

# We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

6,900

Open access books available

185,000

International authors and editors

200M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index  
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?  
Contact [book.department@intechopen.com](mailto:book.department@intechopen.com)

Numbers displayed above are based on latest data collected.  
For more information visit [www.intechopen.com](http://www.intechopen.com)



## Re-Engineering in OPCAB Surgery

Murali P. Vettath, Et Ismail, Av Kannan and Athmaja Murali  
Kozhikode Kerala  
India

### 1. Introduction

Coronary artery bypass surgery is a procedure that started off with the first implantation of the internal mammary artery to the cardiac muscle in 1946 by Vineberg [Vineberg AM, 1954]. Later, the coronary anastomosis distal to the occlusion using the saphenous vein graft (SVG) or the internal mammary artery (IMA) was experimentally conceived by Murray [Murray et al, 1954]. Bailey et al [Bailey et al, 1957] were the first group to approach the problem of coronary occlusion in 1957. Though the pioneers of OPCAB were Goetz and colleagues [Goetz et al, 1961] and Kolessov [Kolessov VL, 1967] who performed the procedure in isolated cases. The first clinical series of consecutive patients was by Trapp and Bisarya [Trapp WG, Bisarya R, 1975] and Ankeney [Ankeney JL, 1975].

Then, with the development of direct coronary surgery, under the leadership of Favaloro [Favaloro RG, 1968] and Green and coworkers [Green GE, Stertz SH 1968], with procedures being performed in an arrested heart with the use of extracorporeal circulation, off-pump coronary surgery was abandoned. Thus the surgeons all over the world started performing CABG on the heart lung machine, and that became the standard of care for patients with coronary artery disease.

In 1981 Enio Buffolo [Buffolo E, et al, 1985] from Brazil and Benneti [Benetti FJ, 1985] from Argentina had started experimenting on this technique of Direct Myocardial revascularization. Both of them published their series around 1985 which rekindled the idea of OPCAB in the western world. It was probably the idea of minimally invasive direct coronary artery bypass graft (MIDCABG), introduced in the mid-1990s by Benneti [Benetti FJ, 1985, 1995], that called attention to the possibility and advantages of not using CPB. Calafiore's [Calafiore AM, et al, 1996, 1998] publications re-enforced the advantages of the LAST (left anterior small thoracotomy) operation. The LIMA stitch was acclaimed as an extraordinary step in the development of off-pump coronary surgery, which allowed grafting of posterior branches of the coronary arteries. The introduction of stabilizers in the mid 1990s further facilitated the procedure [Borst C, 1996]. Eric Jansen, was one of those surgeon in the mid nineties who was probably the man who had made the word -Octopus- so very popular in the rest of the world. The article published in 1991 by Benetti [Benetti FJ et al, 1991] in Chest, gave confidence to the Cardiac surgeons around the world to perform OPCAB in all anterior vessels. But even then the circumflex territory became a danger zone for most surgeons to perform a safe coronary anastomoses. Though LIMA stitch was used quite often, it was the availability of the Positioners that made the process of Verticalisation of the heart more comfortable.

By the end of the 90's, most of the surgeons in India and in the far east had been performing OPCAB in 90% of their Coronary artery patients, but by early 2000, there was a sharp decline in the numbers, as most of the surgeons did not find the comfort zone in OPCAB surgery, and that their patency rates were being questioned. In the 1990s the visibility of coronary anastomosis was again a doubtful proposition, and also converting, and going on to the pump became a recipe for disaster. Then came the comparative trials of OPCAB and ONCAB, which obviously brought in results which showed that both the techniques produce nearly the same results, and that the patency was a question of concern [Kim KB, et al, 2001 & Puskas JD, et al, 2001]. The Rooby trial showed that, at 1 year of follow-up, patients in the off-pump group had worse composite outcomes and poorer graft patency than did patients in the on-pump group [A. Laurie Shroyer, et al, NEJM, 2009]. The surgeons had then come to a conclusion that OPCAB is good in experienced hands and the results in that group of people have been outstanding.

The appeal of avoiding cardiopulmonary bypass with its direct and indirect physiological insult, the prospect of improved clinical outcomes, and the favorable economic impact gives OPCAB the potential of preference that may mark the dawn of a new era in our search for the optimal surgical strategy for the treatment of coronary artery disease.

OPCAB has been performed in many different ways. It's like different ways of skinning a cat. Ultimately, the gold standard of a perfect patent coronary anastomosis remains the corner stone of a good surgeon and a good operation. It is to be emphasized here that Coronary artery bypass surgery has come a long way from performing them off pump, then on pump and now going back to off pump. But the most important point, one has to bear in mind is that, the surgeon has to do what he is most comfortable with and by which he would be able to give the best result.

The topic of Re-engineering in OPCAB came up, because, there was an engineering that was done during the early phase of OPCAB by the great pioneers of this procedure. But what happened along the way was that these procedures were not reproducible by lesser mortals like us and hence we had to re-engineer this procedure to suit us.

## 2. Theoretical reason of avoiding the pump

It is logical to suppose that avoiding CPB would abolish the SIRS (systemic inflammatory response syndrome) and its untoward physiological impact. [Gu Y.J, 1999]. Gu Y.J, investigated the inflammatory response with OPCAB, and found that complement activation and consequently systemic inflammatory response occurred (due to surgical trauma) but the extent and severity were curtailed.

Comparison with on-pump CABG confirms a limited and less severe form of inflammatory response. Strüber [Strüber M., et al, 1999 & Matata B.M. et al, 2000] and Matata and their coworkers reported significant increases in the levels of specific biological markers of inflammation following on-pump CABG compared to OPCAB. The inflammatory indicators that were evaluated in both studies and their results are summarized:

- Activated complement factor 3a (C3a) demonstrated between 5- and 12-fold rise over the preoperative level after commencement of CPB, and minimal rise in the OPCAB patients.
- Proinflammatory interleukin 8 (IL-8) increased 5-folds with CPB whilst the level was only slightly altered with OPCAB.

- Tumor necrosis factor (TNF-) peaked 24–48 h after CPB at a significantly higher value compared to OPCAB patients who had no increase. Tumor necrosis factor receptors 1 and 2 were elevated to three times their preoperative level only with CPB.
- Different markers tested in each study (interleukin 6 and plasma elastase) were significantly elevated with CPB. OPCAB patients showed a blunted response.

The other variables of CPB such as haemodilution, non-pulsatile flow, and aortic cross-clamping, which may act in concert with SIRS to increase postoperative morbidity, are eliminated by the avoidance of CPB.

Thus avoiding the heart lung machine would be a logical solution in performing coronary artery bypass surgery

### 3. Myocardial preservation

Adequate myocardial preservation is crucial in CABG operations. Preoperative resuscitation of ischemic myocardium enables recruitment of hibernating myocardium and forms an important component of any myocardial protection strategy. The intraoperative strategy varies (within physiological boundaries) as much from patient to patient as it is from surgeon to surgeon, to the extent that a good clinical outcome becomes the ultimate determinant of the optimal strategy. Even with the same surgeon, the strategy is adapted to the patient and clinical scenario that a prescriptive regimen is not standard. The objective of intraoperative myocardial preservation is to enable efficient myocardial energy management by reducing cardiac metabolic demands on the one hand, while improving myocardial oxygen supply and utilization on the other [Buckberg G.D et al,1996].

In on-pump CABG, cardioplegia or cross-clamp fibrillation are conventional methods of intraoperative myocardial protection. Cardioplegia favorably affects myocardial energy metabolism but results in the alteration of both the intra- and extracellular milieu and, together with CPB can precipitate changes in cardiac performance postoperatively [Mehlhorn U.,1995]. Cross-clamp fibrillation can increase the endocardial viability ratio and lead to similar changes in cardiac function. In both strategies of myocardial protection, a period of global myocardial ischemia is followed by reperfusion with oxygen-rich blood predisposing to reperfusion injury which manifests as myocardial stunning and arrhythmias in the early postoperative period.

Since deliberate induction of global ischemia is unnecessary in OPCAB, it is logical to suppose that iatrogenic biochemical injury to the myocardium would not occur. More so, the blunted inflammatory response with avoidance of CPB is characterised by low production of IL-8 which is involved in myocardial injury. In fact, Atkins et al. first suggested that OPCAB preserved cardiac function in 1984 [Atkins C.W. et al,1984]. In different prospective randomized studies, Ascione [Ascione R.et al,1999], Penttilä [Penttilä H.J.,et al,2001], Van Dijk [Van Dijk D.et al,2001], Czerny [Czerny M.,et al 2001], Bennetts [Bennetts J.S.et al,2002], and Masuda [Masuda M.et al,2002], and their collaborators reported minimal change in the biochemical markers of myocardial injury (troponin T and/or creatinine kinase-MB isoenzyme), and in some cases, better myocardial function after OPCAB compared to on-pump CABG. Changes in myocardial metabolism indicative of oxidative stress due to local ischemia when the target coronary artery is occluded to enable visualization for distal anastomoses have been reported in OPCAB [Matata B.M. et al 2002]. Compared to on-pump CABG, OPCAB is associated with better myocardial energy preservation, less oxidative stress and minimal myocardial damage [Penttilä H.J et al.2001].

However, emerging evidence suggests that intraoperative myocardial protection in OPCAB can provide an added advantage [Guyton R.A. Et al,200 & Muraki S.et al.2001]. In their pioneering report, Trapp and Bisarya gave an exquisite description of coronary perfusion and the instantaneous improvement in the ECG and blood pressure during OPCAB. Vassiliades et al. [Vassiliades T.A .et al,2002] compared active coronary perfusion using a perfusion pump, with passive perfusion by a cannula connected from the aorta to the graft, and no coronary perfusion, after the distal anastomosis in a randomized clinical trial. They found lower troponin I levels with active and passive coronary perfusion, but cardiac performance was better with active coronary perfusion. The use of intracoronary shunt during OPCAB has also been shown to preclude left ventricular dysfunction [Yeatman M.et al 2002].

Reperfusion injury can occur from regional ischemia due to a combination of underlying coronary obstructive pathology, stabilization and anastomotic techniques, compounded by episodes of hypotension which precede revascularisation. The precarious normoxic and normothermic passive coronary perfusion may be insufficient to protect against myocardial damage in such clinical scenarios.

The concept of myocardial protection in OPCAB is less tedious. In most cases passive coronary perfusion with intracoronary shunts will suffice, but in the presence of heightened cardiac risk such as recent acute myocardial ischemia or infarction, and severely impaired left ventricular function active coronary perfusion is advantageous especially in multi-vessel revascularization.

The role of Intra-aortic balloon pump (IABP) in patients with Ischemic myocardium and in low ejection fraction would be discussed later in the chapter. As of today, apart from using intra coronary shunt, the use of aorto-coronary shunts in some instances have been a disposable worth remembering.

**Hemodynamic instability** has been the major concern in performing OPCAB even today. Though we have been able to master the technique of positioning the heart by the use of various technique and devices, this still remains a major concern. Exposure of the coronary artery target sites requires the heart to be lifted, rotated, dislocated and displaced producing a distortion of cardiac geometry and consequently hemodynamic fluctuations frequently occur. As a result, the early reports of OPCAB described single or double grafts limited to anterior target sites. The corrective measures for these hemodynamic changes include volume loading, trendelenberg positioning, and displacement of the heart into the opened right pleura, use of inotropes, vasopressors, vasodilators, intra-aortic balloon pump, and right heart circulatory support [Mathison M.et al, 2000 & Kim K.B. et al, 2001].

