Decades have passed since studies comparing coronary artery bypass grafting (CABG) with medical therapy for multivessel coronary disease indicated a survival advantage of surgery in the subset of patients with significant left ventricular impairment.1–3 These investigations changed the prevailing clinical impression such that severe left ventricular (LV) dysfunction might be an indication for revascularization as opposed to a relative contraindication. Although the studies might currently be deemed obsolete by many measures, they continue to inform societal guidelines with regard to CABG and LV dysfunction.4,5 Recently, the long-term outcomes after the Surgical Treatment for Ischemic Heart Failure (STICH) trial have reinforced the potential benefits of surgical revascularization in patients with congestive heart failure and an ejection fraction of <35%.6 Over the intervening period, numerous trials have compared percutaneous coronary intervention (PCI) with CABG in patients with stable angina and multivessel disease. Aside from diabetes mellitus, the trials by and large have demonstrated equivalence in the end points of death and myocardial infarction. So can one extrapolate equivalence for PCI with CABG in patients with LV dysfunction? The short answer is no. There is scant direct evidence from randomized trials comparing the 2 methods of revascularization because patients with congestive heart failure or severe LV dysfunction have typically been underrepresented or excluded.7–9

Acknowledging the lack of a large randomized evidence base, there are theoretical reasons why PCI might perform less well than CABG in patients with LV dysfunction. PCI, by its nature, addresses short segments of severe stenosis. However surgery will also address the intervening disease that might progress to become culprit lesions in the future.10 This disadvantage of PCI is likely to be particularly important in patients with limited LV reserve who over the longer term will be less tolerant of repeated myocardial injury from unprotected new culprit lesions, stent restenosis, or thrombosis. Similarly, the acute risk of microvascular embolization (no reflow) is unique to PCI and likely to be poorly tolerated in those with a low LV ejection fraction. In fact, there is a paucity of data on the impact of microvascular function on outcomes of revascularization, which deserves further study.11 Finally, PCI, at least historically, is less apt than CABG to achieve complete revascularization, itself a marker of survival.

But the landscape of PCI is ever changing. The extraordinary pace of adoption of new technologies has meant that some randomized trials comparing CABG with percutaneous transluminal coronary angioplasty, then bare metal stents, and later first-generation drug-eluting stents were considered outdated soon after completion. This is not a criticism of the trials but a fact of life for any trial taking place against a backdrop of change. Current drug-eluting stents, comprising a thin-strut cobalt-chromium (or platinum-chromium) platform, biocompatible polymer, and everolimus (or zotarolimus) antiproliferative agent, represent a major advance over their first-generation counterparts. Second-generation stents are more flexible and therefore able to be delivered in complex anatomy, while possessing remarkably low rates of stent restenosis and thrombosis.12,13 Alongside improvement in the devices themselves, increased use of the radial artery as an access site, judicious use of fractional flow reserve and intravascular imaging, deployment of periprocedural LV support devices, and increased use of the radial artery as an access site, judicious use of fractional flow reserve and intravascular imaging, deployment of periprocedural LV support devices, and increased use of the radial artery as an access site, judicious use of fractional flow reserve and intravascular imaging, deployment of periprocedural LV support devices, and increased use of the radial artery as an access site, judicious use of fractional flow reserve and intravascular imaging, deployment of periprocedural LV support devices, and increased use of the radial artery as an access site, judicious use of fractional flow reserve and intravascular imaging, deployment of periprocedural LV support devices, and increased use of the radial artery as an access site, judicious use of fractional flow reserve and intravascular imaging.

It is within this contemporary milieu of percutaneous revascularization that an article in this issue of Circulation addresses how patients with severe LV dysfunction might be served by multivessel PCI by using everolimus-eluting stents in comparison with CABG.16 Bangalore and colleagues16 performed an observational study, selecting 4616 patients with 2- or 3-vessel coronary artery disease (excluding left main) and LV ejection fraction ≤35% from New York State registries over a 4-year period. Approximately one-third underwent PCI with everolimus-eluting stents, with these patients being slightly older but with less extensive coronary disease in comparison with the remaining two-thirds who underwent CABG. Because of differences in baseline characteristics between PCI and CABG groups, propensity score matching was used to generate 1063 matched pairs, enabling the authors to compare the effectiveness of the 2 therapies. Overall rates of long-term all-cause mortality were found to be no different between the 2 groups. There were fewer strokes with PCI, but more myocardial infarctions and repeat revascularizations over a median follow-up of 2.9 years.

**Percutaneous Coronary Intervention Versus Coronary Artery Bypass Grafting in Patients With Left Ventricular Dysfunction**

Do We Have the Evidence?

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The opinions expressed in this article are not necessarily those of the editors or of the American Heart Association.

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(Circulation. 2016;133:2125-2127. DOI: 10.1161/CIRCULATIONAHA.116.022733.) © 2016 American Heart Association, Inc.

