ADVANCES IN CORONARY SURGERY

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INTRODUCTION

The first successful aortocoronary bypass operation was periormed in 1964 by Garrett, Howell, and DeBakey in Houston.26 That same year, Kolesov in Leningrad performed the first planned anastomosis between the left internal thoracic artery and the left anterior descending artery.[27] The future development of coronary angiography, cardiopulmonary bypass and cardioplegia helped coronary bypass surgery evolve from these first seminal events, and by the mid 1980s, coronary revascularization using cardiopulmonary bypass had become an accepted technique with durable outcomes.

In July of 1979, Andreas Gruentzig launched the era of percutaneous coronary intervention (PCI) with the development of percutaneous transluminal coronary angioplasty.[28] Although outcomes were not as durable, the difference in morbidity and mortality made it an attractive alternative to surgery. The development of stent technology improved outcomes, and the introduction of drug-eluting stents in the new millennium dramatically reduced in-stent restenosis. As coronary bypass surgery continues to be refined, the challenge is to minimize the morbidity and mortality while preserving the proven durability of surgical revascularization.

EVOLUTION OF LESS INVASIVE CORONARY SURGERY

Cardiopulmonary bypass (CPB) and sternotomy contribute to the potential morbidity of coronary surgery. Several scudies have demonstrated that CPB induces a systemic inflammatory response syndrome by activating cellular and non-cellular cascades (coagulation, complement and kallikrein).[29-32]

Improvements in technique and technology, however, coupled with the recognition of the anesthesiologist's pivotal role, have prompted the evolution of off-pump coronary artery bypass (OPCAB).

BENEFITS OF OPCAB

Reduced mortality: Higher risk patients-female gender, atheromatous aortic disease, aged over 70 years, renal failure, acute myocardial infarction, LV function< 30% and re-operations-have improved mortality rates with OPCAB (Table 1), and some studies have shown this to be true for all patients (Figure 1).[4, 8-13] A review of two large databases of 8,499 patients undergoing isolated CAB with and without CPB showed a 49%

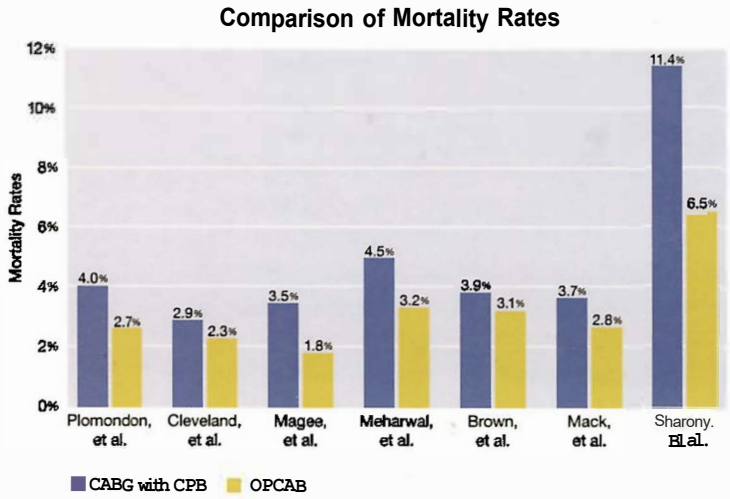

Figure 1.
Comparison of mortality rates (studies performed on high-risk patients)

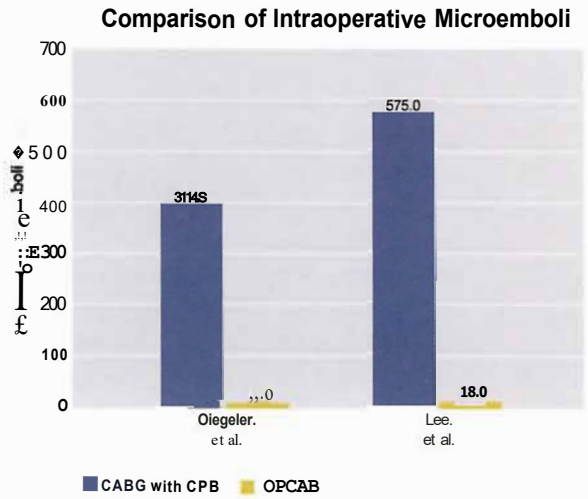

Figure 2.
Comparison of intraoperative microemboli (prospective randomized study)