What we had **re-engineered** over the last five years is to avoid the Trendelenberg position. And we practice an **anti-Trendelenberg position** of the patient, where the patient lies on the table with the head end up. This is very useful in patients with ischemia, where the pulmonary artery (PA) pressure is high. This maneuver reduces the PA pressure, and thereby reduces the left ventricular end diastolic pressure (LVEDP). This is exactly what the patient would do when he develops chest pain in his room. He sits up and tries to catch his breath. That is what we help him do in the operation theater as he is anaesthetised.

If the CVP is low and the right ventricle looks empty, then we give a fluid challenge to improve his preload. But we always try to avoid the Trendelenberg position.

In late nineties, the principle of OPCAB was to perform the coronary anastomosis at a heart rate of less than 60 per minute. Hence, the patients coming for surgery used to be well beta blocked, so that it would be easy to perform the anastomosis. But, most of these patients





Fig. 1. Photo showing the operation table with the head end elevated and tilted to the side of the surgeon.

ended up having inotropes and vasoconstrictors to maintain hemodynamics. Ischemic patients when given either of them, they develop further ischemia and become bad.

What we had re-engineered here, was to increase the heart rate .To attain that, we use intermittent boluses of Injection Atropine (0.6mgs per milliliter), which is only a Chronotropic agent and not an Inotrope. Thus, avoiding unnecessary strain on the myocardium. We aim at a rate above 100 per minute and this keeps the heart briskly contracting and avoiding the usual hemodynamic collapse seen in the early days.

We do not use vasopressors or vasodilators in any of our patients undergoing OPCAB.The only drug the patient would be given intermittently is the Atropine injection. We use Glycerol trinitrate(GTN) in our patients after the distal anastomosis, and that too as an antihypertensive only.

Mueller et al. found no change in the hemodynamics during exposure of the posterior and anterior wall arteries, and only marginal change for the lateral wall artery with a 'no compression' technique [Mueller X.M et al,2002]. It has been suggested that the use of left ventricular apical suction device for cardiac positioning provokes less hemodynamic instability compared with pericardial retraction sutures [Sepic J.et al,2002].

The technique which we have developed is to cut down the pericardium on the right side, down to the inferior vena cava, and to leave the right pleura opened. We routinely open the left pleura to help in the mammary dissection. Hence, in all our patients we have all the three chambers- the mediastinum and both the pleural cavity, remaining in continuity with each other.

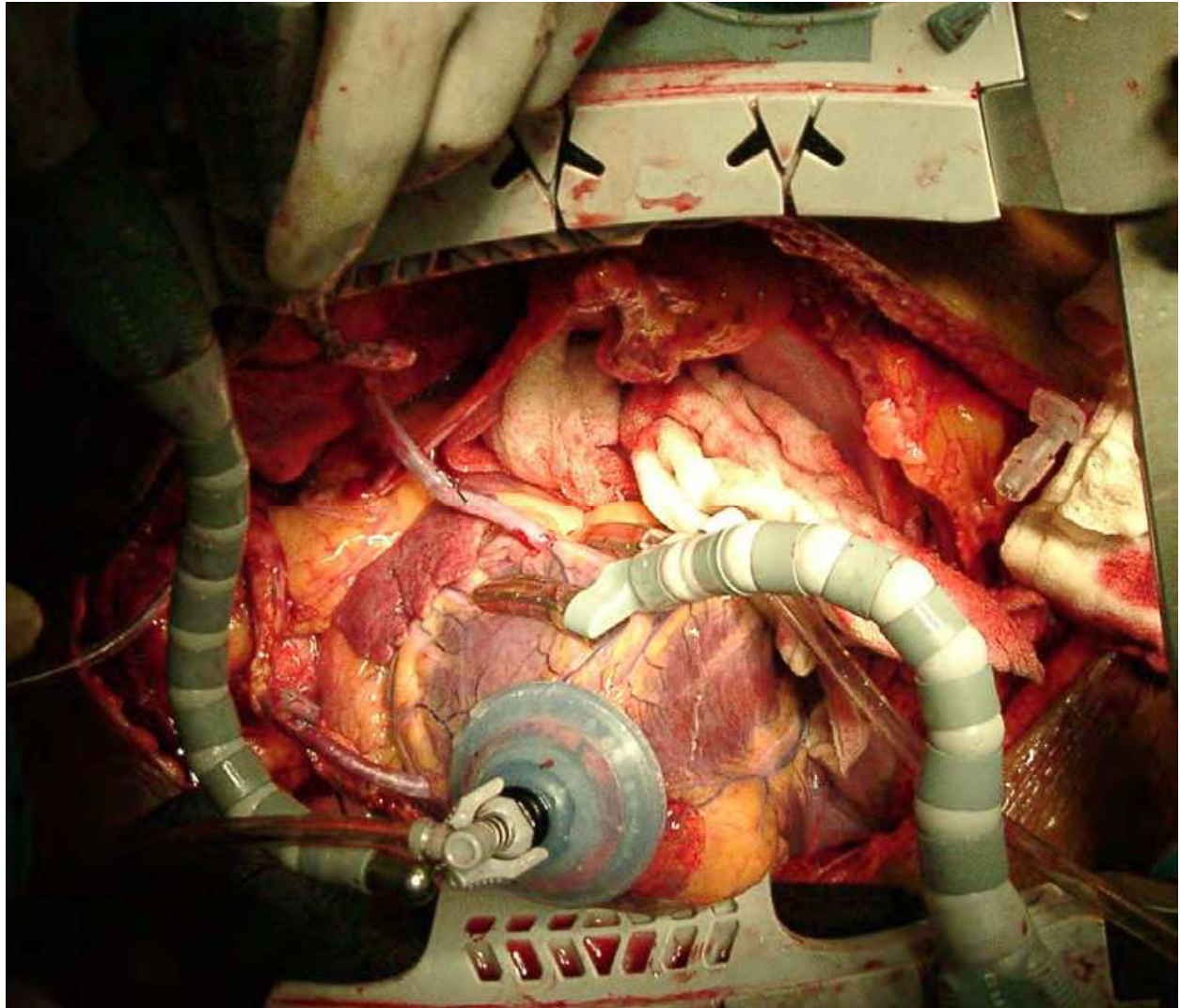


Fig. 2. Showing the Positioner verticalising the heart and the stabilizer used on the marginal circumflex.

We too routinely use the Positioner for lifting the apex of the heart. The suction pressure used is not more than 150-200 mm of Hg. The positioner is always used in an off apex position, so as to avoid sucking the Left anterior descending (LAD) coronary artery. We use this pressure to avoid excessive damage to the apex. We also watch the suction tube, to see if any blood is being sucked. In such cases, the positioner is removed and repositioned in a different place. In case of grafting of the circumflex and the Posterior descending artery (PDA) this heart is only Verticalized and not tilted to the right side. This lifting of the apex, increases the left and the right ventricular volume. And in case the PDA, is being grafted, then we tilt the head end down, so as to increase the visibility of the PDA. This probably would be the only time when the Trendelenberg position is used. By this time the LAD is already perfused, and this has relieved the ischemia. If the visibility of the circumflex is bad, then the table is dropped down to its maximum and the positioner moved to right a bit. With this maneuver, even the Atrioventricular groove could be visualized.



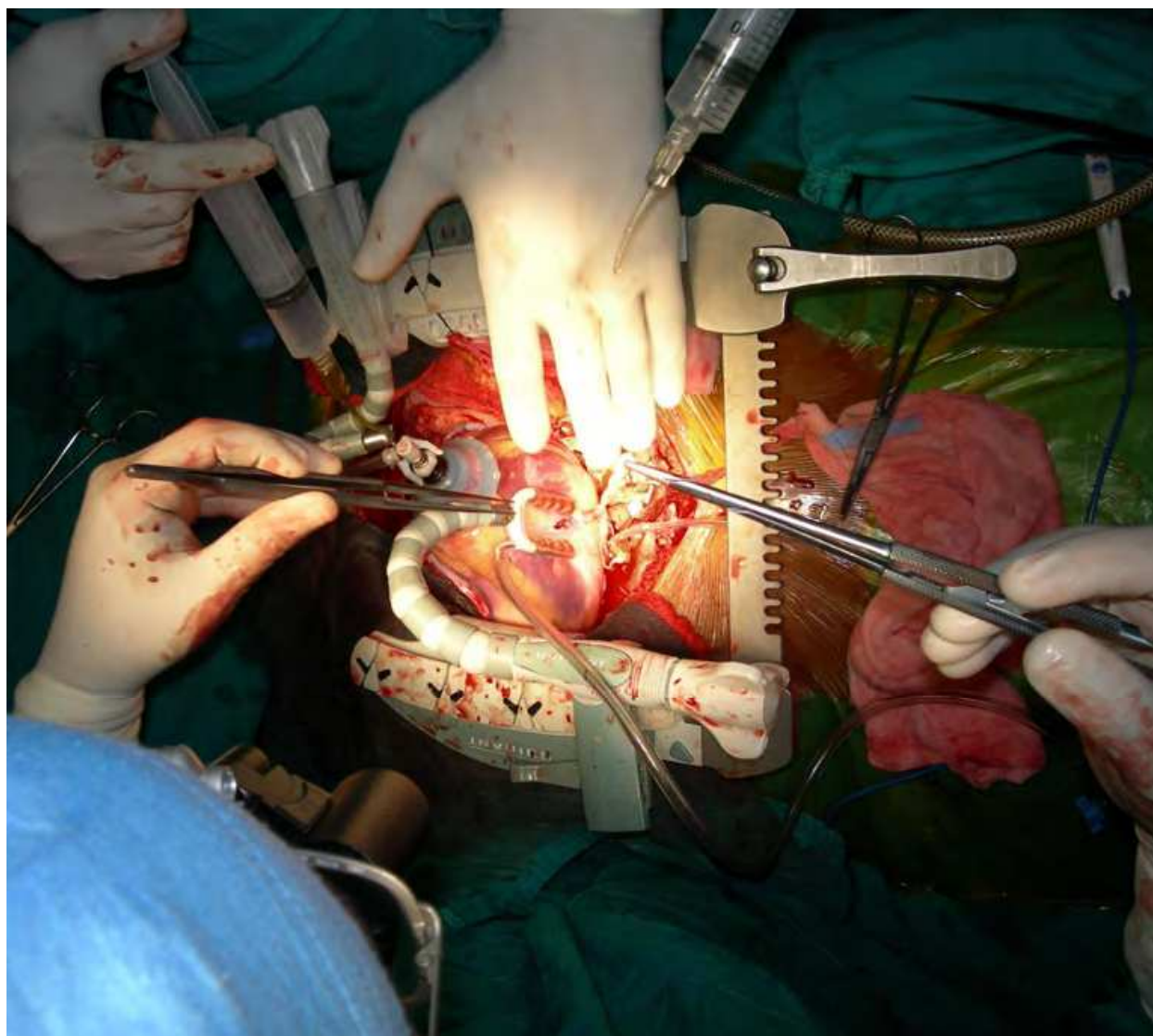


Fig. 3. Showing the heart totally verticalized by the use of the positioner, and the stabilizer in position around the PDA.

