

EDITORIAL COMMENT

Assessment of Graft Patency During Coronary Artery Bypass Graft Surgery*

Mitigating the Risk

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Graft patency and completeness of revascularization are major determinants of long-term outcome following coronary artery bypass graft (CABG) procedures (1,2). Even though the results of percutaneous coronary intervention are routinely assessed with on-table X-ray angiography, the patency of grafts is not routinely determined during either on-pump (ON-CABG) or off-pump (OP-CABG) revascularization. Methods to assess graft patency during coronary surgery suffer from some combination of being unreliable, cumbersome, time-consuming, costly, or potentially dangerous. Yet in specific circumstances, there is value in intraoperative assessment of graft patency. If methods to document graft patency during CABG surgery were as easy and effective as those used during percutaneous coronary intervention, they would be routinely employed. Choosing the best available technology in the most critical situations may be the correct paradigm to ensure the best surgical outcomes.

[See page 604](#)

The paper in this issue of *JACC* by Waseda et al. (3) compares 2 different methods of intraoperative graft assessment with the gold standard of X-ray angiography. The techniques that the authors compare are transit time flowmetry (TTFM) and intraoperative fluorescence imaging (IFI). Both techniques allow for intraoperative assessment of graft patency that is relatively efficient and noninvasive

while being of low risk to the patient. TTFM, in its various iterations, has been used for several decades, but IFI was first described in 2002 (4).

TTFM uses Doppler signals to assess mean graft flow and pulsatility index (the difference between maximum and minimum flow divided by mean flow). This simple, inexpensive, and readily available method appears to suffer from poor sensitivity (in 1 series, only a 25% ability to detect greater than 50% graft stenosis or graft occlusion) (5,6). Although others have had better results (95% sensitivity, using a cutoff of <15 ml/min) with TTFM technology, they believe that “its main limitation is the lack of standard interpretation of the TTF parameters” (7,8). In the current article by Waseda et al. (3), 289 grafts were studied by X-ray angiography, TTFM, and IFI. Six grafts with acceptable flow by TTFM had graft failure when interpreted by IFI and were revised. Conversely, 21 grafts with “abnormal” TTFM flow demonstrated acceptable patency with IFI (20 of 21 were later confirmed to be patent by X-ray angiography). For these and other reasons, cardiac surgeons have not embraced TTFM technology as a panacea for determining intraoperative graft patency.

Intraoperative fluorescence imaging uses the fluorescence properties of indocyanine green dye to image the newly constructed grafts and the native coronary circulation (9). Indocyanine green may be administered via a central venous line or directly into the bypass graft (better image quality). The maximum penetration of the laser beam is 1 to 2 mm of soft tissue. Intraoperative fluorescence imaging has 3 important drawbacks: 1) it requires direct illumination of the graft (potentially difficult on the back of the heart); 2) the entire graft cannot be imaged in the same sequence by a single central

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venous injection; and 3) it requires at least partial "skeletonization" of pedicled grafts and native coronary arteries to adequately visualize the distal anastomosis. Because of these drawbacks, Waseda et al. (3) found that only 75% of grafts were completely visualized. Nine grafts that had been deemed to have acceptable flow by IFI were later found to be occluded by X-ray angiography (3.1% false negative rate). Although IFI appears to have an advantage over TTFM in sensitivity, it is also more cumbersome, time-consuming, and expensive.

Despite the limitations of IFI, the technology described by Waseda et al. (3) can be used with both ON- and OP-CABG (including minimally invasive direct CABG) techniques. That Waseda and his group (3) clearly believe that long-term outcomes are of primary importance is shown not only by their routine use of IFI during OP-CABG, but also their high-frequency use of arterial grafts (37% internal thoracic arteries, 38% radial arteries, 3% gastroepiploic arteries, and only 22% saphenous vein grafts). OP-CABG is technically demanding and has a steep learning curve (10). The fact that the percentage of CABGs performed off-pump has remained steady for the past 5 years at about 20% (Society of Thoracic Surgeons and Veterans Affairs databases) suggests that the majority of surgeons do not embrace OP-CABG techniques. The potential benefits of OP-CABG (less blood loss, fewer neurologic complications, cost savings, and even improved mortality in female patients) can only be justified if graft patency rates and completeness of revascularization are similar to ON-CABG in the hands of the surgeon performing the procedure (1). Hence the need for a comprehensive, cost-effective, simple to use, and effective method of assuring on-table graft patency.

Waseda et al. (3) focus on the use of IFI technology in the specific circumstance of OP-CABG surgery. They state, "the clinical benefits of OP-CABG are partly offset by a mildly higher rate of early graft occlusion." In fact, several prospective randomized controlled trials and a meta-analysis suggest that grafts performed during OP-CABG have a significantly lower patency rate and have less complete revascularization than grafts constructed ON-CABG (11-13). These results reflect the technical demands of OP-CABG procedures and may account for the surprising 27% utilization of the

intra-aortic balloon pump in the report by Waseda et al. (3). One group even suggested the need for informed consent if OP-CABG techniques are to be used (14). Conversely, a recent publication asserts, "numerous retrospective as well as randomized prospective studies have demonstrated that OP-CABG is associated with decreased risk-adjusted morbidity and mortality compared with ON-CABG" (1,15).

The disparate results described here may be explained by surgical technical ability and dedication to OP-CABG techniques. However, the results quoted are not necessarily mutually exclusive. To resolve the issue, we need long-term follow-up of graft patency and outcomes. A more complete and statistically robust study (Veterans Affairs Cooperative Studies Program #517) is now complete and analyzed. More than 2,200 patients were randomized to OP- or ON-CABG. The primary manuscript is currently in preparation (F. Grover, personal communication, March 2009). These data should resolve the issue of the potential acute advantages of OP-CABG against the potential late problems related to graft failure and less than complete revascularization.

Who should use techniques to ensure intraoperative graft patency and when (10)? Waseda et al. (3) have made an excellent effort to tease out the most effective strategy that ensures graft patency with the greatest likelihood of being accepted by the cardiothoracic surgical community. The most important procedures that will benefit from such real-time analysis include, but are not limited to, anastomoses that are deemed to be technically difficult by the operating surgeon, surgeons initiating an OP-CABG program, and procedures performed in teaching institutions. Given the increase in hybrid procedures being performed in newly equipped operating suites, future opportunity exists to perform on-table graft and native coronary X-ray angiograms during procedures in which graft patency may be in doubt (16,17). When graft failure at the end of 1 year may approach 30%, why settle for less than the gold standard (18)?

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