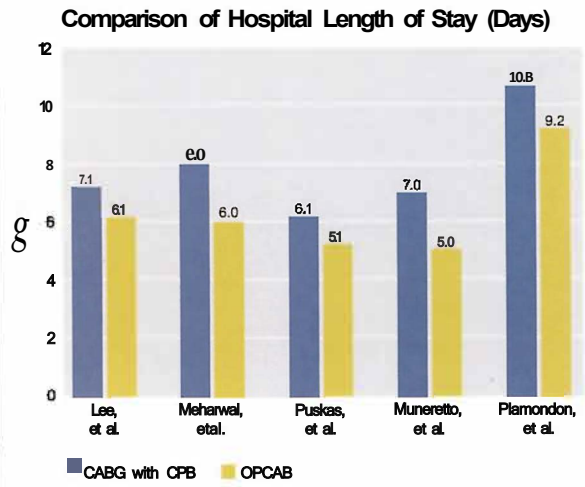

Figure 5.

Comparison of hospital length of stay (prospective randomized study; studies performed on high-risk patients)

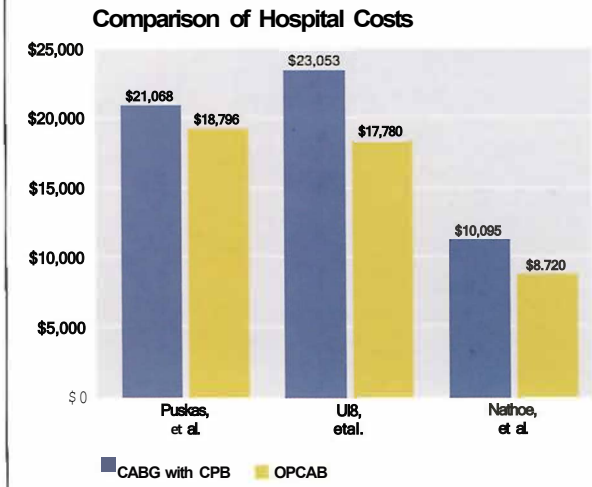

Figure 6.

Prospective randomized study

Puskas reported a study in 2004 that randomized 200 unselected patients to OPCAB and CCAB.7 There was no difference in the number of grafts performed in each group {3.39 OPCAB versus 3.4 CCAB) and angiographic patency at one year was similar (93.6% OPCAB and 95.8% CCAB).

OPCAB IN THE METHODIST DEBAKEY HEART CENTER

Close collaboration between the surgeon **and** anesthesiologist is especially important in OPCAB to achieve the best possible outcomes.

Surgical Strategy: At che Methodist DeBakey Heart Center, modern platforms have provided the means for excellent mechanical stabilization. Apical suction devices allow manipulation of the heart without compromising the spiral contractile action that is so critical for adequate ejection. This allows access co all parts of the heart, including posterior vessels near the atrioventricular groove.

Accuracy of distal anastomoses is ensured by good stabilization, the use of mister/blower devices to aid visualization and the routine use of intracoronary shunts. Shunts serve the dual role of preventing regional ischemia and providing a temporary intracoronary scaffold co allow for accurate anastomoses without luminal compromise. Clips to allow an interrupted suture technique are being introduced to i_{mp}rove com?liance at the anastomosis.

Epi-aortic scanning is used to select sites for the proximal anastomoses, and clampless techniques are used for the proximal anastomoses (Heartstring Connector, Guidant Corp.) to minimize aortic manipulation and the risk of embolization.

Graft patency is confirmed using ultrasound-based transit time flow measurement in all grafts. This will soon be augmented with intraoperative fluorescence angiography using indocyanine green (Novadaq Corp.) given intravenously.

Anesthetic Strategy: In the anesthesia literature, there is enough evidence to suggest **that** the type of general anesthetic agent used in patients undergoing coronary revascularization with CPB does not affect the outcome. However, recent studies using epidural anesthesia as an adjunct co general anesthesia confirmed several benefits that may affect patient outcome.