#### 4. Quality of distal anastomosis

Performing vascular anastomoses on small arteries on a beating heart can be a daunting and frustrating adventure, and so far, no available method of target vessel stabilization can achieve a steady bloodless field comparable to an arrested heart. This was a major concern with OPCAB. The beating heart with a bloody operating field poses a major challenge to delicate tissue handling, and casts a shadow of uncertainty about the quality of the distal anastomosis. However, with the application of effective target vessel stabilization, and efficient visualization systems the early and mid-term patency of OPCAB has been encouraging

The stabilizers we use are the suction stabilizers. The position of the stabilizer is very important to achieve a very stable anastomotic site to perform a good coronary anastomosis. We have tried all types of suction stabilizers, from the Medtronic -Octopus II, III and the Octopus IV. We are now using the Maquet, which was the previous Guidant - Acrobat



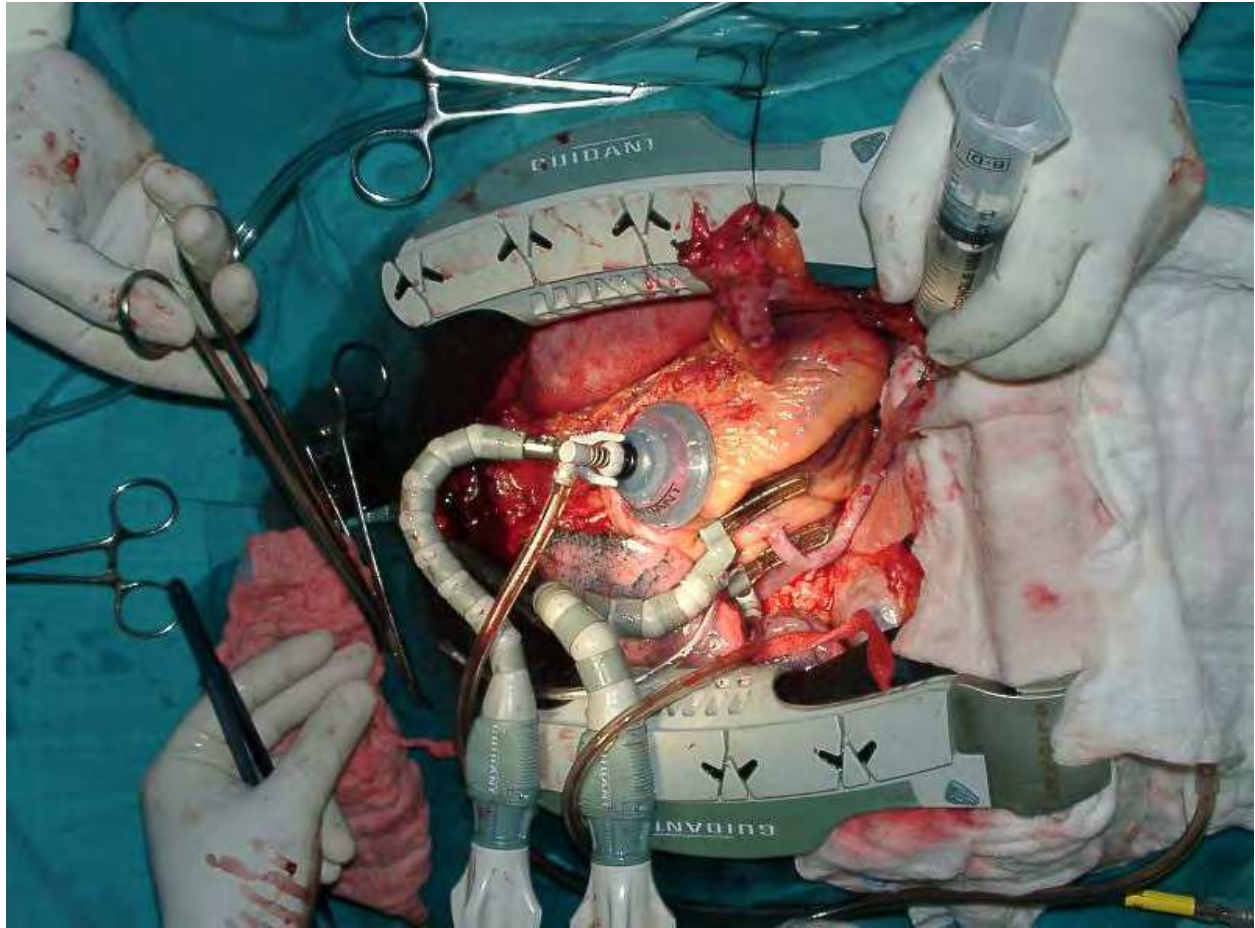


Fig. 4. Photograph showing the positioner on the RV free wall to graft the distal RCA or the acute marginal.

stabilizer. The Re-engineering in this is the pressure used for suction of these stabilizers. We use 100-150 mm of Hg on these stabilizers. The stabilizer is positioned according to the convenience of the surgeon. The position of our stabilizer is shown in the photographs. We do not use any suction while stabilizing the lateral wall, as the heart is allowed to fall on the stabilizer pods.

In order to achieve a stable bloodless field while accessing the coronary artery, we use the following technique. After stabilizing the coronary artery by using the acrobat stabilizer, we use a 5.0 polypropylene suture to run around the proximal part of the coronary artery, proximal to where the arteriotomy is planned to be made. The two ends of the 5.0 polypropylene are suspended using rubber shod. They are tightened just before the coronary arteriotomy is made. This is made using the bevel of a 18 gauge needle on a 2 ml syringe. After the nick is made on the coronary artery, the forward or the backward cutting scissors is used to open the coronary artery. A Castroviejo scissors is used to open the arteriotomy. The arteriotomy is usually one centimeter long. Then the intra-coronary shunt is inserted according to the size of the coronary artery. The shunt is to be deaired after inserting the proximal end first, then the snare is released and the then the distal end is inserted. Then the anastomosis of the coronary is performed using the conduits as preferred. We use shunts in nearly all the distal anastomosis.

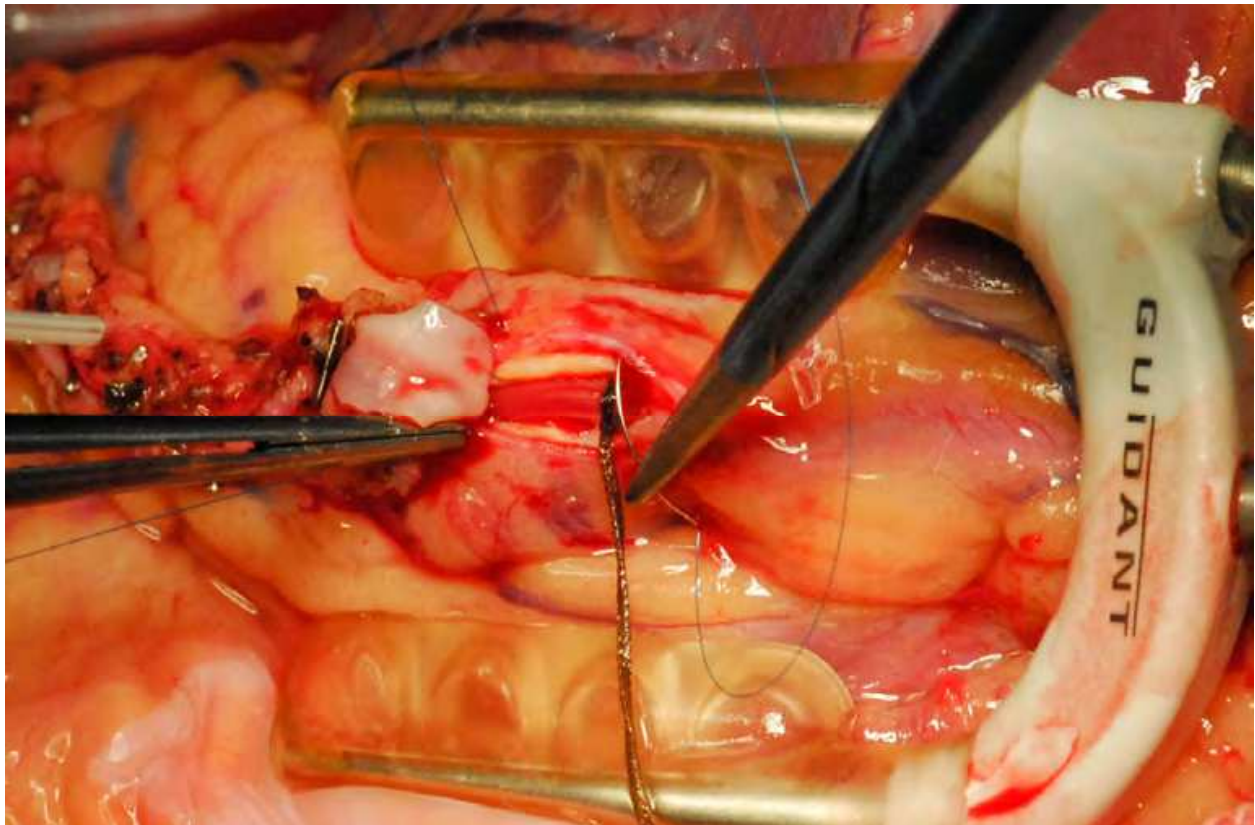


Fig. 5. Showing the clarity of the coronary anastomosis, while performing LIMA to LAD anastomosis.

## 5. Incomplete myocardial revascularisation

Early reports of OPCAB in the literature were uniformly consistent in the low number of grafts per patient [6,10]. The selection of patients with mainly single-vessel disease may, in part, explain this finding. But the persistence of lower average number of grafts in later comparative studies [Gundry S.R et al,1998 & Arom K.V. et al,2000] places OPCAB in a contentious position which detracts from its potential benefits. In their retrospective study, Gundry and colleagues reported a significantly lower mean number of grafts, and a two-fold increase in cardiac re-intervention rate during a 7-year period with off-pump performed without cardiac stabilization, compared to on-pump CABG. This finding has been corroborated by other reports, and exemplifies incomplete revascularization with OPCAB. Effective cardiac retraction, stabilization and visualization systems with patient positioning enables grafting of all graftable targets, making complete myocardial revascularization (CMR) attainable in OPCAB [Calafiore A.M et al 1995 & Cartier R et al, 2000], and this has been demonstrated in a recent prospective randomized study [Puskas J.D et al,2003]. However, incomplete myocardial revascularization with OPCAB is still reported in retrospective studies. Technical difficulties due to small caliber of target vessels or their intramyocardial course, poor exposure of target sites, precarious intraoperative hemodynamic state, electrophysiological instability and inexperience of the surgeon are some of the reasons for incomplete myocardial revascularization.

