

# Beating Heart Surgery - Current Concepts

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**C**ontinuity Every year, globally, thousands of patients undergo Coronary Artery Bypass Grafting (CABG). Traditionally CABG is performed with the assistance of the heart lung machine on cardiopulmonary bypass (CPB) which is still considered a gold standard in this form of surgery.<sup>1</sup> The advantage of performing CABG on CPB is that it allows cessation of heart beat so that the surgeons can operate on a surface which is blood-free and still.

Off-pump Coronary Artery Bypass surgery (OPCAB) or 'beating heart' surgery is different in that the heart lung machine is not used and the heart is not stopped. Technological advances and new kinds of operating equipment now allow the surgeon to bypass a blocked coronary artery in a controlled operative environment where the heart is still beating but the operating area is stabilized and relatively still. The rest of the heart keeps pumping and circulating blood to the body. 'Beating heart surgery' is however not a revolutionary new approach or a new operation. The first 'off-pump' revascularization was performed by Kolesov in 1967 to bypass a block in the left anterior descending artery.<sup>2</sup> Favoloro used this method in 1968 for bypassing the right coronary artery.<sup>3</sup>

Off-pump coronary artery bypass claims to reduce the complications attributed to cardiopulmonary bypass, which have been thoroughly documented.<sup>4</sup> This method is intellectually appealing with many theoretical and practical advantages and is rapidly becoming the method of choice rather than an alternative procedure. At present, centers perform varying percentages of their CABG cases off-pump and this suggests that the last word has not been said about OPCAB.

Some of the adverse effects of cardiopulmonary bypass are due to the whole body response to the non physiologic nature of CPB. These include complement and neutrophil inactivation, platelet damage, hemodilution, alteration in fluid balance, coagulopathies, metabolic disturbances, alterations in cardiac function and CNS (Table 1).<sup>6</sup> There have been studies which have shown that OPCAB is comparable to conventional CABG in terms of mortality, peri-operative infarction, neurological complications. However it appears to be superior in terms of hospital stay, morbidity, number of blood transfusions required, hematological and pulmonary dysfunction. There is a definite place for OPCAB in certain high risk groups such as severe left ventricular dysfunction, advanced age, stroke, chronic renal failure, COPD, heavily calcified aortas and hybrid procedures (CABG in combination with stenting) Table 2.

Small diffusely diseased target vessels and intra myocardial vessels remain some limitations of OPCAB. Occasionally, during a beating heart operation, CPB might be instituted to safely complete the operation. Common reasons mandating conversion from an off-pump to an on-pump procedure include hemodynamic instability, failure to adequately expose the target vessel, deep intramyocardial course of the target vessel, and global ventricular ischemia. The reported incidence of conversion to CPB ranges from a low of 1.1% to a high of 16.3%.<sup>7</sup> Patients who require conversion may be at greater risk of complications or death, and the procedure will cost more.

**Table 1:** Adverse effects of Cardiopulmonary bypass (CPB)<sup>5</sup>

Adverse effects	Clinical sequelae
Complement and neutrophil activation	Vasoconstriction, with increase in capillary permeability, leading to fluid shift into the interstitial compartment; increased risk of microemboli
Platelet damage and release of vasoactive substances	Impaired haemostasis, hypertension
Haemodilution	Interstitial edema, including pulmonary edema
Increase in levels of renin, angiotensin	Sodium and water retention, SIADH
Metabolic disturbances	Electrolyte imbalances, hyperglycemia
Hypothermia	Alteration in systemic vascular resistance
Embolism of gas, debris, fat	Alteration in CNS function
Alteration in pulmonary function	Alveolar collapse, retention of secretions, increased pulmonary shunting
Alterations in GI function	Splanchnic vasoconstriction

SIADH: Syndrome of inappropriate antidiuretic hormone

CNS: Central nervous system

GI: Gastrointestinal

**Table 2:** Special indications for Off-pump coronary artery bypass (OPCAB) surgery<sup>5</sup>

Low left ventricular ejection fraction
Left main stem disease
Advanced age
Stroke
Chronic renal failure
Chronic obstructive pulmonary disease
Sleep apnea syndrome
Atheromatous disease of the aorta
Acute myocardial infarction
Reoperations
OPCAB as a combined procedure has been done with transmyocardial laser revascularization, carotid endarterectomy, abdominal aortic aneurysm repair, lung surgery, and gastrectomy

Though a standard median sternotomy is often chosen for grafting in OPCAB there have been other approaches like left and right thoracotomy,<sup>8</sup> mini/partial sternotomy,<sup>9,10</sup> and other incisions.<sup>11</sup> These have been usually done for single vessel grafting or re-do coronary artery surgery. More recently left thoracotomy approach has been used for multivessel grafting as described by Koba, Al Sabti and Sharma in this issue.

