Cardiac angiography and the progress of heart surgery

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The modern era of cardiac angiography began in 1954 with the advent of the fluoroscopic image amplifier. Before that time, from the early 1940s, two groups of physicians were involved in the performance of clinically oriented studies to clarify the nature of cardiac abnormalities. Radiologists were developing angiocardiographic techniques with progressively sophisticated large film changers and cardiologists were involved in the development of catheterization techniques to explore the cavities of the heart and great vessels for the measurement of pressures, flows, and shunts. Both techniques were constrained by severe limitations. In the study of congenital malformations of the heart, physiologic data obtained in the study of complex malformations were often inadequate to define the true anatomic nature of the malformations. In contrast, attempts to introduce relatively large quantities of contrast agent into peripheral veins to photograph its passage through the heart were attended by high risk, particularly in cyanotic patients. Simultaneous opacification of multiple overlapping intracardiac structures severely limited precise identification of intracardiac pathology. However, these limitations were not of overwhelming importance in the era when our surgical efforts were confined to excision of aortic coarctations, ligations and division of pa-

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tent ducti and closed mitral commissurotomies. They were, however, occasionally responsible for tragic diagnostic errors that led to the misapplication of surgical efforts to produce aortic-pulmonary shunts in patients with cyanotic congenital malformations.

The advent of true intracardiac surgery, facilitated by the development of the pump oxygenator in 1954, spurred the demand for more precise definition of intracardiac structures. The advent of the fluoroscopic image amplifier at about the same time provided a means to meet this demand during the period 1955 to 1960. This instrument facilitated the development of techniques that combined catheter exploration of the heart and great vessels with selective opacification of individual chambers of the heart with relatively small doses of contrast agents, recording the images with motion picture photography. Exploitation of these techniques during that period provided a marked improvement in our ability to understand the nature of complex intracardiac malformations and provided our surgical colleagues with information that was absolutely essential to their efforts to close septal defects and aortic pulmonary windows, and to relieve intracardiac obstructions.

By 1958 we were aware that the application of these techniques might provide a better basic standard of diagnosis for patients with coronary artery disease. The basic premise was and remains simple. In most of these patients, angina pectoris, myocardial infarction, and death are caused by obstructive lesions in the coronary arteries. If the location and severity of these obstructions could be precisely defined, we should be able to reduce significantly diagnostic errors, provide an objective means to evaluate the success or failure of available therapeutic efforts and to study the natural history of the disease.

In 1958 we undertook a series of studies in dogs directed toward this end. We quickly learned that selective injection of contrast media into the right or left coronary sinus provided consistently better visualization of the coronary artery arising from that sinus than we could accomplish by the use of larger quantities of contrast agents in the performance of aortography. In collaboration with our surgical colleagues we learned that we could recognize the presence and relative severity of obstructions produced by incomplete ligation of branches of the left coronary artery. In 1959, for the first time we were able to demonstrate patency of an anastomosis of the left brachiocephalic artery to the divided anterior descending coronary artery of a dog. During that period we were also able to demonstrate in the human by selective opacification of the internal mammary artery that pericardial poudrage failed to provide an increment of new myocardial perfusion as postulated by Claude Beck.

In early 1959, during the performance of an aortogram in a patient with severe rheumatic heart disease, we accidentally injected 40 cc of 90% Hypaque into the right coronary artery. This caused transient cardiac arrest, which was overcome by the simple expedient of having the patient cough forcibly, in order to force opacified blood through the myocardial bed. Normal sinus rhythm was restored within approximately 15 seconds. This experience led to the development of deliberate selective coronary arteriography.

In January 1961, we studied a patient in whom Vineberg had 5 years previously performed an internal mammary artery implant and for the first time demonstrated that this technique could

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provide a small source of myocardial perfusion. During the years that followed, Effler and later Favaloro extended this technique in an effort to improve myocardial perfusion to all major segments of the left ventricle. In 1961 and 1962 we were able to document a few successful efforts by Effler to overcome severe localized coronary artery obstructions by the use of vein or pericardial patch grafts.

By 1962 we were able to demonstrate the physiologic and morphologic characteristics of early efforts to replace aortic and mitral valves in patients with severe valve regurgitation or calcific stenosis. Since these early efforts were made with Starr-Edwards prostheses, similar studies have continued through the years with a large series of valve configurations.

In May 1967, Favaloro performed what we thought was the first interposed vein graft to overcome a severe obstruction in the right coronary artery. We did not learn until 1971 that a successful bypass vein graft to a coronary artery had been performed earlier by Garret in Houston. From 1967 through 1970 we enjoyed the privilege of studying the successes and occasional failures of Favaloro's efforts to extend the use of bypass vein graft techniques to all major segments of the coronary artery tree.

In 1972 we began to evaluate the efforts of Favaloro and Loop to use the internal mammary arteries as bypass grafts to the left anterior descending coronary artery and to proximal segments of the left circumflex coronary artery. In the study of hundreds of such patients in the years since we have documented patency with effective perfusion in 97% of such grafts. In our experience this patency rate is significantly higher than any that has been attained with vein grafts.

As these efforts continue with the long-term passing of time, it becomes progressively more evident that they have been richly rewarded by significant improvements in the longevity and functional capacity of thousands of patients with coronary arteriosclerosis. We hope to see the day when they may help to document objectively successful prevention of the disease.

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