Today we have no contraindications for OPCAB, the intramyocardial coronary arteries, small coronary arteries and diffuse coronary arteries [Anil D Prabhu et al, 2007&2008], have



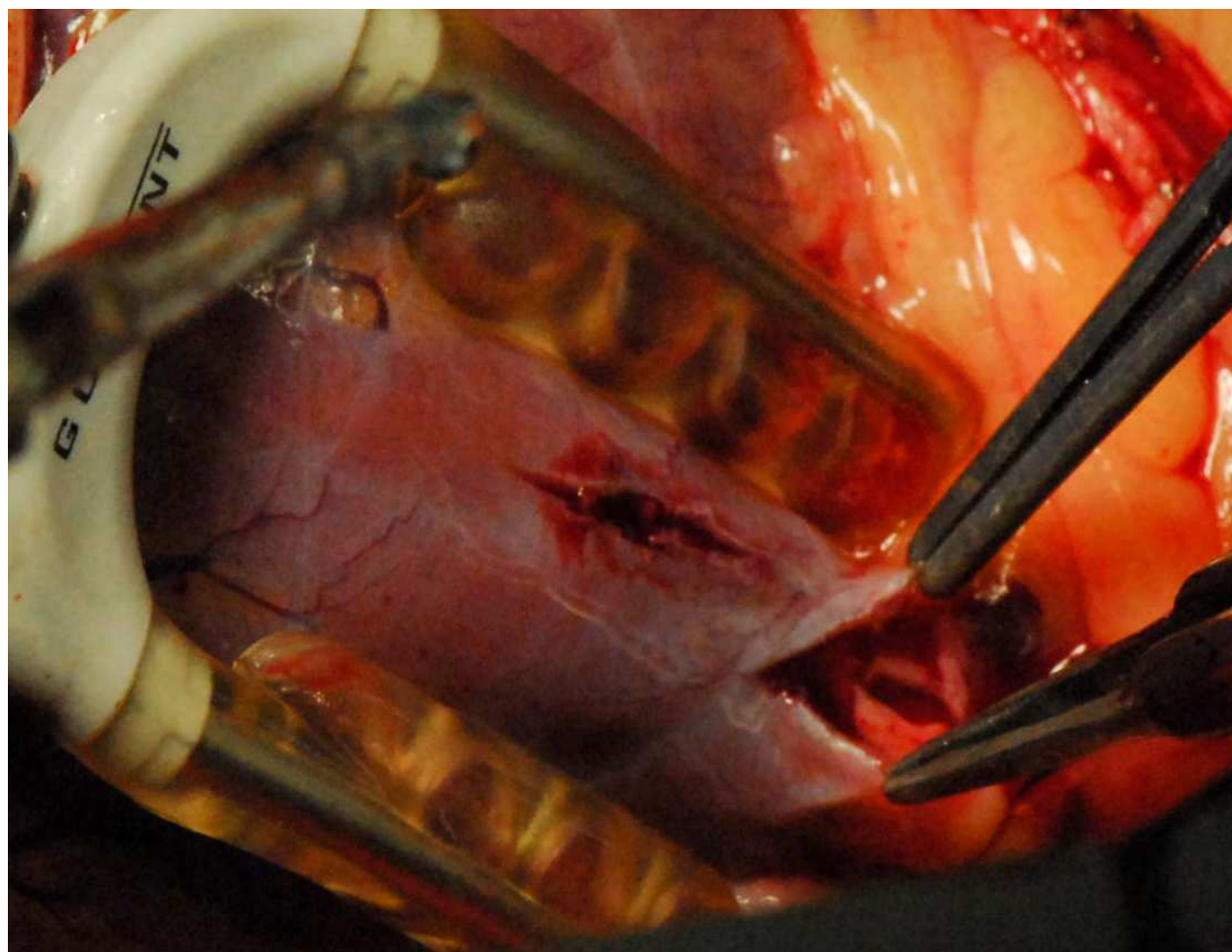


Fig. 6. Showing the dissection on the buried intramuscular coronary artery on the lateral wall of the heart.

been a thing of the past. Any patient who needs to undergo CABG would be able to have his coronary artery bypass surgery using the OPCAB technique.

## 6. High risk surgical patients

OPCAB has been demonstrated to offer prognostic advantage over on-pump CABG in patients with exaggerated surgical risk from complicated coronary artery disease and/or debilitating co-morbidities [Tashiro T et al,1996,Akiyama K.et al,1999,Yokoyama T. et al,2000 & Prifti E et al,2000]. More importantly, the preoperative optimization of high risk patients plays a crucial role in determining the clinical outcome for both methods of myocardial revascularization.

Acute myocardial infarction and depressed left ventricular function constitute a high surgical risk with on-pump CABG, because the myocardial damaging effects of CPB and the often cumbersome and, inefficient intraoperative myocardial protection do not prevent immediate postoperative cardiac dysfunction [Buckberg Get al,1996,Christenson J.T..et al,1997 & D'Ancona G,2001]. OPCAB achieves comparatively better outcomes in patients who have myocardial revascularization soon after recent AMI [Locker C,2001]. Mohr et al. [Mohr R et al 1999] reported a mortality of 1.7% with 1- and 5-year actuarial survival rates of 94.7 and 82.3%, respectively, in a series of 57 patients in which 56% had emergency surgery



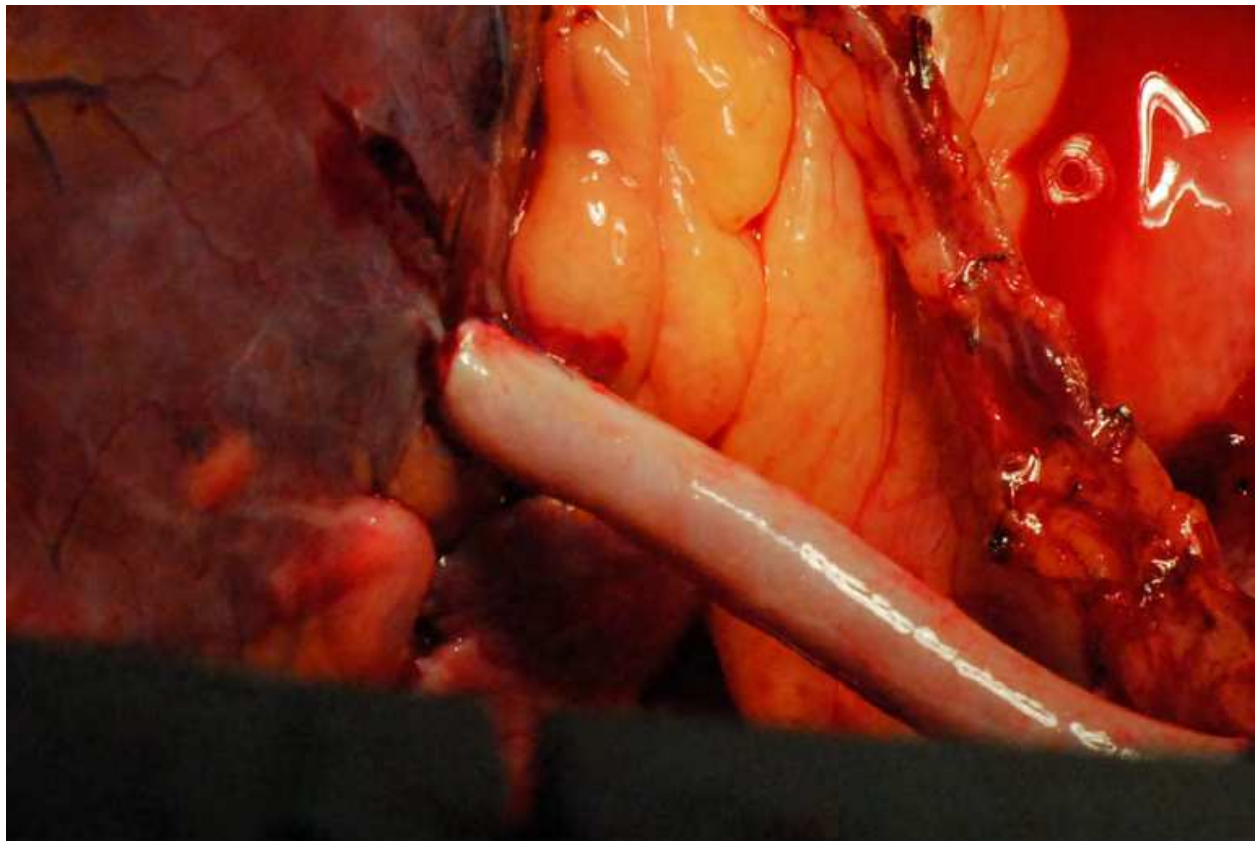


Fig. 7. Showing the vein graft after anastomosis on the coronary artery.

within 48 hr of acute myocardial infarction and some were in cardiogenic shock. OPCAB decreases the operative risk in the presence of impaired left ventricular function [Nakayama Y. et al, 2003]

Preoperative renal impairment is an independent predictor of poor prognosis after on-pump CABG [Ascione R et al 1999]. OPCAB preserves renal function better than on-pump CABG [Ascione R. et al, 2001], and available evidence favors the preferential use of OPCAB for patients with chronic renal for a better early clinical outcome.

Patients with coexisting chronic obstructive airway disease derive better early clinical benefit from CABG performed without CPB compared with on-pump surgery [Güler M et al, 2001], although in low-risk patients, OPCAB induces impairment of the mechanics of the respiratory system, lung and chest wall similar to on-pump CABG [Roosens C et al, 2002].

Elderly patients are considered high risk surgical patients because of their reduced functional capacity and the presence of co-morbidities. Correspondingly, the outcome of on-pump CABG in this group is characterized by increased morbidity and mortality [Montague N.T et al, 1985, Mullany C.J et al, 1980 & Hirose H, 2000]. Interestingly, OPCAB has been shown to improve the clinical outcome in this growing population of surgical patients [Boyd W.D et al, 1999, Stamou S.C et al, 2000, Al-Ruzzeh S et al, 2001 & Hoff S.J. et al, 2002]. Specifically, the incidence of stroke, perioperative myocardial infarction, duration of mechanical ventilation, blood transfusion, length of intensive care and hospital stay, and mortality are decreased.

## 7. Vettath's anastamotic obturator

In patients with diffusely diseased coronary arteries and in patients with diseased aortas, OPCAB has remained a life saver. We had developed the Vettaths anastomotic obturator (VAO) (Murali.P.Vettath,2003,2004) – which , is is an aortic anastomosis enabling device. This allows the surgeon to avoid the side clamp on the aorta, when a no touch technique is required in cases of diseased aorta. In patients with plaquey aortas, where a saphenous vein top end is to be connected, this could be used to make an anastomosis on a no plaquey zone in the aorta. The technique is to identify a soft spot and make two purse string sutures with 3.0 polypropylene around the intended zone of anastomosis. The purse strings are about a centimeter in diameter. A stab wound is made using a no.11 blade and an aortic punch is used to make a punch hole on the aorta. The VAO is then inserted into the hole and one of the 3.0 purse strings are used to snare the bleeding around the VAO if it persists. The aortic systolic pressure may be maintained at around 100 mm of Hg. The advantage is that this allows the surgeon to perform a hand sewn anastomosis on the vein graft. This is like the devices that are available in the market, like the Heartstring and the Enclose device. This is like an instrument and is made of steel and can be reused and could help in avoiding a stroke in elderly patients. We have performed more than 500 top ends using this device and is a good one to have in the armamentarium of a cardiac surgeon. This is also a good tool to use in redo CABG, when a proximal anastomosis could be made on the hood of the old vein graft.

The VAO is also a useful tool in cases where a combined aortic valve replacement is done with a CABG. Here it is useful when the side clamp needs to be avoided.

## 8. Diffusely diseased coronary arteries

The diffusely diseased coronary arteries have been a curse in the south East-Asian population, and more so in patients with Indian origin. This is seen in these patients in the younger age group and they are usually termed inoperable. The disease is so diffuse that grafting area in the coronary arteries are studded with plaques. We had developed our own technique of Vettath's technique of long mammary patch on LAD without endarterectomy on beating heart. We had performed this on more than 200 patients since the last 9 years. We have also published the same (Murali Vettath,2008 ) in couple of journals. In fact we have been reviewing these patients with coronary angiograms and the results have been quite gratifying.

## 9. Vettath's technique of long mammary patch

A single stabilizer is used if the arteriotomy is <4 cm. If it exceeds >4 cm, two stabilizers (one facing each other) are used for coronary stabilization. The arteriotomy extends distally to reach the normal lumen of LAD. Proximal extent of arteriotomy is kept just short of the most severe proximal lesion to avoid competitive flow from native LAD.