Anesthetic management of patients undergoing off-pump surgery requires continuous attention to the surgical procedure and good communication with the surgical team. High Thoracic Epidural Anesthesia (HTEA), coupled with general anesthesia, has been found to limit the stress response to surgery in patients undergoing abdominal aneurysm repair.

Omitting CPB in OPCAB and adding epidural blockade are two maneuvers that greatly reduce the inflammatory response. Sympathetic blockade of the heart by HTEA reduces energy expenditure of the myocardium, improves myocardial oxygen balance and prevents intraoperative tachycardia and hypertension. Post-operative epidural infusion of 0.1% b_{up}ivacaine and 1 mcg/ml of fentanyl or low-dose clonidine after cardiac surgery resulted in superior pain control when compared to opioid PCA. A randomized study by Scott et al. showed reduced time to extubation, and reduction in pulmonary complications and postoperative arrhythmias in patients undergoing coronary revascularizacion with the addition of HTEA.[22] Many other studies have shown a significant reduction of intubation time after cardiac surgery in patients with HTEA.

We reviewed 170 patients who underwent OPCAB at the Methodist DeBakey Heart Center with a combination oflight, totally intravenous general anesthesia and HTEA followed by 72 hours of epidural analgesia, and compared them with a matched group of 50

patients who underwent OPCAB surgery under general anesthesia followed by opioids for postoperative pain control. Patients with HTEA were extubated earlier, spent less time in the ICU, had shorter hospital length of stay and had a statistically significant reduction in postoperative atrial arrhythmias as compared to GA only.

In the last three years, more than 600 patients have had HTEA as an adjunct to cardiac surgery at the Methodist DeBakey Heart Center. There have been no serious complications related to HTEA, and patient satisfaction is very high due to the excellent postoperative pain control.

CONCLUSION

Almost all patients who require coronary surgery can now receive OPCAB, which offers all the benefits of CCAB with significantly reduced morbidity and mortality-especially in higher risk patients. The addition of HTEA has further improved outcomes, and we have the largest experience of this in the United States. Robotic technology offers the future prospect of totally endoscopic beating heart coronary bypass using arterial conduits; when combined with PCI to achieve a "hybrid" procedure, we may soon be able to offer durable and complete revascularization with minimal morbidity.

Affected Group	Improved Clinical Outcomes (OPCAB versus CABG with CPS)
Women	• Reduced mortality rates • Fewer transient ischemic attacks (TIA) and strokes • Fewer post-operative transfusions • Decreased length of stay
Elderly(> 70 years)	• Reduced strokes • Lower incidences of post-operative atrial fibrillation • Fewer blood transfusions
Diabetics	• Lower stroke rates • Decreased blood product use • Reduced incidences of prolonged ventilation • Reduced post-operative atrial fibrillation • Reduced renal failures requiring dialysis
Atheromatous Aortic Disease	• Reduced hospital mortality • Reduced strokes • Higher freedom from post-operative complications
Poor left ventricular function (EF s 30%), Left Main Stenosis, Acute Myocardial Infarction, Reoperations, Renal Failure	• Reduced mean blood loss • Reduced post-operative atrial fibrillation • Reduced prolonged ventilation time • Lower ICU stay • Decreased hospital length of stay

Table 1

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improvement in early survival with OPCAB (1.8% versus 3.5% with CPB).[10] A review of 17,000 isolated coronary bypass operations performed in 2001 in the HCA hospital system showed that 21.6% were done off-pump. Mortality in this group was 1.98% compared to 2.38% in the on-pump group ($p < 0.5$).

Reduced **neurocognitive** impairment **and stroke:** Transcranial Doppler studies have shown a forty-fold reduction in microemboli with OPCAB and improved neurocognitive outcomes.[14, 15] A prospective randomized scudy showed less neurocognitive impairment in the OPCAB group at one week (27% versus 63% with CPB, p = .004) and at 10 weeks (10% versus 40% with CPB, p = .017) (Figure 2).[16]

OPCAB reduces stroke rates in women, the elderly, diabetics and those with poor LV function, although this has not been shown to be *so* in lower-risk groups.[18-20] A review by Cleveland et al. of 118,150 CAB procedures from the Society of Thoracic Surgeons database, found that OPCAB reduced the absolute risk of stroke from 1.99% to 1.25% ($p < .001$) (Figure 3).[9, 12, 13, 17-20]

