Comparative study between off-pump and on pump coronary artery bypass surgery in patients with poor cardiac function

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By

Dr: Ali Elsayed Ali Ismail

M.B.B.Ch., M.Sc in anesthesia Faculty of Medicine, Ain Shams University

Under supervision of

Prof. Dr. Mahmoud Sherif Mostafa Nagy

Professor of Anesthesia and Intensive care
Faculty of Medicine - Ain Shams University

Prof. Dr. Mohammed Ismail Abdelfatah Elseedy

Professor of Anesthesia and Intensive care
Faculty of Medicine - Ain Shams University

Ass. Prof. Dr. Walid Abdelmeged Mohammed Eltaher

Assistant Professor of Anesthesia and Intensive care
Faculty of Medicine - Ain Shams University

Faculty of Medicine
Ain Shams University

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ABG	**Arterial blood gas**
ACT	**Activated clotting time**
AF	**Atrial fibrillation.**
CABG	**Coronary artery bypass graft**
CBP	**Cardiopulmonary bypass.**
EF	**Ejection fraction**
IJV	**Internal jugular vein**
LAD	**left anterior descending coronary artery**
LCx	**left circumflex coronary artery**
LMCA	**left main coronary artery**
OPCAB	**Off pump coronary artery bypass.**
PDA	**posterior descending artery**
RCA	**right coronary artery**
RCT	**Randomized Controlled Trials**
RCTs	**Randomized controlled trials.**
SD	**Standard deviation**
SIRS	**Systemic inflammatory response syndrome.**
TNF	**Tumor necrotic factor.**

Introduction

CABG still remains the gold standard treatment today for patients with three-vessel disease. The indications are well documented and the results relatively satisfying in terms of morbidity, mortality and ischemic resurgence **(ACC/AHA 2004).**

The incidence of risk factors and preoperative comorbidities is increasing and many patients arrive for surgery at an advanced age, with severe left ventricular dysfunction, chronic renal disease, peripheral vascular disease, chronic bronchopulmonary disease, etc. **(Lloyd-Jones *et al,* 2004).**

Off-pump strategy is to be able to carry out revascularization as complete as possible, under technical conditions offering maximum safety for the patient, by avoiding triggering of possible complications induced by CPB and by avoiding myocardial ischemia **(El-Hamamsy *et al,* 2006).**

Their is equivalent outcomes with off-pump compared to on-pump surgery especially with regards to postoperative mortality, stroke, myocardial injury, atrial fibrillation, need for transfusion and hospital stay**(Bainbridge *et al,* 2007).**However most of these studies were performed in highly select and relatively low-risk patient groups, where mortality and morbidity rates were already low.

The results of off-pump surgery are dependent on a complex interaction of many factors that include the skill and experience of the surgeon and appropriate patient selection for certain techniques. Off-pump surgery is a very safe and efficacious alternative to conventional revascularization in certain hands and should be increasingly utilized in the

high-risk groups. In low-risk patients, CPB remains safe and completeness of revascularization should not be compromised. To this end, both methods of revascularization will continue to have a role in revascularization and they both continue to evolve. Further trials will continue to supplement the current knowledge we have on the subject with the aim of making coronary surgery even safer than it is today **(Yasir and David, 2009).**

Anatomy of Coronary arteries

The coronary artery system divides naturally into two distributions, left and right. From the stand point of surgeon, the coronary artery system is divided into four parts: the left main coronary artery (LMCA), the left anterior descending coronary artery (LAD) and its branches, the left circumflex coronary artery (LCx) and its branches, and the right coronary artery (RCA) and its branches. The branches of each of the last three vessels must also be known **(Fig.1) (Kouchoukos *et al.*, 2003).**

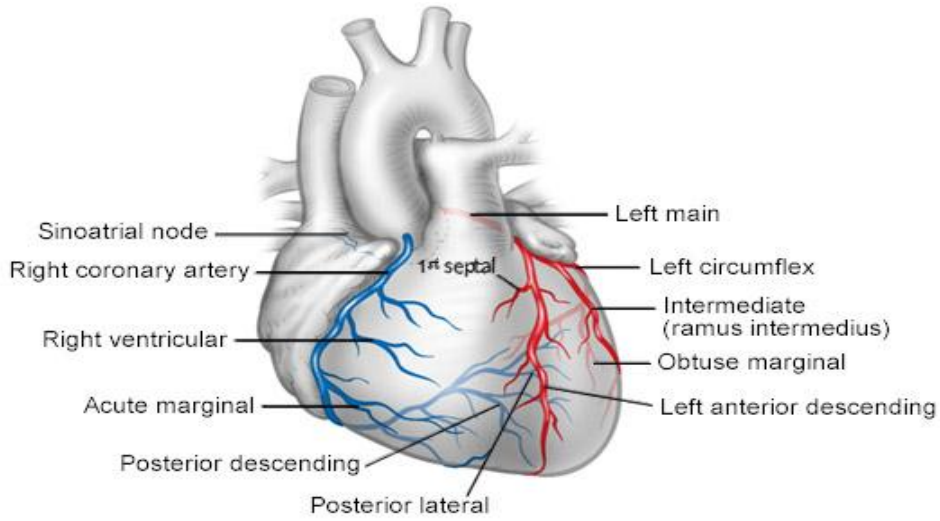

FIGURE 1 ***(Quoted from Cohn and Edmunds, 2003).***

LEFT MAIN CORONARY ARTERY (LMCA)