Distal coronary perfusion during anastomosis is maintained using conventional intracoronary shunts (Clearview, Medtronic Inc, Minneapolis, MN, USA). If the arteriotomy exceeds 3-4 cm, cut ends of aorto- coronary shunts (Quickflow, Medtronic Inc, Minneapolis, MN, USA) are used. These may be tailored to use in arteriotomies upto 6-7 cms. In this technique, hither to undescribed (Vettath's modification of aorto-coronary shunts), the distal perfusion tips of aorto- coronary shunts are cut and inserted into the coronary artery. The

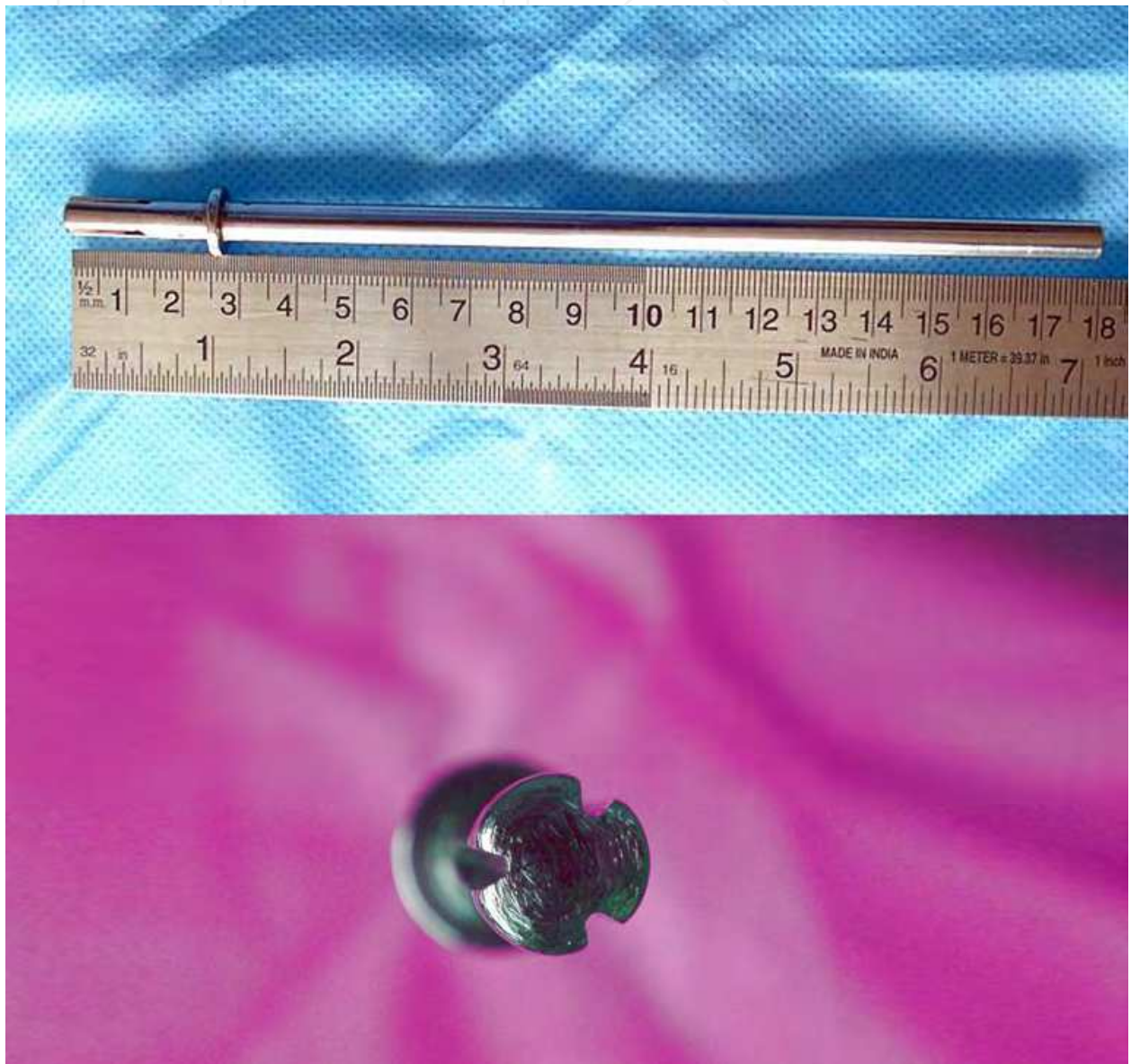


Fig. 8. Shows the Vettath's anastomotic obturator , the whole length of the device and the working end of the piece that goes into the aorta.



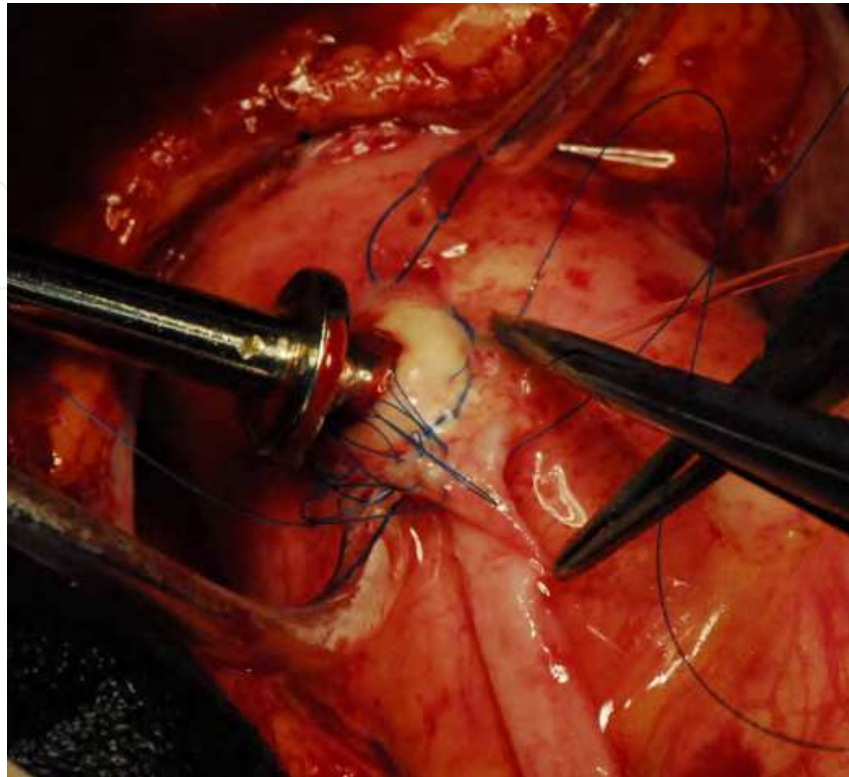


Fig. 9. Shows the close up of the top end anastomosis in progress using the VAO

bulb is inserted into the end from where the blood flows (i.e., into distal coronary lumen if the flow is retrograde and vice-verse). If the shunt does not sit inside the coronary (or it bowstrings), it is tacked down with a tacking suture taken in the midpoint of arteriotomy. This tacking suture is taken out at the end of anastomosis, along with the shunt. We use 7-0 polypropylene for this tacking suture. Occasionally, when native coronary flow is negligible and/or coronary lumen is  $<1$  mm, the LAD is snared proximally with circumferential suture and LIMA to LAD anastomose was done. LIMA is slit to match the coronary arteriotomy and LIMA to LAD anastomosis is performed using 7-0 polypropylene. The plaques are excluded from the lumen of the reconstructed LAD. Diagonals and perforators are included in the new lumen. Posterior 25% of reconstructed coronary artery is formed by native coronary artery and anterior 75% by LIMA. Approximately 10 minutes were taken to construct a 2cm patch and an additional 5 minute per each added centimeter of patch was taken for anastomosis.

The advantage of this technique is that the intima is left intact and no injury is made on it. The avoidance of endarterectomy is a definite reason for the patency in our study. We also do not add any anticoagulants or anything other medications, than those used for the normal CABG patients. Also that in spite of our long anastomosis, patients remain quite stable all along the anastomotic time. This technique of long patch has also been described by Takanashi [S.Takanashi,2003.]

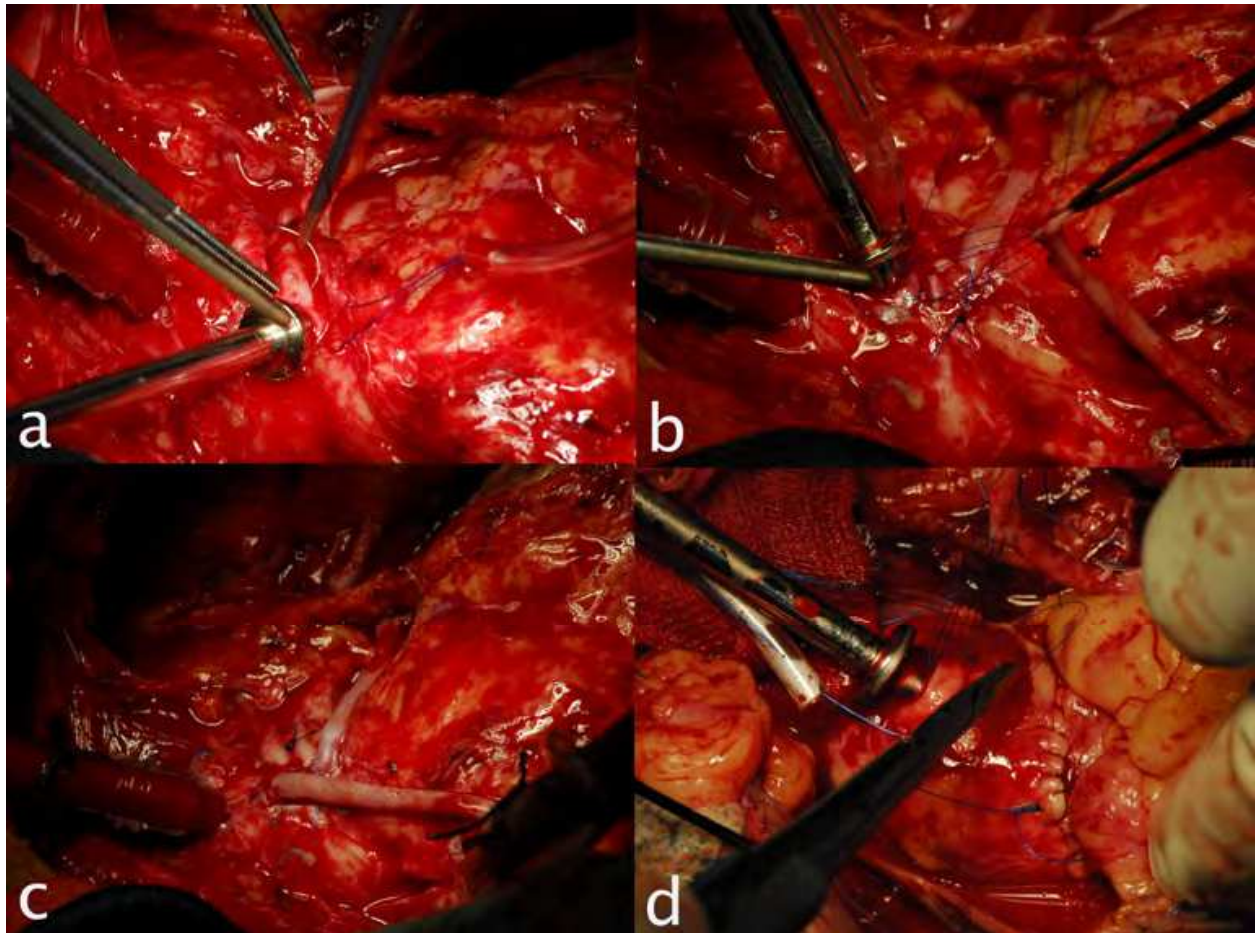


Fig. 10. Shows:

- (a) The VAO is inserted into the vein hood of the blocked vein graft. In a re do CABG- On pump.
- (b) The suturing being done on the top end of the vein graft.
- (c) The anastomosed vein graft s in position.
- (d) The top end of the vein graft in a CABG plus AVR done without using side clamp

## 10. Role of IABP in OPCAB

The use of intra-aortic balloon pump (IABP) either preoperatively or intraoperatively, to reduce operative risk and to facilitate posterior vessel OPCAB has been well documented. IABP has been useful in high-risk patients with left main coronary artery disease (> 75% stenosis), intractable resting angina, post infarction angina, left ventricular dysfunction (ejection fraction < 35%), or unstable angina.

