

## EDITORIAL



## Current Status of Off-Pump Coronary-Artery Bypass

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Until the mid-1990s, coronary-artery bypass grafting (CABG) was performed with the use of cardiopulmonary bypass with the induction of ischemic cardiac arrest (on-pump). This surgical approach provided excellent exposure in a bloodless field with an arrested heart, allowing for precise performance of coronary anastomoses.<sup>1</sup> However, there was concern about potentially deleterious effects of cardiopulmonary bypass. Such effects include the induction of the systemic inflammatory response syndrome by the bypass circuit with consequent multiorgan injury and the risk of stroke or other systemic embolic events caused by the cross-clamping of the aorta. For these reasons, some surgeons began performing CABG procedures without cardiopulmonary bypass on the beating heart (off-pump). The clinical literature has been mixed to date on the relative efficacy of off-pump CABG as compared with on-pump CABG.

Puskas and colleagues,<sup>2</sup> who have extensive experience with the off-pump technique, reported very acceptable early outcomes in their randomized trial comparing off-pump with on-pump CABG in 200 patients, with similar rates of early death and stroke and similar survival rates at 8 years. Early graft patency was similar in the two groups, though a trend toward lower long-term patency was seen at 8 years in the off-pump group.

In 2009, Shroyer and colleagues<sup>1</sup> reported the results of the Randomized On/Off Bypass (ROOBY) trial (ClinicalTrials.gov number, NCT00032630), comparing the two techniques. This study, involving 2203 patients at 18 Veterans Affairs medical centers, showed no significant difference in the primary short-term composite outcome of death or complications (reoperation, new mechanical support, cardiac

arrest, coma, stroke, or renal failure) between the two groups. However, the rate of the 1-year composite outcome of death, myocardial infarction, or coronary reintervention was significantly higher in the off-pump group. Fewer grafts were performed in the off-pump group, and there were more incomplete revascularizations. One-year rates of graft patency were lower in the off-pump group. The trial showed no significant between-group differences in rates of perioperative stroke or neurocognitive outcomes at 1 year, thus failing to show a major presumed advantage for off-pump CABG.

Lamy and colleagues<sup>3</sup> now report the 30-day outcomes of off-pump versus on-pump CABG in the CABG Off or On Pump Revascularization Study (CORONARY). This study involving 4752 patients is the largest prospective, randomized trial investigating the relative efficacy of off-pump CABG. As in the ROOBY trial, there was no significant difference in the rate of the primary composite outcome (death, myocardial infarction, stroke, or renal failure requiring dialysis) between the two techniques. Fewer blood transfusions were required in the off-pump group, and there were more cases of acute kidney injury, longer ventilator times, and a higher incidence of reoperation for bleeding in the on-pump group. However, there were more early repeat revascularizations in the off-pump group. Also, as in the ROOBY trial, fewer grafts were performed in the off-pump group. Neurocognitive data were collected in this study<sup>4</sup> but were not analyzed for reporting at this time; such data will have a major influence on the interpretation of the primary trial results. Unfortunately, postoperative coronary arteriography was not performed, which is an important limitation of the study.

However, the true relative efficacy and durability of off-pump CABG will probably be determined by longer-term follow-up. Several recent studies have raised concern about the long-term efficacy of off-pump CABG. A meta-analysis of randomized trials by Takagi and colleagues<sup>5</sup> showed an increase in late ( $\geq 1$  year) all-cause mortality for off-pump CABG, and a large single-center study by Hu and colleagues<sup>6</sup> involving 6665 consecutive patients showed some early minor advantages for off-pump CABG but an increase in the rate of the composite adverse outcome of repeat revascularization, cardiac death, myocardial infarction, and stroke at an average of 4.5 years. The long-term outcomes of the CORONARY trial will be assessed at 5 years.<sup>4</sup>

There are some notable differences between the ROOBY and CORONARY trials. The ROOBY trial was designed to be reflective of typical clinical practice and included surgeons of varying degrees of experience; a resident was frequently the primary surgeon. The CORONARY trial, in contrast, was limited to surgeons with more extensive off-pump experience, and no trainees were permitted to act as primary surgeons. In addition, the CORONARY trial included a somewhat higher risk group of patients, who are thought by some observers to derive a greater relative benefit from the off-pump technique. These differences did not result in a significant difference in the short-term outcome between the two trials. Whether they will influence the long-term outcome remains to be seen.

Lamy and colleagues have made an important contribution to the understanding of the relative efficacy of off-pump and on-pump CABG, demonstrating, as have others, nearly equivalent early results for the two techniques. Their longer-term data should shed more light on this controversial topic and on specific subgroups of patients who might benefit from off-pump CABG.

Disclosure forms provided by the author are available with the full text of this article at [NEJM.org](http://NEJM.org).

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