Active involvement of the anesthesia team is essential for successful OPCAB. They help by maintaining coronary perfusion pressure and adequate cardiac output during cardiac manipulations and unfavorable positioning of the heart.

Immediate post-operative nursing care of the patient in the Intensive Care Unit (ICU) has changed in OPCAB surgery because OPCAB patients often arrive extubated or are extubated soon after. Nurses caring for these patients have had to become skilled in pain management as well as in handling various airway problems. For the typical cardiac surgical ICU nurse, management of inotropic support and measurement of chest tube output has been replaced with placement of nasopharyngeal airways, titration of narcotics, early mobilization and reassurance of the patient.

Beating heart surgery is fast becoming a safe alternative to conventional CABG. However, the available data on clinical experience with this technique should be interpreted with caution, since most of these studies are non-randomized with an element of selection, observation and publication bias. It is important to remember that the results of both on and off-pump coronary bypass operations are excellent. Both have a very low risk of death, stroke and myocardial infarction. Off-pump surgery can significantly reduce morbidity and cost of care.<sup>12</sup>

Will off-pump coronary artery surgery replace conventional coronary artery surgery? The answer at present is 'no'. Off-pump and on-pump surgery are complementary techniques for achievement of myocardial revascularization, each with its advantages and disadvantages in patients with specific characteristics. The good news for heart patients is that coronary bypass surgery is already extremely safe and effective and becoming even more so.

The health care system of Oman has been so successful that life expectancy has shown a remarkable increase from 49.3 years in 1970 to 74.29 years in 2006.<sup>13</sup> In addition, changes in lifestyle have resulted in a longer exposure to risk factors for coronary artery disease such as hypertension and diabetes mellitus. The ultimate decision to perform one or the other form of surgery depends to a large extent on the patient's coronary anatomy, risk factors and the surgeon's preference.

## References

1. Alvarez JM, Cooke JC, Shardey GC, Goldstein J, Harper RC. Orthodox Coronary Artery Bypass Surgery: The Gold Standard In Surgical Coronary Artery Disease Intervention. *Asia Pac Heart J* 1999;8:148-153 .
2. Kolesov VI. Mammary artery-coronary artery anastomosis as method of treatment for angina pectoris. *J Thorac Cardiovasc Surg* 1967 Oct;54(4):535-544.
3. Favoloro RG. Saphenous vein autograft replacement of severe segmental coronary artery occlusion: operative technique. *Ann Thorac Surg* 1968 Apr;5(4):334-339.
4. Favoloro RG. Critical analysis of Coronary artery bypass graft surgery: a 30 year journey. *J Am Coll Cardiol* 1998;31:1-63 .
5. Raja SG, Berg GA. Outcomes of off-pump coronary artery bypass surgery: current best available evidence. *Indian Heart J* 2007 Jan-Feb;59(1):15-27.
6. Butler J, Rucker GM, Westaby S. Inflammatory response to cardiopulmonary bypass. *Ann Thorac Surg* 1993 Feb;55(2):552-559.
7. Edgerton JR, Dewey TM, Magee MJ, Herbert MA, Prince SL, Jones KK, et al. Conversion in off-pump coronary artery bypass grafting: an analysis of predictors and outcomes. *Ann Thorac Surg* 2003 Oct;76(4):1138-1142, discussion 1142-1143.
8. Calafiore AM, Giammarco GD, Teodori G, Bosco G, D'Annunzio E, Barsotti A, et al. Left anterior descending coronary artery grafting via left anterior small thoracotomy without cardiopulmonary bypass. *Ann Thorac Surg* 1996 Jun;61(6):1658-1663, discussion 1664-1665.
9. Niinami H, Takeuchi Y, Suda Y, Ross DE. Lower sternal splitting approach for off-pump coronary artery bypass grafting. *Ann Thorac Surg* 2000 Oct;70(4):1431-1433.
10. Ricci M, Salerno TA, Houck JP. Manubrium-sparing sternotomy and off-pump coronary artery bypass grafting in patients with tracheal stoma. *Ann Thorac Surg* 2000 Aug;70(2):679-680.
11. Subramanian VA, Patel NU. Transabdominal minimally invasive direct coronary artery bypass grafting (MIDCAB). *Eur J Cardiothorac Surg* 2000 Apr;17(4):485-487.
12. Nathoe HM, van Dijk D, Jansen EW, Suyker WJ, Diephuis JC, van Boven WJ, et al; Octopus Study Group. A comparison of on-pump and off-pump coronary bypass surgery in low-risk patients. *N Engl J Med* 2003 Jan;348(5):394-402.
13. Ministry of Health Oman. Available at: [http://www.moh.gov.om/stat/HTML\\_FILE/Health%20Indicators.htm](http://www.moh.gov.om/stat/HTML_FILE/Health%20Indicators.htm). Accessed on May 10, 2008.