i>	Retrospective study 1024 patients	899	124	At discharge	Lower incidence of stroke and comparable graft patency to ONCAB
10. Current outcomes of off-pump coronary artery bypass grafting: evidence from real world practice. <i>Davierwala PM.</i>	Review				OPCBG early outcomes are comparable but ONCBG provides a survival benefit in the long term according to a majority of publications in literature.

Blood damage is an unavoidable side effect of extracorporeal circulation as is some degree a systemic inflammatory response (SIRS) with 5-7% of patients developing some form of serious complication (Lamy, 2012). Other potential risks are: Post perfusion syndrome (also known as "pump head"), Hemolysis, Capillary leak syndrome, Clotting of blood in the circuit – can block the circuit (particularly the oxygenator) or send a clot into the patient. Air embolism Leakage – a patient can rapidly exsanguinate (lose blood perfusion of tissues) if a line becomes disconnected. To avoid the risk of these complications when treating coronary artery disease surgically with a coronary artery bypass graft (CABG) using CPB, what is commonly referred to as on-pump coronary artery bypass (ONCAB), a technique for performing CABG without stopping the heart and using CPB was developed referred to as off-pump coronary artery bypass OPCAB. OPCAB was in theory superior ONCAB in many ways as it spared patients the burden of CPB with the inevitable increase in transfusion demands and inflammatory response and therefore lowering the surgical load. As the aorta is neither clamped nor cannulated a lower risk of neurological complications and complications from the cannulation site in the aorta is likely. It is also cheaper than ONCAB as both the CPB machinery, the extra personnel needed to run it and possibly the higher frequency of complications all added to the price of an ONCAB, making OPCAB appealing to countries with limited resources. The disadvantage of OPCAB is that instead of fitting the graft to a coronary artery on a still heart in a bloodless field the grafting is made to a beating heart. Getting a good anastomosis and avoiding iatrogenic damage to the coronary arteries demands more technical skill from the surgeon in OPCAB compared to ONCAB.

Today OPCAB widely performed is safe and effective and there are numerous techniques available – limited thoracotomy, video assisted. Since the popularization OPCAB two decades ago it has become the most common CABG variant performed in countries like Japan and India while in Europe and the USA ONCAB is the most common and OPCAB is performed in 8 to 25 % of cases (Apostolakis, 2017). During this time which method is the superior one has been hotly contested. Three major RCT's have been performed the Randomized On/Off Bypass Trial (ROOBY with 2203 patients) (Shroyer, 2017). CABG Off or On Pump Revascularization Study (CORONARY with 4752 patients) (Lamy, 2012) and Danish On-pump versus Off-pump Randomization Study (DOORS with 900 patients) (Houliand, 2012). There have also been numerous smaller RCTs, retrospective studies and numerous meta-analyses pooling patients from numerous smaller trials. Despite this significant result showing the superiority of one method over the other have proven elusive.

Evidence: E_ (1,2,3,4,5,6)

Large observational studies like ROOBY, CORONARY and DOORS, especially in recent follow-up studies, have tended to favor ONCAB.

E,1_ The theorized superiority of OPCAB in death and major complications never materialized and there was no significant difference in short term primary outcomes.

E,2_ OPCAB grafts where less patent with a higher rate of revascularization (Lamy, 2012; Shroyer, 2017; Khan, 2004 and Benedetto, 2017).

E,3_ There has been some controversy regarding the skill of the surgeons performing the OPCAB where it has been suggested that the high conversion rates compared to other studies where indicative of lacking surgical skill in the surgeons performing the OPCAB surgeries as the studies where performed in countries where ONCAB was the most common CABG method (Seki, 2017).

E,4_ Other instead suggested smaller studies showing OPCAB superiority utilized patients that where not entirely representative and therefore had better results (Khan, 2004).

E,5_ The recent 5 years follow up to CORONARY showed higher all-cause mortality, but no difference in cardiac mortality, and worse composite outcomes for OPCAB compared to ONCAB (Shroyer, 2017).

E,6_ OPCAB graft patency was more significantly inferior than ONCAB but OPCAB patients required fewer transfusions when compared to ONCAB.

For a summary of the conclusions of the most recent publications in the field above Table 1.

Conclusion

As Table 1 shows ONCAB and OPCAB outcomes are comparable in most areas. In a well selected patient in a high-risk subgroup with a surgeon skilled in OPCAB there are potential benefits compared to ONCAB but the overall trend in recent large RCTs and follow-up studies point to the average CABG patient being better served by ONCAB due to better graft patency and fewer complications.

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