OPCAB vs CABG: Where is the Difference?

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Learning Objectives

- Explain the anesthetic implications of both techniques
- Describe results of major trials and potential biases

Background

Although not widely known, the first successful coronary artery bypass was performed in 1960 by Robert H. Goetz at the Albert Einstein College of Medicine in New York.(1) By report, the anastomosis, using a specially designed metal ring for the internal mammary artery, took under 20 seconds. The patient, who underwent the operation for intractable angina, returned to work as a taxi driver following an uneventful recovery and survived for more than a year afterwards. Several years later, Vasilii Kolesov of Russia reported an anastomosis using a suture technique more closely resembling that used in modern cardiac surgery,(2) and for a period of time it was the only technique utilized.(3) So, the birth of coronary artery bypass grafting (CABG), one of the most commonly performed elective surgical procedures in the world, actually occurred without the use of extracorporeal circulation. It is somewhat ironic that the “gold standard” became the use of cardiopulmonary bypass (CPB) for the procedure and off-pump coronary artery bypass (OPCAB) surgery the “newcomer.”

CABG surgery using CPB

The first successful use of CPB occurred in 1953 when John Gibbon closed an atrial septal defect in an 18 year old patient.(4) The technology was crude at the time, however, and it was not until much later that CPB would be applied toward coronary revascularization procedures, which were also in their infancy. The first successful coronary artery bypass using a piece of saphenous vein and extracorporeal circulation is largely credited to Rene Favaloro at the Cleveland Clinic in 1967.(5) Enthusiasm for the procedure grew and by 1969 there were around 500 hospitals in the United States with CPB capability performing around 5,000 revascularization procedures of one type or another annually.(6) Given that there are more than 13 million Americans with CAD, it is no surprise that this number has ballooned to 400,000 CABG procedures now performed annually,(7) with about 80% of them utilizing CPB.
From an anesthetic point of view, the challenges of CPB come not during the actual CABG procedure, but from preparing for its initiation and separation. Factors contributing to inflammatory and hemostatic activation during CPB have been extensively reviewed and the anesthesiologist’s goal is to minimize their sequelae.(8,9) Often what is done for CABG on CPB is directly opposite to management for OPCAB. For example, fluid restriction in the pre-CPB period is often employed to minimize hemodilution. For OPCABs, however, fluid loading is often required to ensure adequate pre-load during cardiac manipulations. The major management differences are summarized in the table below.

### Major Management Differences of CABG on CPB vs OPCAB

<table>
<thead>
<tr>
<th>Stage of Procedure</th>
<th>CABG on CPB Concerns</th>
<th>OPCAB Concerns</th>
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<tbody>
<tr>
<td>Conduit Harvest</td>
<td>Minimize myocardial MVO2</td>
<td>Consider need for loading inotropes in anticipation of heart manipulations</td>
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<tr>
<td></td>
<td>Restrict IVF to minimize hemodilution</td>
<td>IVF administration to ensure adequate pre-load</td>
</tr>
<tr>
<td>Initiation of CPB</td>
<td>Ensure adequate anticoagulation</td>
<td>(N/A)</td>
</tr>
<tr>
<td></td>
<td>Antifibrinolytic use common</td>
<td>ACT target less well-defined</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aspirin often administered</td>
</tr>
<tr>
<td>Distal Anastomoses</td>
<td>Keep heart quiescent</td>
<td>Keep heart beating; epicardial pacing often employed</td>
</tr>
<tr>
<td></td>
<td>Minimal hemodynamic disturbances</td>
<td>Major hemodynamic disturbances</td>
</tr>
<tr>
<td>Separation from CPB</td>
<td>Ramp up inotropic support</td>
<td>(N/A)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Often able to wean pressors following distal completion</td>
</tr>
<tr>
<td>Procedure End / Misc.</td>
<td>Rewarming managed by perfusionist</td>
<td>Hypothermia a problem – need active heating measures throughout operation</td>
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</table>

### OPCAB Surgery

From a surgical standpoint, it is more difficult to sew on a beating heart. This problem has been ameliorated by specialized devices developed and marketed in the mid-1990’s that help position the heart and stabilize the involved section of myocardium. Despite these advances, communication between the surgeon and anesthesiologist is critical to determine what position the patient will or will not
tolerate. In order to alleviate some of the hemodynamic consequences of OPCAB during distal anastomoses, surgical maneuvers such as opening the pleural space to alleviate compression and employing intracoronary shunts can be used. A 3 minute “trial” period prior to arteriotomy is helpful to avoid emergent conversion to CPB, which is associated with a significantly higher mortality rate.(10)

**Outcomes of CABG with CPB versus OPCAB**

There are passionate proponents and opponents when it comes to this issue. The major points of contention are generally summed up as follows:

**Pro-OPCAB Arguments**

- Reduced neurocognitive dysfunction by avoiding cannulation and aortic cross-clamping
- Avoidance of the systemic inflammatory response and its post-op sequelae
- Decreased blood product use with better post-op pulmonary and renal function

**Pro CABG with CPB Arguments**

- Incomplete revascularization with OPCAB / poorer long-term graft patency
- Emergency conversion of OPCAB to CPB results in higher mortality
- OPCAB has higher degree of technical difficulty with no proven advantages

Multiple randomized controlled trials have been performed to address these arguments, but most have been insufficiently powered to detect differences in a procedure with such a low morbidity and mortality rate. Some better-known RCTs directly comparing CABG with (on) and without (off) the use of CPB are presented below with their latest follow-up and limitations.

<table>
<thead>
<tr>
<th>Trial (n=On/n=Off)</th>
<th>Follow-up / Major Conclusions</th>
<th>Notes</th>
</tr>
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<tbody>
<tr>
<td>BHACAS I &amp; II (201/200)</td>
<td>6-8 year FU: No difference in graft patency or perceived QOL(11)</td>
<td>Significant improvement in OPCAB between trials I and II</td>
</tr>
<tr>
<td>Octopus Study (139/142)</td>
<td>5 year FU: No difference in cognitive function or cardiac outcome(12)</td>
<td>Low-risk patient population only</td>
</tr>
<tr>
<td>SMART (99/98)</td>
<td>6-8 year FU: No difference in mortality or graft patency, lower costs in OPCAB(13)</td>
<td>Single center; highly experienced surgeons in OPCAB</td>
</tr>
<tr>
<td>ROOBY Study (1099/1104)</td>
<td>1 year FU: Lower graft patency and higher mortality in OPCAB(14)</td>
<td>Low risk males only; very high OPCAB to CPB conversion rate</td>
</tr>
<tr>
<td>CORONARY Study (2377/2375)</td>
<td>1 year FU: No significant difference in mortality, QOL, or cognitive function(15)</td>
<td>Largest multicenter RCT to date; planned 5 year FU</td>
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</table>

A recent Cochrane meta-analysis of 86 trials including over ten thousand patients concluded that OPCAB provided no benefit with regard to stroke or MI and, in fact, demonstrated lower long-term survival.(16) However, as mentioned above, most RCTs involve only low risk patients
with an expected STS mortality of 1-2%. In an observational analysis of the STS database (14,766 patients), Puskas and colleagues reported lower hospital mortality in the highest-risk group with OPCAB.(17) It is likely that the best approach to CABG will depend upon patient risk factors and surgeon experience. Exactly what factors favor OPCAB and what surgeons are experienced enough will likely remain a matter of debate for some time.

References