Preoperative IABP counterpulsation has been shown to have better outcomes compared with perioperative or postoperative insertion in critical patients, and off-pump surgical procedures have been advocated to reduce mortality in high-risk patients.

In patients with high risk factors, higher mortality and morbidity rates have been demonstrated in spite of massive pharmacologic support combined with postoperative IABP support. IABP therapy results in a more favorable myocardial blood supply, increased stroke volume and cardiac output through augmentation of the diastolic pressure, and afterload reduction (Christenson, 1997, 1999). Intraoperative or postoperative IABP insertion has been reported to be associated with higher operative mortality rate and device-related complication rate, as compared with preoperative use of IABP.

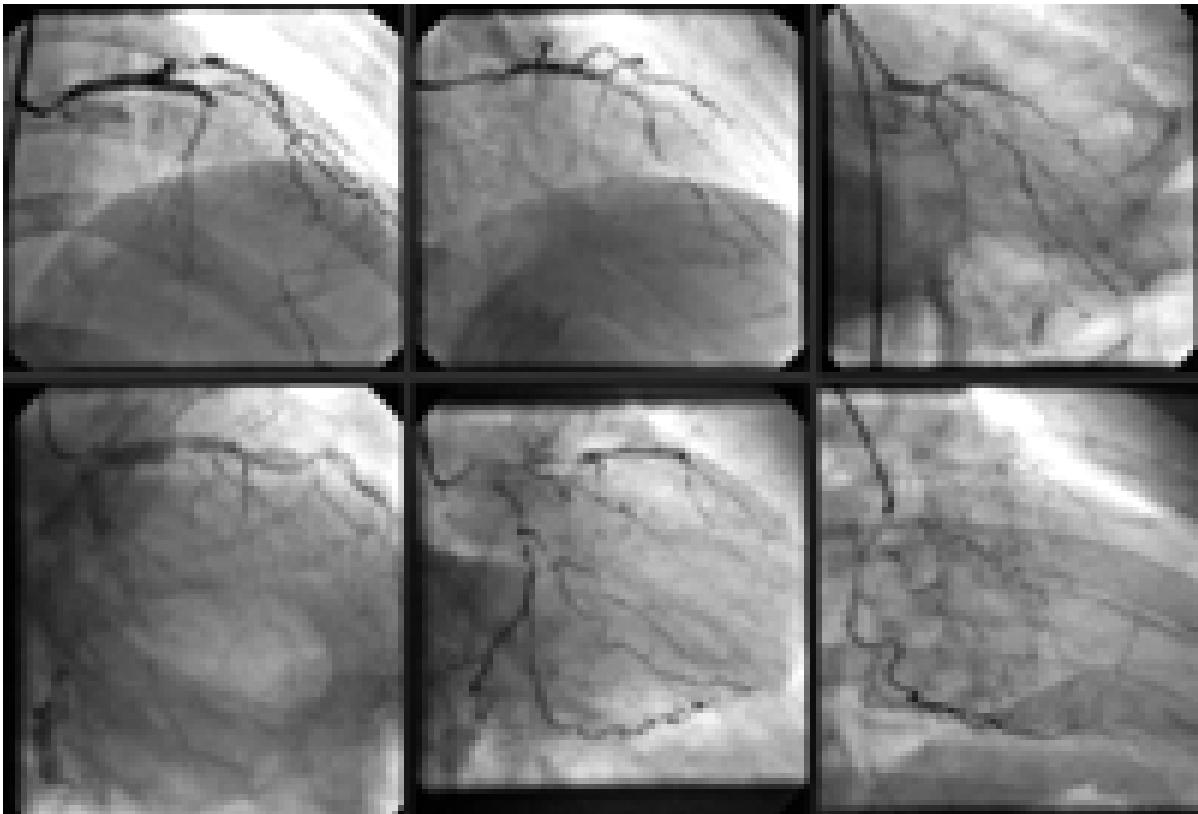


Fig. 11. Shows the Coronary angiograms of patients, showing diffusely diseased coronary arteries.

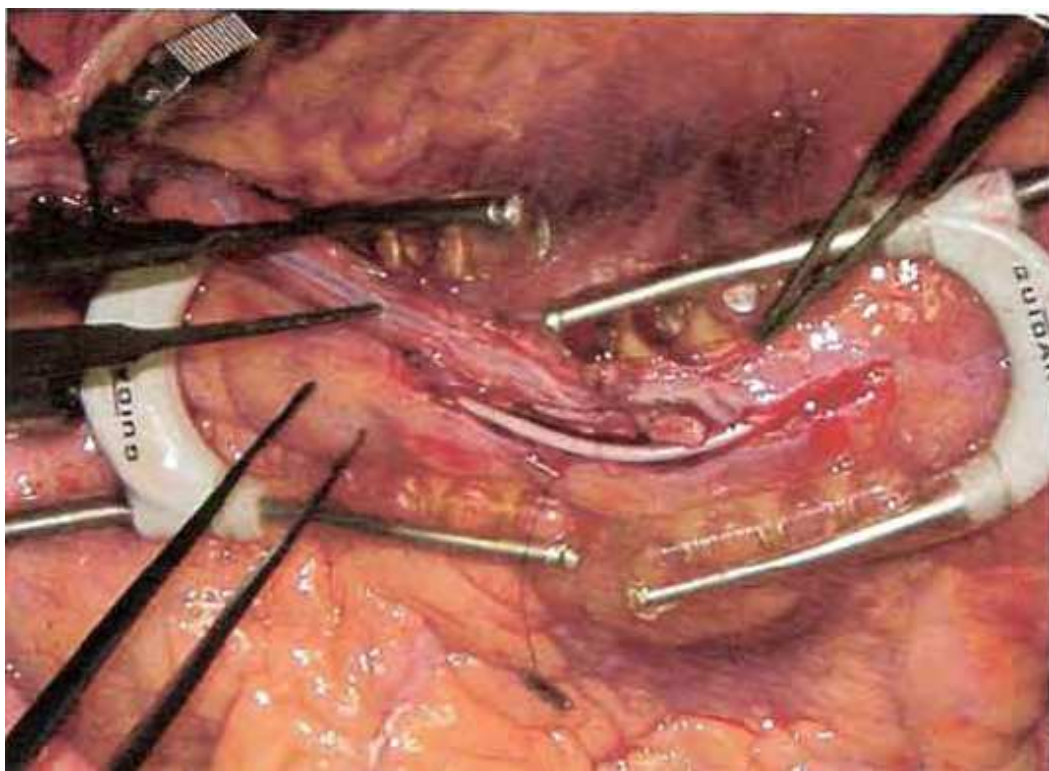


Fig. 12. Showing the Double stabilizer technique while performing the long mammary patch anastomosis of LIMA on the LAD without endarterectomy.



Any patient who has a hemodynamic compromise or has an inclination to crash, gets an IABP inserted sheath less.(8 or &7 Fr). We had the IABP inserted in the early days when we had the patient included in one of the high risk group like- left main coronary artery disease (> 75% stenosis), intractable resting angina, ST depression more than 2.5mm,Post-infarction angina, Left ventricular dysfunction (ejection fraction < 35%), or unstable angina. We had noticed that the use of IABP was not high in the left main disease group and low ejection fraction group, but was high in patients with ongoing ischemia. Hence we re-engineered our use of IABP such that every patient undergoing OPCAB gets a femoral arterial line and this is used for monitoring along with the radial arterial line. When a patient becomes ischemic during lifting the heart and while positioning for lateral wall grafting, then the heart is repositioned, and a sheathless IABP inserted. This is then used till the distal anastomosis is over. Once the anastomosis is complete and the heart repositioned for top end anastomosis, then the IABP is kept on standby mode. Then after the top end anastomosis is over, the heparin is reversed. Once the reversal is over and when the patient remains hemodynamically stable, we remove the IABP on the table, after inserting another femoral arterial line in the other groin. This technique has been very useful and we have been following this for the past four years, with excellent results. In fact this technique is being sent for publication. We have not had to reintroduce any IABP in any of these patients over the last four years.

TOTAL NO. OF OFF PUMP (OPCAB)					
FROM	TO	OFF PUMP CASES	CONVERSION	IABP	MORTALITY
07-2002	12-2002	47	NIL	NIL	NIL
01-2003	12-2003	177	12	1	NIL
01-2004	12-2004	238	6	NIL	1
01-2005	12-2005	300	NIL	6	3
01-2006	12-2006	248	NIL	10	4
01-2007	12-2007	261	1	13	NIL
01-2008	12-2008	228	NIL	24	2
01-2009	12-2009	282	NIL	15	1
01-2010	12-2010	338	NIL	22	1
TOTAL		2155	19	97	12
TOTAL IABP USAGE = 2.5%					
FIRST 1000 PATIENTS HAD CONVERSION OF 1.8% & MORTALITY OF 0.8%					
SECOND 1000 PATIENTS HAD CONVERSION OF 0.1% & MORTALITY OF 0.4%					

11. Results

We had analyzed the results of our last 2000 OPCAB patients. It was noticed that we had a higher rate of conversion onto the heart lung machine in our first thousand, when compared the second thousand. Probably, that was our initial learning curve which was seen in our technique, which we have developed and standardized. The use of IABP had been low in the early years, and probably the reason for the increased conversion on to the Heart lung machine. But as we understood the use of IABP, we found it more user friendly. Also the need

for the balloon pump only for distal anastomosis did come as a surprise to us. In the last 1600 odd patients, we had to convert only one patient on to the heart lung patient (That too when the patient developed intractable Ventricular arrhythmia). The mortality of the second thousand patients had come down by half and we have been able to maintain that result. Our results of the different parameters like the use of ionotropes, number of grafts, Renal failure, perioperative Myocardial infarction etc, in comparison with our two groups of patients have been elucidated in the Table below.