Reduced blood loss and fewer transfusions: Two prospective randomized studies have shown that OPCAB results in a 41% and 56% reduction in patients requiring blood transfusions (Figure 4).[5, 21]

Reduced perioperative complications: In a large database review of 11,717 OPCAB patients and 106,423 patients undergoing conventional coronary bypass (CCAB), the risk-adjusted incidence of complications was 10.62% in OPCAB versus 14.15% in CCAB ($p < 0.0001$).[9] Several studies, including a large meta-analysis of 53 studies, have shown reduced wound infection, renal failure, perioperative myocardial infarction, atrial fibrillation, ventilation requirements and reoperation for bleeding.[24] These differences are more pronounced in higher risk patients.

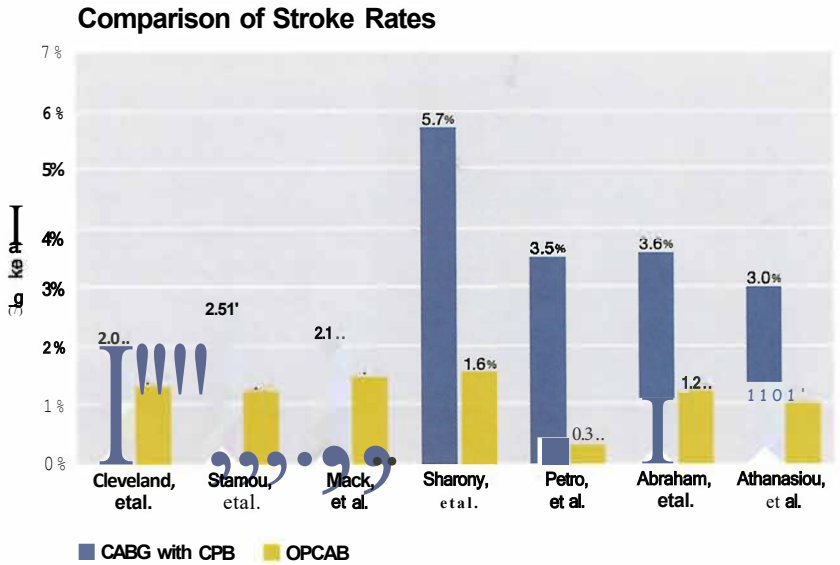

Figure 3.
Comparison of stroke rates (studies performed on high-risk patients)

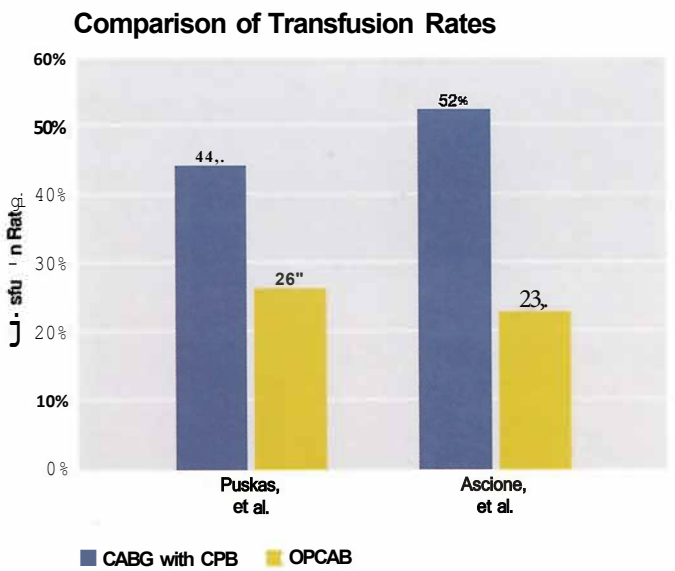

Figure 4.
Comparison of transfusion rates (prospective randomized study)

Reduced hospital length of stay (LOS) and cost: Decreases of approximately 50% in ICU LOS and one to two days in hospital LOS have been reported, with cost savings up to 30% per patient (Figures 5 and 6).[2, 4-8, 25]

Graft patency and completeness of revascularization: Several studies by experienced surgeons have confirmed that the ability to achieve complete revascularization in patients with multivessel disease is no longer in question.[1, 6]

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