The **left coronary artery** (**LCA)** arises from the aorta above the left cusp of the aortic valve. The part that is between the aorta and the bifurcation only is known as the left main artery (LM), while the term 'LCA' might refer to just the left main, or to the left main and all its eventual branches. The LMCA extends from the ostium in the left sinus of Valsalva to its bifurcation into the LAD and LCx branches. Its usual length is 10 to 20 mm, with a

range of 0 to 40 mm. It normally courses between the pulmonary trunk and the left atrial appendage to reach the left atrioventricular groove. The main stem divides into two major arteries of nearly equal diameter: the left anterior descending artery and the circumflex artery. Rarely (in 1% of persons), the LMCA is absent, the LAD and LCx arteries originating directly from the aorta via separate ostia **(Charles and Kahn, 2004)**.

Left Anterior Descending Artery

The "LAD", or left anterior descending artery (or anterior interventricular branch of the left coronary artery, or anterior descending branch) continues directly from the bifurcation of the left main stem, coursing anteriorly and inferiorly in the anterior interventricular groove, it reaches the apex of the heart in 78% of cases. It passes at first behind the pulmonary artery and then comes forward between that vessel and the left auricula to reach the anterior interventricular sulcus, along which it descends to the incisura apicis cordis. It supplies the anterolateral myocardium, apex, and interventricular septum. The LAD typically supplies 45-55% of the left ventricle (LV) **(Williams, *et al.* 1995).**

The LAD gives off three types of branches: septals, diagonals and the right ventricular branches. Septals originate from the LAD at 90 degrees to the surface of the heart, perforating and supplying the intraventricular septum. Typically there are 3 to 5 septal perforators; the initial one is the largest and commonly originates just beyond the takeoff of the first diagonal. This perpendicular orientation is a useful marker for identification of the left anterior descending artery on corononary angiograms. The septal perforators supply blood to the anterior two thirds of the ventricular septum **(Schlant and Silverman, 1986).**

Diagonals run along the surface of the heart and supply the lateral wall of the LV and the anterolateral papillary muscle. Digonal branches may be 2 to 6 in number, course along the anterolateral wall of the left ventricle and supply this portion of the myocardium. The first diagonal generally is the largest and may arise from the bifurcation of the left main stem (formerly known as the intermediate artery), which is found in 37% of the general population and is considered a normal variant **(Kouchoukos *et al.*, 2003).**

Right ventricular branches, which may not always be present, supply blood to the anterior surface of the right ventricle. One or more branches to the right ventricle connect with infundibular branches from the proximal RCA. This important route for collateral flow is the loop of Vieussens **(Kouchoukos *et al.*, 2003).**

Circumflex Artery

The "LCX" or left circumflex artery arises from the left main coronary artery roughly at a right angle to the anterior interventricular branch. It courses along the left atrioventricular groove and, in 85% to 95% of patient terminates near the obtuse margin of the left ventricle. In 10% to 15% of patients, it continues around the atrioventricular groove to the crux of the heart to give rise to the posterior descending artery (left dominance). It follows the left part of the coronary sulcus, running first to the left and then to the right, reaching nearly as far as the posterior longitudinal sulcus **(Vincke *et al.*, 2006)**.

The primary branches of the left circumflex coronary artery are the obtuse marginals. They supply blood to the lateral aspect of the left ventricular myocardium, including the posteromedial papillary muscle and anterolateral papillary muscle. Often, their position can then be identified at

operation by the altered color (reddish or light tan) of the overlying thin muscle layer compared with that of the remainder of the ventricular wall. Additional branches supply blood to the left atrium. A large branch originating from the proximal LCx and coursing around the left atrium near the atrioventricular groove is termed the atrial circumflex artery, in 40–50 percent of hearts; the sinus node artery occasionally originates from the first few millimeters of the LCx and 60% from right coronary artery. When the circumflex coronary artery supplies the posterior descending artery (left dominant), it also supplies the atrioventricular node **(Schlant and Silverman, 1986).**

The LCX supplies 15-25% of the left ventricle in right-dominant systems. If the coronary anatomy is left- dominant, the LCX supplies 40-50% of the left ventricle **(Vincke *et al.*, 2006)**.