ROLE OF IABP IN OPCAB		
	FIRST 1000	2 <sup>ND</sup> 1000
CONVERSION	1.8%	0.1%
NO OF GRAFTS	3.5%	3.9%
INOTROPIC USE	75%	2%
RENAL FAILURE	3%	0.2%
PERI OP MI	<1%	0.4%
STROKE	0.4%	0.2%
MORTALITY	0.8%	0.4%
IABP	16	40

12. Conclusion

The advance that has been made in the surgical management of coronary artery disease has placed us in a vantage position of judging the outcome of our management techniques not only by morbidity and mortality incurred, but also by the potential of our treatment modality to cause harm. This is why OPCAB has generated renewed, widespread and sustained interest. The resurgence of OPCAB has also ignited a keen enthusiasm in the refinement of CPB techniques and the management of on-pump CABG patients. In most practices, OPCAB is paradoxically dependent on, and guaranteed by the presence of the CPB machine. We would like to stress here that OPCAB is not for everyone. It is definitely not for the faint hearted surgeon, It needs a Team with a MINDSET. And the team has to gear itself from being able to perform CABG on full Cardiopulmonary bypass, with cross clamp and cardioplegia, to performing CABG on pump with a beating heart, and then going on to just cannulating the aorta, and then stabilizing the heart and performing OPCAB, to doing a full OPCAB. This should be a slow transition, than a sudden change. Then the results would be good. There has been numerous article comparing OPCAB with ONCAB, but in our opinion, a surgeon performing OPCAB would not have to perform ONCAB, what ever the coronary anatomy is, if he sets his mind to it.

In our last 12 years of OPCAB experience and over 2500 OPCABs, we have been able to perform the last 1600 OPCABs with only one conversion to the heart lung machine. That was when patient developed intractable arrhythmia. Hence in our opinion, intractable arrhythmia is the only reason for conversion. The mortality in the first one thousand patients have been 0.8% and in the second thousand is 0.4%. This proves to say that OPCAB has definitely reduced the mortality in coronary surgery. And if trained well we would be able to perform the same in patients with any ejection fraction.

### 13. References

- Akiyama K., Ogasawara K., Inoue T., Shindou S., Okumura H., Negishi N., Sezai Y. Myocardial revascularization without cardiopulmonary bypass in patients with operative risk factors. *Ann Thorac Cardiovasc Surg* 1999;5:31-35
- Al-Ruzzeh S., George S., Yacoub M., Amrani M. The clinical outcome of off-pump coronary artery bypass surgery in the elderly patients. *Eur J Cardiothorac Surg* 2001;20:1152-1156.
- A. Laurie Shroyer, Ph.D., Frederick L. Grover, M.D., Brack Hattler, M.D., Joseph F. Collins, Sc.D., Gerald O. McDonald, M.D., Elizabeth Kozora, Ph.D., John C. Lucke, M.D., Janet H. Baltz, R.N., and Dimitri Novitzky, M.D., Ph.D. for the Veterans Affairs Randomized On-Pump versus Off-Pump Coronary-Artery Bypass Surgery. On/Off Bypass (ROOBY) Study Group. *N Engl J Med* 2009; 361:1827-1837.
- Anil D Prabhu, MCh, Ismail E Thazhkuni, PhD, Sunil Rajendran, MRCS, Ranjish A Thamaran, MS, Kannan A Vellachamy, MD, Murali P Vettath, MD. Mammary patch reconstruction of left anterior descending coronary artery. *Asian Cardiovasc Thorac Ann* 2008;16:313-317
- Anil D. Prabhu, MCh, Rafeek A. Karim, MCh, Sunil Rajendran, FRCS, Ismail E. Thazhkuni, PhD, Ranjish A. Thamaran, MS, Kannan A. Vellachami, MD, Murali P. Vettath, MCh. Vettath's technique of long mammary patch reconstruction of a diffusely diseased left anterior descending coronary artery without endarterectomy on the beating heart. *The Heart Surgery Forum* #2007-1155 11 (2) P 64-67, 2008 doi: 10.1532/HSF98.20071155 <http://cardenjennings.metapress.com>
- Ankeney JL. To use or not use the pump oxygenator in coronary bypass operations *Ann Thorac Surg* 1975;19:108-109.
- Arom K.V., Flavin T.F., Emery R.W., Kshetry V.R., Janey P.A., Petersen R.J. Safety and efficacy of off-pump coronary artery bypass grafting. *Ann Thorac Surg* 2000;69:704-710.
- Ascione R., Lloyd C.T., Gomes W.J., Caputo M., Bryan A.J., Angelini G.D. Beating versus arrested heart revascularization: evaluation of myocardial function in a prospective randomized study. *Eur J Cardiothorac Surg* 1999;15:685-690.
- Ascione R., Lloyd C.T., Underwood M.J., Gomes W.J., Angelini G.D. On-pump versus off-pump coronary revascularization: evaluation of renal function. *Ann Thorac Surg* 1999;68:493-498.
- Ascione R., Nason G., Al-Ruzzeh S., Ko C., Ciulli F., Angelini G.D. Coronary revascularization with or without cardiopulmonary bypass in patients with preoperative nondialysis-dependent renal insufficiency. *Ann Thorac Surg* 2001;72:2020-2025



- Atkins C.W., Boucher C.A., Pohot G.M. Preservation of interventricular septal function in patient having coronary artery bypass grafts without cardiopulmonary bypass. *Am Heart J* 1984;107:304-309.
- Bailey CP, May A, Lemon WM. Survival after coronary endarterectomy I men . *JAMA* 1957;167:641.
- Benetti FJ. Direct coronary surgery with saphenous vein bypass without either cardiopulmonary bypass or cardiac arrest *J Cardiovasc Surg* 1985;26:217-222.
- Benetti FJ. Video assisted coronary bypass surgery *J Cardiovasc Surg* 1995;10:620-625.
- Benetti F.J., Naselli C., Wood M., Geffner L. Direct myocardial revascularization without extracorporeal circulation. Experience in 700 patients. *Chest* 1991;100:312-316
- Bennetts J.S., Baker R., Ross I.K., Knight J.L. Assessment of myocardial injury by troponin T in off-pump coronary artery grafting and conventional coronary artery graft surgery. *ANZ J Surg* 2002;72:105-109.
- Borst C, Jansen EW, Tulleken CA, et al. Coronary artery bypass grafting without cardiopulmonary bypass and without interruption of native coronary flow using a novel anastomosis site restraining device ("Octopus") *J Am Coll Cardiol* 1996;27:1356-1364.
- Boyd W.D., Desai N.D., Del Rizzo D.F., Novick R.J., McKenzie F.N., Menkis A.H. Off-pump surgery decreases postoperative complications and resource utilization in the elderly. *Ann Thorac Surg* 1999;68:1490-1493
- Buckberg G.D., Allen B.S. Myocardial protection management during adult cardiac operations. In: Baue A.E., Geha A.S., Hammond G.L., Laks H., Naunheim K.S., eds. *Glenn's thoracic and cardiovascular surgery*. Stamford: Apple & Lange, 1996:1653-1687.
- Buckberg G.D., Allen B.S. Myocardial protection management during adult cardiac operations. In: Baue A.E., Geha A.S., Hammond G.L., Laks H., Naunheim K.S., eds. *Glenn's thoracic and cardiovascular surgery*. Stamford: Apple & Lange, 1996:1653-1687.
- Buffolo E, Andrade JCS, Succi JE, et al. Direct myocardial revascularization without cardiopulmonary bypass *Thorac Cardiovasc Surg* 1985;33:26-29
- Calafiore AM, Gianmarco GD, Teodori G, et al. Left anterior descending coronary artery grafting via left anterior small thoracotomy without cardiopulmonary bypass *Ann Thorac Surg* 1996;61:1658-1665.
- Calafiore AM, Vitolla G, Mazzei V, et al. The Last operation technique and results before and after stabilization era. *Ann Thorac Surg* 1998;66:998-1001.
- Calafiore A.M., Di Giammarco G., Teodori G., Mazzei V., Vitolla G. Recent advances in multivessel coronary grafting without cardiopulmonary bypass. *Heart Surg Forum* 1998;1:20-25.
- Cartier R., Brann S., Dagenais F., Martineau R., Couturier A. Systematic off-pump coronary artery revascularization in multivessel disease: experience of three hundred cases. *J Thorac Cardiovasc Surg* 2000;119:221-229.
- Christenson J.T., Simonet F., Badel P., Schmuziger M. Evaluation of preoperative intra-aortic balloon pump support in high risk coronary patients. *Eur J Cardiothorac Surg* 1997;11:1097-1103.
- Christenson J., Simonet F., Badel P., Schmuziger M. The effect of preoperative intra-aortic balloon pump support in patients with coronary artery disease, poor left-

- ventricular function (LVEF < 40%) and hypertensive LV hypertrophy. *Thorac Cardiovasc Surg* 1997;45:60-64.
- Christenson J., Simonet F., Badel P., Schmuziger M. Optimal timing of preoperative intraaortic balloon pump support in high-risk coronary patients. *Ann Thorac Surg* 1999;68:934-939
- Czerny M., Baumer H., Kilo J., Zuckermann A., Grubhofer G., Chevtchik O., Wolner E., Grimm M. Complete revascularization in coronary artery bypass grafting with and without cardiopulmonary bypass. *Ann Thorac Surg* 2001;71:165-169.
- D'Ancona G., Karamanoukian H., Ricci M., Kawaguchi A., Bergsland J., Salerno T. Myocardial revascularization on the beating heart after recent onset of acute myocardial infarction. *Heart Surg Forum* 2001;4:74-79.
- Favaloro RG. Saphenous vein graft in the surgical treatment of coronary artery disease *J Thorac Cardiovasc Surg* 1968;58:178-185.
- Goetz RH, Rohman M, Haller JD, et al. Internal mammary-coronary anastomosis. A nonsuture method employing tantalum rings *J Thorac Cardiovasc Surg* 1961;41:378-386.
- Green GE, Stertzner SH, Reppert EH. Coronary artery bypass graft *Ann Thoracic Surg* 1968;5:443-450
- Güler M., Kirali K., Toker M.E., Bozbuga N., Ömeroglu S.N., Akinci E., Yakut C. Different CABG methods in patients with chronic obstructive pulmonary disease. *Ann Thorac Surg* 2001;71:152-157.
- Gundry S.R., Romano M.A., Shattuck O.H., Razzouk A.J., Bailey L.L. Seven-year follow-up of coronary artery bypasses performed with and without cardiopulmonary bypass. *J Thorac Cardiovasc Surg* 1998;115:1273-1278.
- Gu Y.J., Mariani M.A., Boonstra P.W., Grandjean J.G., Oeveren W.V. Complement activation in coronary artery bypass grafting patients without cardiopulmonary bypass: the role of tissue injury by surgical incision. *Chest* 1999;116:892-898.
- Guyton R.A., Thourani V.H., Puskas J.D., Shanewise J.S., Steele M.A., Palmer-Steele C.L., Vinten-Johansen J. Perfusion-assisted direct coronary artery bypass: selective graft perfusion in off-pump cases. *Ann Thorac Surg* 2000;69:171-175.
- Hoff S.J., Ball S.K., Coltharp W.H., Glassford D.M., Jr., Lea J.W., IV, Petracek M.R. Coronary artery bypass in patients 80 years and over: is off-pump the operation of choice?. *Ann Thorac Surg* 2002;74:S1340-S1343.
- Kim KB, Lim C, Lee C, et al. Off-pump coronary artery bypass may decrease the patency of saphenous vein grafts *Ann Thorac Surg* 2001;72:1033-1037.
- Kim K.B., Lim C., Ahn H., Yang J.K. Intraaortic balloon pump therapy facilitates posterior vessel off-pump coronary artery bypass grafting in high-risk patients. *Ann Thorac Surg* 2001;71:1964-1968.
- Kolessov VL. Mammary artery coronary anastomosis as method of treatment for angina pectoris *J Thorac Cardiovasc Surg* 1967;54:535-544.
- Locker C., Shapira I., Paz Y., Kramer A., Gurevitch J., Matsa M., Pevni D., Mohr R. Emergency myocardial revascularization for acute myocardial infarction: survival benefits of avoiding cardiopulmonary bypass. *Eur J Cardiothorac Surg* 2000;17:234-2385.