Circulation is available at http://circ.ahajournals.org DOI: 10.1161/CIRCULATIONAHA.116.022733
Several limitations to the analyses merit consideration. As the authors acknowledge, although sophisticated statistical matching might adjust for differences in baseline variables, it cannot eliminate the effect of these differences completely. More so, it cannot account for unmeasured confounders that are inherent to any observational study. Selection bias is part and parcel of clinical decision making. Unmeasured factors that might have influenced clinician recommendations include the presence of diffuse rather than focal disease (SYNTAX score was not recorded) and extent of noncardiac comorbidities. Of the numerous noncardiac comorbid conditions that influence outcomes in the contemporary population undergoing PCI, only chronic obstructive pulmonary disease and dialysis were recorded and accounted for in the current study. Similarly, patient-specific values and preferences cannot be accounted for in this comparative effectiveness analysis.

A recent single-center study showed that the majority of deaths after multivessel PCI in the current era are from noncardiac causes. The primary end point of the current study was all-cause mortality. More might have been learned with knowledge of cause-specific mortality. Were rates of noncardiac mortality similar between groups? This would have strengthened the case for adequacy of matching. Were cardiac deaths the same in both groups? This might have lent credence to the authors’ conclusions that PCI with everolimus-eluting stents is an acceptable alternative to CABG in patients with multivessel disease and LV dysfunction.

Although randomized, controlled trials may be the gold standard for evidence, these too have their limitations. These include entry bias in regard to the inclusion criteria that mandate clinical equipoise for both therapies and are therefore more selective and less applicable to practice at large. The duration of the trials required to complete enrollment is another limitation, particularly in the setting of rapidly changing technologies. But is it what it is, and we need to understand that registries and trials each have their limitations but can be in use in a complementary manner. An example of the differences between trials and registries was demonstrated in the Bypass Angioplasty Revascularization Investigation (BARI) studies. In the randomized trial, diabetic patients fared poorly with percutaneous transluminal coronary angioplasty. But in the nonrandomized registry they fared equally well in comparison with those treated by CABG. This is because in clinical practice (as is reflected in the registry) higher-risk patients were preferentially referred for CABG. This practice, which is appropriately based on existing evidence, must also be occurring in the New York State population, and conclusions of observational analyses must therefore be tempered.

What can we make of the authors’ tentative suggestion that with a lower stroke risk and faster recovery time, PCI might be preferable to CABG for the majority of patients with multivessel disease and severe LV systolic impairment? History teaches us that it is never a good idea to write off CABG. The authors’ own analyses suggest a signal for survival advantage for CABG in patients with 3- vessel rather than 2-vessel disease. This is consistent with findings of numerous randomized trials indicating that subgroups with extensive or diffuse disease fare better with CABG. More so, any potential benefit of CABG may not become apparent for many years, certainly longer than the follow-up period of the current study. As an example, the STICH trial comparing CABG with medical therapy in patients with ischemic LV dysfunction showed no significant mortality difference between treatment arms at 5 years, but a substantial survival advantage for surgery after 10 years.

The current study suggested that completeness of revascularization with PCI attenuated the outcome gap between PCI and CABG. It is interesting, however, that this was achieved in only 20% of the PCI group (before matching). Although the reasons for this seemingly low proportion of complete revascularization will be multifactorial, anatomic deterrents might include the presence of a chronic total occlusion. With recent major advances in techniques and success rates for chronic total occlusion intervention, complete revascularization by PCI should soon be achievable in greater proportions of patients with multivessel disease. There is potential for improvement in surgical outcomes too. The majority of CABGs in the New York State registry used a single arterial graft. With increasing recognition that multiple arterial conduits confer better long-term outcomes, it is possible that the PCI-CABG gap may widen again in future.

How else might the study of Bangalore and colleagues inform contemporary clinical practice? With the burgeoning population of older patients presenting with coronary disease, burdened by comorbidities, it seems reasonable to allow LV function to drop down the priority list of factors that inform revascularization decisions in these patients. Whether LV function should be dismissed altogether as a decision factor for PCI versus CABG in younger, less comorbid patients or in those perceived to be at higher risk for recurrent cardiac events is less certain.

To get back to the original question: Do we have the evidence? The answer is unequivocally no and what is needed is the inclusion of more patients with LV dysfunction and heart failure in future trials of revascularization. Comprehensive registries such as the New York State registry play a role in demonstrating results in a wide practice setting but provide only 1 piece of the evidence to guide clinical decision making.

Disclosures
Dr Gersh reports consulting (minor) for Boston Scientific Corp and Medtronic Inc. Dr Gulati reports no conflicts.

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KEYWORDS: Editorials; coronary artery bypass; coronary artery disease; percutaneous coronary intervention; stents; ventricular dysfunction, left
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Circulation. 2016;133:2125-2127; originally published online May 5, 2016; doi: 10.1161/CIRCULATIONAHA.116.022733
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

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