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CABG at 50 (or 107?) - The Complex Course of Therapeutic Innovation

David S. Jones, M.D., Ph.D.

Department of the History of Science, Harvard University, Department of Global Health and Social Medicine, Harvard Medical School

Anniversaries offer physicians an opportunity to commemorate the crucial discoveries of modern medicine, such as vaccination (14 May 1796), ether (16 October 1846), or insulin (11 January 1922). However, zeroing in on a specific date can obscure important dynamics. Innovation in medicine is a complex and continuous process, not a single moment in time. The history of coronary artery bypass grafting (CABG) demonstrates the subtleties well. This week marks the fiftieth anniversary of an important event: on 9 May 1967 Cleveland Clinic surgeon René Favaloro performed his first CABG. By 1970 he and his colleagues had performed over 1000 operations. Impressed by his results, surgeons throughout the United States adopted the technique. But even though Favaloro's work popularized CABG, he was not the first to perform the operation. Moreover, he quickly modified his initial approach to CABG. Favaloro and other surgeons have subjected the operation to ongoing modification ever since. CABG, like all significant medical interventions, is the product of innumerable innovations by many physicians. The histories we tell must reflect this.

The idea for CABG had existed for decades. In 1910 Alexis Carrel published in *Annals of Surgery* an account of an operation he performed on a dog: he used a segment of carotid artery to connect the descending aorta to the left coronary artery.^(1, 2) If the key aspect of innovation is the idea, then Carrel has no rival for CABG. Carrel, however, only reported a single, unsuccessful attempt. The dog developed ventricular fibrillation and died. Carrel concluded that the procedure would only succeed if a surgeon could complete the anastomoses in under three minutes, something beyond even his prodigious surgical skill.

Discouraged by Carrel's experience, surgeons tried other approaches to tackle coronary disease over the next fifty years.^(1, 2) Some reduced cardiac workload with thyroidectomy or sympathectomy. Others tried to increase blood supply to the myocardium by dusting the heart with asbestos to induce vascular adhesions, suturing omentum onto the heart, ligating or implanting the internal thoracic artery, or ligating the coronary sinus. CABG, however, was not forgotten. In the 1940s and 1950s Toronto surgeon Gordon Murray conducted animal experiments. He excised coronary segments, inserted interposition grafts, and placed bypass grafts from various arteries. Ventricular fibrillation and graft thrombosis occurred frequently. Moscow surgeon Vladimir Demikhov also experimented with coronary bypass grafts, successfully anastomosing the internal thoracic artery in dogs in July 1953.⁽³⁾ Michael DeBakey surveyed the field in 1964 and found twelve or fourteen laboratories

working on coronary artery bypass. He did not think that any of these techniques, with an average success rate of just 50 percent, were ready for human use.(2)

Surgeons, however, had begun to try.(1, 2) In May 1960 German emigre Robert Goetz anastomosed the right internal thoracic artery onto the right coronary artery of a patient at Van Etten Hospital in the Bronx.(4) In 1962 David Sabiston used a saphenous vein graft to create a bypass from the ascending aorta to the right coronary artery. Leningrad's Vasili Kolesov performed a successful internal thoracic artery bypass graft in February 1964; he completed over thirty operations by 1969.(3) In November 1964 Edward Garrett and DeBakey placed a saphenous graft between the aorta and left coronary artery. Donald Kahn and William Longmire each performed two procedures in 1966. Most of these surgeons were discouraged. Goetz's colleagues prevented him from performing a second bypass.(4) Sabiston became discouraged after his patient died from a post-operative stroke. Garrett's patient experienced a perioperative infarction. One of Longmire's patients died during the surgery and other patient's graft failed. Only Kolesov pursued a long case series.

If credit belongs to the surgeon who operated first on a patient, then Goetz wins the prize. He was also the first to publish, though he buried his achievement in a two-sentence addendum to a 1961 article about his animal experiments.(3) Kolesov published his results -- in Russian -- in 1965.(3) Longmire published in 1966, but in a French journal.(2) Kolesov reported his results on twelve patients in the *Journal of Thoracic and Cardiovascular Surgery* in October 1967. Sabiston, Garret, and Kahn did not publish until much later (1974, 1973, 1971).