RIGHT CORONARY ARTERY (RCA)

The right coronary artery (RCA) originates above the right cusp of the aortic valve. It travels down the right atrioventricular groove, towards the crux of the heart. The RCA usually is a single large artery; it courses from the aorta anteriorly and laterally before descending in the right atrioventricular groove and curving posteriorly at the acute margin of the right ventricle. In 85–90 percent of hearts, the right coronary artery crosses the crux, where it makes a characteristic U-turn before bifurcating into the posterior descending artery and the right posterolateral artery. In the region of the acute margin of the heart, a relatively constant long branch of the RCA arises, the acute marginal artery, which courses most of the way to the apex of the heart **(Kirklin and Barratt-Boyes, 1993).**

The acute marginal artery crosses the diaphragmatic surface of the right ventricle in 10% to 20% of hearts and reaches the anterior aspect of the diaphragmatic portion of the ventricular septum, to which it gives branches **(Adams and Treasure, 1985)**.

In 50–60 percent of hearts, the artery to the sinus node arises from the proximal portion of the right coronary artery. The blood supply to the atrioventricular node (in patients with right dominant circulation) arises from the mid-portion of the U-shaped segment. The posterior descending artery runs along the posterior interventricular groove, extending for a variable distance toward the apex of the heart. It gives off perpendicular branches, the posterior septal perforators, that course anteriorly in the ventricular septum. Typically, these perforators supply the posterior one-third of the ventricular septal myocardium **(Schlant and Silverman, 1986).**

Variations in the RCA are common.It may have a dual origin from the right sinus of Valsalva. In about 10% of hearts, it bifurcates within a few millimeters of the aortic ostium, forming two diverging trunks of equal size. In half the cases, the artery supplying the infundibulum of the right ventricle arises separately **(Harlan *et al.*, 1996).**

In addition to supplying blood to the right ventricle (RV), the RCA supplies 25% to 35% of the left ventricle (LV). In 85% of patients, the RCA gives off the posterior descending artery (PDA) (Right dominant). In the other 15% of cases, the PDA is given off by the left circumflex artery (Left dominant). The PDA supplies the inferior wall, ventricular septum, and the posteromedial papillary muscle **(Charles and Kahn, 2004)**.

Review of literature

Trials comparing percutaneous coronary intervention and coronary artery bypass grafting (CABG) in patients candidates for either procedure have found no significant difference in the rates of death or myocardial infarction during follow-up **(Biondi-Zoccai, *et al.* 2003).**

However, repeat revascularization is required more frequently after percutaneous coronary interventions with or without the use of stents, prior to the development of drug-eluting stents; patients with multi-vessel coronary artery disease requiring revascularization would often undergo CABG rather than a percutaneous intervention because of concern about the likelihood of restenosis. Other factors such as left main coronary artery disease, diabetes mellitus and technical feasibility also influenced the decision to proceed with CABG **(Powell, *et al.* 2004).**

The first work relating to coronary artery bypass surgery was carried out as early as 1910 on a beating heart **(Carrel 1910).**

The first successful cardiac operation using cardiopulmonary bypass (CPB) in 1953 that cardiac surgery developed rapidly. In the pioneering days of CPB, the morbidity and mortality associated with the use of the pump-oxygenator was high, therefore coronary surgery initially developed without using CPB. In 1966, Kolessov reported a series of six cases in which the left internal mammary artery was anastomosed with the left anterior descending artery, with five survivors **(Kolessov 1967).**

Subsequent development of CPB with the advent of bubble oxygenators and the use of cardioplegia resulted in increased popularity and,

as a result of the success of work by Favaloro in 1969, the use of CPB in coronary artery surgery became widespread **(Favaloro 1968).**

Although CABG performed with cardiopulmonary bypass (CPB), owing to less frequent need for repeat revascularization or re-intervention, has become a well-established treatment modality for patients with coronary artery disease, there is increasing evidence that CPB may be responsible for some of the morbidity associated with CABG. The systemic inflammatory reaction initiated by the extracorporeal circuit results in mechanical trauma to blood, activation of various immunological cascades (complement, cytokines), impaired hemostasis, neurological, renal and gastrointestinal dysfunction **(Edmunds 2003).**

Furthermore, aortic cannulation, cross clamping and CPB can result in microembolization and macroembolization, with subsequent neurological and other end-organ injury, including global myocardial ischemia/reperfusion injury **(Blauth, *et al.* 1992).**

A short and mid-term results of randomized controlled trials (RCTs) comparing drug-eluting stents with bare metal stents have shown significant reductions in the incidence of in stent restenosis with drug-eluting stents **(Fajadet, *et al.* 2005).**

These encouraging results coupled with the less invasive nature of percutaneous coronary techniques and the concerns regarding CPB associated morbidity have led to a decline in referral for surgical myocardial revascularization and prompted surgeons to undertake off-pump coronary artery bypass (OPCAB) in the hope that CABG would be safer if CPB could be avoided. Off-pump coronary artery bypass is currently the focus of