- Masuda M., Morita S., Tomita H., Kurisu K., Nishida T., Tominaga R., Yasui H. Off-pump attenuates myocardial enzyme leakage but not postoperative brain natriuretic peptide secretion. *Ann Thorac Cardiovasc Surg* 2002;8:139-144.
- Matata B.M., Sosnowski A.W., Galiñanes M. Off-pump bypass graft operation significantly reduces oxidative stress and inflammation. *Ann Thorac Surg* 2000;69:785-791.
- Mathison M., Buffolo E., Jatene A.D., Jatene F., Reichenspurner H., Matheny R.G., Shennib H., Akin J.J., Mack M.J. Right heart circulatory support facilitates coronary artery bypass without cardiopulmonary bypass. *Ann Thorac Surg* 2000;70:1083-1085.
- Mehlhorn U., Allen S.J., Adams D.L., Davies K.L., Gogola G.R., de Vivie R., Laine G.A. Normothermic continuous antegrade blood cardioplegia does not prevent myocardial edema and cardiac dysfunction. *Circulation* 1995;92:1940-1946.
- Mohr R., Moshkovitch Y., Shapira I., Amir G., Hod H., Gurevitch J. Coronary artery bypass without cardiopulmonary bypass for patients with acute myocardial infarction. *J Thorac Cardiovasc Surg* 1999;118:50-56.
- Montague N.T., Kouchoukos N.T., Wilson T.A., Bennett A.L., Knott H.W., Lochridge S.K., Erath H.G., Clayton O.W. Morbidity and mortality of coronary bypass grafting in patients 70 years of age and older. *Ann Thorac Surg* 1985;39:552-557.
- Mueller X.M., Chassot G., Zhou J., Eisa K.M., Chappuis C., Tevæarai H.T., von Seggesser L.K. Hemodynamics optimization during off-pump coronary artery bypass: the 'no compression' technique. *Eur J Cardiothorac Surg* 2002;22:249-254.
- Mullany C.J., Darling G.E., Pluth J.R., Orszulak T.A., Schaff H.V., Ilstrup D.M., Gersh B.J. Early and late results after isolated coronary artery bypass surgery in 159 patients aged 80 years and older. *Circulation* 1990;82(5 Suppl):IV229-IV236.
- Hirose H. Coronary artery bypass grafting in the elderly. *Chest* 2000;117:1262-1270.
- Muraki S., Morris C.D., Budde J.M., Velez D.A., Zhao Z., Guyton R., Vinten-Johanson J. Experimental off-pump coronary artery revascularization with adenosine-enhanced reperfusion. *J Thorac Cardiovasc Surg* 2001;121:570-579.
- Murray G., Porcheron R., Hilario J., Rosemblau W. Anastomosis of a systemic artery to the coronary artery. *Can Med Assoc J* 1954;59:471.
- Nakayama Y., Sakata R., Ura M., Itoh T. Long-term results of coronary artery bypass grafting in patients with renal insufficiency. *Ann Thorac Surg* 2003;75:496-500.
- Penttilä H.J., Lepojärvi M.V.K., Kiviluoma K.T., Kaukoranta P.K., Hassinen I.E., Peuhkurinen K.J. Myocardial preservation during coronary surgery with and without cardiopulmonary bypass. *Ann Thorac Surg* 2001;71:565-571.
- Prifti E., Bonacchi M., Giunti G., Frati G., Proietti P., Leacche M., Salica A., Sani G., Brancaccio G. Does on-pump/beating-heart coronary artery bypass grafting offer better outcome in end-stage coronary artery disease patients?. *J Card Surg* 2000;15:403-410.
- Puskas J.D., Thourani V.H., Marshall J.J., et al. Clinical outcomes, angiographic patency and resource utilization in 200 consecutive off-pump coronary bypass patients. *Ann Thorac Surg* 2001;71:1477-1484.
- Puskas J.D., Williams W.H., Duke P.G., Staples J.R., Glas K.E., Marshall J.J., Leimbach M., Huber P., Garas S., Sammons B.H., McCall S.A., Petersen R.J., Bailey D.E., Chu H., Mahoney E.M., Weintraub W.S., Guyton R.A. Off-pump coronary artery bypass grafting provides complete revascularization with reduced myocardial injury, transfusion requirements, and length of stay: a prospective randomized

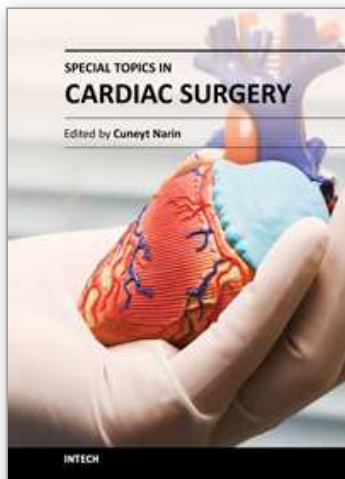


- comparison of two hundred unselected patients undergoing off-pump versus conventional coronary artery bypass grafting. *J Thorac Cardiovasc Surg* 2003;125:797-808
- Roosens C., Heerman J., De Somer F., Caes F., Van Belleghem Y., Poelaert J.I. Effects of off-pump coronary surgery on the mechanics of the respiratory system, lung, and chest wall: comparison with extracorporeal circulation. *Crit Care Med* 2002;30:2430-2437.
- Sepic J., Wee J.O., Soltesz E.G., Hsin M.K., Cohn L.H., Laurence R.G., Aklog L. Cardiac positioning using an apical suction device maintains beating heart hemodynamics. *Heart Surg Forum* 2002;5/volume-nr>:279-284
- Stamou S.C., Dangas G., Dullum M.K., Pfister A.J., Boyce S.W., Bafi A.S., Garcia J.M., Corso P.J. Beating heart surgery in octogenarians: perioperative outcome and comparison with younger age groups. *Ann Thorac Surg* 2000;69:1140-1145.
- Strüber M., Cremer J.T., Gohrbandt B., Hagl C., Jankowski M., Völker B., Rückoldt H., Martin M., Haverich A. Human cytokine responses to coronary artery bypass grafting with and without cardiopulmonary bypass. *Ann Thorac Surg* 1999;68:1330-1335.
- Shuichiro Takanashi, Toshihiro Fukui, Yasuyuki Hosoda, and Yoshihiro Shimizu. Off-pump long onlay bypass grafting using left internal mammary artery for diffusely diseased coronary artery. *Ann. Thorac. Surg.*, Aug 2003; 76: 635 – 637.
- Svedjeholm R., Huljebrant I., Hkanson E., Vanhanen I. Glutamate and high dose glucose-insulin-potassium (GIK) in the treatment of severe cardiac failure after cardiac operations. *Ann Thorac Surg* 1995;59:S23-S30.
- Tashiro T., Todo K., Haruta Y., Yasunaga H., Tachikawa Y. Coronary artery bypass grafting without cardiopulmonary bypass for high-risk patients. *Cardiovasc Surg* 1996;4:207-211.
- Trapp WG, Bisarya R. Placement of coronary artery bypass graft without pump-oxygenator *Ann Thorac Surg* 1975;19:1-9.
- Van Dijk D., Nierich A.P., Jansen E.W.L., Nathoe H.M., Suyker W.J.L., Diephuis J.C., van Boven W., Borst C., Buskens E., Grobbee D.E., de Medina E.O.R., de Jaegere P.P.T. Early outcome after off-pump versus on pump coronary bypass surgery. *Circulation* 2001;104:1761-1766.
- Vassiliades T.A., Nielsen J.L., Lonquist J.L. Coronary perfusion methods during off-pump coronary bypass: results of a randomized clinical trial. *Ann Thorac Surg* 2002;74:S1383-S1389.
- Vettath, Murali P; Kannan, A.V.; Sheen Peecheeyen, C.S.; Baburajan, A.K.; Vahab, Abdul and Sujith, M.P.
- Vettath's anastamotic obturator: A simple proximal anastamotic device. Murali P Vettath. *The heart surgery forum* #2003-73305 6 (5), 2003 Online address: [www.hsforum.com/vol6/issue5/2003-73305.html](http://www.hsforum.com/vol6/issue5/2003-73305.html)
- Vettath P Murali. Vettath's anastamotic obturator – our experience of 269 proximal anastamosis.(2004). *Heart Lung and Circulation*, 13. pp. 288-290. *Heart Lung and Circulation* 2004; 13:288-290
- Vineberg AM . Development of anastomosis between coronary vessels and transplanted mammary artery: *Med Assoc J* 1954;594:71

- Yeatman M., Caputo M., Narayan P., Ghosh A.K., Ascione R., Ryder I., Angelini G.D. Intracoronary shunts reduce transient intraoperative myocardial dysfunction during off-pump coronary operations. *Ann Thorac Surg* 2002;73:1411-1417.
- Yokoyama T., Baumgartner F.J., Gheissari A., Capouya E.R., Panagiotides G.P., Declusin R.J. Off-pump versus on-pump coronary bypass in high-risk subgroups. *Ann Thorac Surg* 2000;70:1546-1550.

IntechOpen

IntechOpen



## **Special Topics in Cardiac Surgery**

Edited by Prof. Cuneyt Narin

ISBN 978-953-51-0148-2

Hard cover, 308 pages

**Publisher** InTech

**Published online** 29, February, 2012

**Published in print edition** February, 2012

This book considers mainly the current perioperative care, as well as progresses in new cardiac surgery technologies. Perioperative strategies and new technologies in the field of cardiac surgery will continue to contribute to improvements in postoperative outcomes and enable the cardiac surgical society to optimize surgical procedures. This book should prove to be a useful reference for trainees, senior surgeons and nurses in cardiac surgery, as well as anesthesiologists, perfusionists, and all the related health care workers who are involved in taking care of patients with heart disease which require surgical therapy. I hope these internationally cumulative and diligent efforts will provide patients undergoing cardiac surgery with meticulous perioperative care methods.

### **How to reference**

In order to correctly reference this scholarly work, feel free to copy and paste the following:

Murali P. Vettath, Et Ismail, Av Kannan and Athmaja Murali (2012). Re-Engineering in OPCAB Surgery, Special Topics in Cardiac Surgery, Prof. Cuneyt Narin (Ed.), ISBN: 978-953-51-0148-2, InTech, Available from: <http://www.intechopen.com/books/special-topics-in-cardiac-surgery/re-engineering-in-opcab-off-pump-coronary-artery-bypass-surgery>

**INTECH**  
open science | open minds

### **InTech Europe**

University Campus STeP Ri  
Slavka Krautzeka 83/A  
51000 Rijeka, Croatia  
Phone: +385 (51) 770 447  
Fax: +385 (51) 686 166  
[www.intechopen.com](http://www.intechopen.com)

### **InTech China**

Unit 405, Office Block, Hotel Equatorial Shanghai  
No.65, Yan An Road (West), Shanghai, 200040, China  
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元  
Phone: +86-21-62489820  
Fax: +86-21-62489821



© 2012 The Author(s). Licensee IntechOpen. This is an open access article distributed under the terms of the [Creative Commons Attribution 3.0 License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

IntechOpen

IntechOpen