Favaloro went next. Forced by politics into self-imposed exile in rural Argentina, Favaloro aspired to become a cardiothoracic surgeon.(2, 5) He flew to Cleveland in January 1962 with only a letter of introduction. As he worked his way up from resident to staff surgeon, he gained expertise with many coronary techniques, including internal thoracic artery implants, endarterectomy, and patch grafts. In 1966 his attention turned to CABG. Favaloro later explained that he learned about saphenous vein grafts from vascular surgeons who used them to repair renal artery stenosis. He likely knew about Kolesov as well. Kolesov had submitted his manuscript to the *Journal of Thoracic and Cardiovascular Surgery* in November 1966. The journal's editor, Brian Blades, sent it to Donald Effler, Favaloro's mentor, for comment. It is likely that Effler read Kolesov's report before Favaloro's first attempt.

Favaloro performed a saphenous vein interposition graft on 9 May 1967.(1, 2, 5) He completed another thirteen before performing his first aorta-to-coronary graft on 19 October. When he published the results from his first fifteen patients in April 1968, he mentioned another 40 in an addendum. His results were soon corroborated by two other surgeons, Dudley Johnson in Milwaukee and George Green in New York. Their case series buttressed Favaloro's claims about the value of CABG. American surgeons adopted the operation enthusiastically. They performed over 100,000 procedures annually by 1977, and over 600,000 in 1997. CABG also provided a crucial precedent for coronary angioplasty, first described by Andreas Grüntzig in 1977.

Surgeons refined CABG continuously. They tested different conduits, including the gastroepiploic artery and radial artery autografts. They learned to place multiple grafts to provide more complete revascularization. They expanded the clinical indications for the procedure: Kolesov performed a CABG for acute myocardial infarction in February 1968 and Favaloro did the same that April.⁽¹⁾ Technical innovations improved clinical outcomes and reduced complication rates. Beating heart CABG and minimally invasive procedures became popular in the 1990s, though these have not replaced traditional approaches. New diagnostic technologies (e.g., intravascular ultrasound, fractional flow reserve) allow more careful patient selection. Patients can now choose hybrid procedures with a combination of angioplasty, stents, and bypass grafts. Biomedical engineers work to develop synthetic vascular grafts, while public health advocates continue to remind us that coronary disease itself is largely preventable.

With every innovation came demands that surgeons submit their techniques to the rigorous standards of the emerging field of evidence based medicine. CABG was one of the first major operations subjected to a randomized controlled trial. The first of these, the Veterans Administration Cooperative Study, appeared in this journal in September 1977. Scores of others have followed. The Society of Thoracic Surgeons established a national cardiac surgery registry in 1989. This has facilitated ongoing efforts at quality improvement. That same year New York state began public reporting of cardiac surgery outcomes. These efforts have made CABG perhaps the most thoroughly examined operation in the surgical repertoire. Cardiac surgeons and cardiologists now collaborate on heart teams to provide the best data to their patients to enable shared decision making.

Coronary revascularization, a major sector of the health care economy, has relieved angina in countless patients and extended the lives of many. Favaloro and his colleagues at the Cleveland Clinic often receive credit for having “revolutionized the treatment of ischemic heart disease.”⁽¹⁾ What was the nature of that revolution? They did not discover the idea of CABG. They were not the first to attempt it. Instead, they orchestrated a case series (something Kolesov had done) and presented their results in a way that persuaded other surgeons (Kolesov had not). Favaloro’s May 1967 operation thus represents not an innovation in surgery but the beginning of the process by which an existing innovation won acceptance. Once accepted, CABG did not remain static. Favaloro’s operation was but one moment in the continuing evolution of the procedure, a multifaceted process of social and scientific innovation that continues today. While it is important to acknowledge key moments in the history of an innovation, it is essential to appreciate innovation’s full complexity.

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