SURGICAL TREATMENT OF ANGINA PECTORIS: A FIFTY YEAR RETROSPECTIVE FROM BAYLOR/METHODIST

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INTRODUCTION

In 1961, we described the surgical treatment of coronary artery disease when surgeons were only beginning to realize that the mechanical blockages might be amenable to operation.1 This report reviews briefly the experimental and clinical approaches to the surgical treatment of coronary occlusive disease, including the role of the Baylor/Methodist investigators.

In 1768, William Heberden[2] first described the syndrome of angina pectoris, stating that "...the sense of strangling, and anxiety with which it is attended, may make it not improperly be called angina pectoris." Edward Jenner3 was the first to correlate angina and coronary disease. His patient, John Hunter, died from calcification of the coronary arteries in 1793, as shown by autopsy. In a letter to Heberden, Jenner3 hypothesized a correlation between Hunter's anginal attacks and the pathologic findings in the coronary arteries. Hunter's angina attacks worsened, and although he did not know the cause, he described its manifestations and noted the emotional component: "My life is in the hands of any rascal who chooses to annoy me," and, indeed, he died during an angry quarrel with his colleagues at St. George's Hospital about teaching programs.4

In 1876, Hammer5 made the first clinical diagnosis of coronary artery occlusive disease in a patient with angina, confirmed by autopsy. Despite these early observations, the role of angina pectoris in coronary occlusive disease was established only after Herrick's report in 1912,6 which provided histologic and electrocardiographic evidence to support this association.

EARLY SURGICAL TREATMENTS

In the earliest surgical treatment of coronary artery disease and cardiac pain, three approaches were considered: (1) the sympathetic nervous system, (2) the thyroid gland, and (3) the collateral blood supply co the heart.[7] In 1899, Francois-Frank[8] and Jonnesco[9] first suggested relief of pain by cardiac denervation and in 1916 successfully performed the procedure. In 1933, Blumgart and associates[10] advocated total thyroideccomy to control cardiac pain, and shorrly thereafter Cutler and Levine[11] performed the procedure for chis purpose. These approaches proved of little value and were soon abandoned. In 1935, Claude S. Beck[12] devised and advocaced the third, more rational approach: developing a collateral circulation to produce a new blood supply to the heart by grafting tissue to the myocardium. He reported relief of angina in a patient several months after he performed a staged operation of roughening of the pericardium, followed by grafting part of the pectoral muscle to the roughened surfaces. Inspired by Beck's experiments and clinical report, others used a variety of different tissue grafts to the myocardium, including omentum,13 stomach,14 jejunum,[15] skin,[16] and lung.[17,18] Over time, none of these procedures proved effective and were therefore not widely accepted.

In the meantime, reports began to appear that ligation of the coronary sinus in animal experiments permitted survival after obstruction of the coronary arteries,[19] a procedure subsequently performed in man with mixed results.[20] It was lacer abandoned after more precise studies showed little effect. Beck,[21] who became incerested in this approach in 1941, initially designed his Beck I procedure co consist in abrasion of the pericardia! surfaces, application of asbescos as an irritant, and partial occlusion of the coronary sinus. His Beck II modification consisted in the application of an aortocoronary sinus graft during the first stage, followed by narrowing of the coronary sinus at its entrance to the right atrium.22 This procedure also failed to gain popularity.

In 1941, Arthur Vineberg proposed another method of increasing the arterial blood supply to the myocardium by direct myocardial implantation of the freely bleeding cut end of the internal mammary artery. Over the next decade, Vineberg and colleagues,[23] along with others, reported encouraging clinical results, but the procedure was later overshadowed by more direct surgical approaches co increasing the coronary blood supply.

The more direct approach began clinically with the application of endarcereccomy, first devised and reported by dos Santos[24] in a patient with occlusion of the femoral artery in the groin caused by a thrombus superimposed on an atheroma. We used this procedure clinically first for occlusions of the common and internal carotid artery.[25] In 1956,

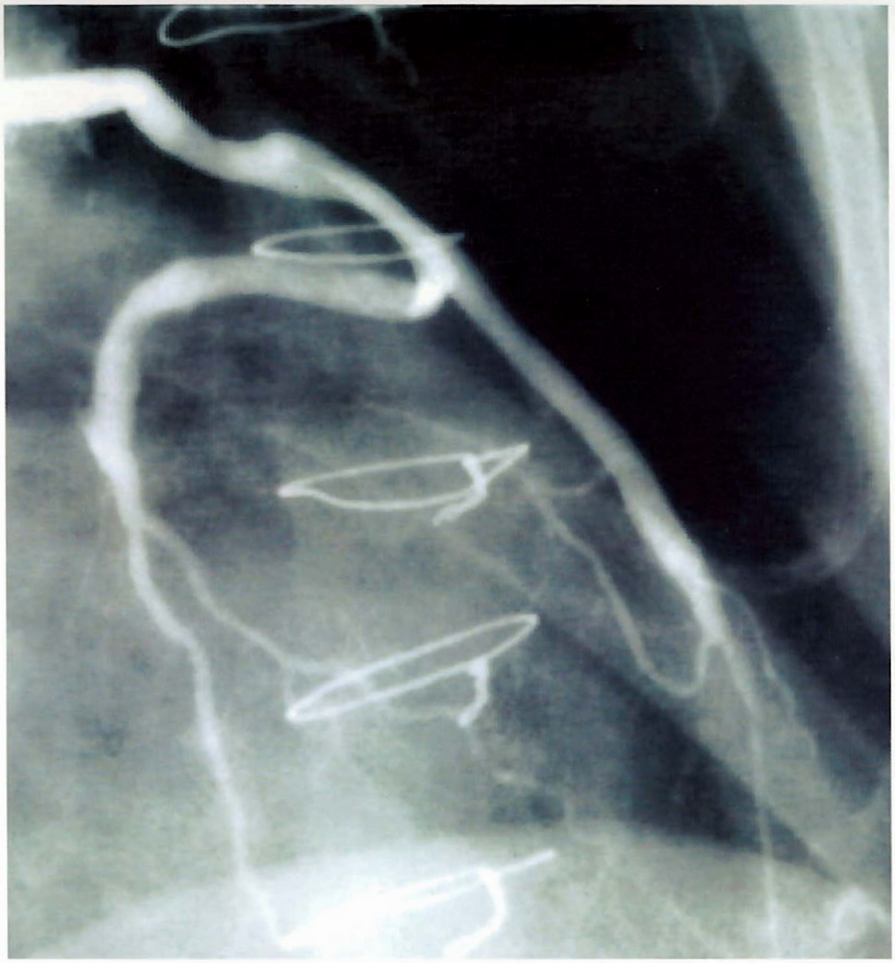

Figure 1. Photograph of coronary angiogram of patient with angina pectoris due to severe stenosis of the left main coronary artery, performed 27 years after coronary bypass operation consisting in homogenous saphenous vein attached distally to the left anterior ascending and obtuse marginal coronary arteries. The angiogram demonstrates the saphenous vein to be functioning normally, with no deterioration in structures. The patient has remained asymptomatic and is reasonably active, traveling to the Middle East annually.

Bailey and associates2[6] first applied ir in coronary occlusive disease. A number of ocher invescigators[27,28] reported clinical uses of this technique wich encouraging results, bur the procedure failed co gain wide application as interest in ocher direct surgical approaches developed.

In a report ofhis experimental studies to the American Surgical Associacion in 1910, Alexis Carrel[29] originally proposed the concept of coronary bypass for occlusive disease. He had used a carotid artery homograft anastomosed proximally co che descending thoracic aorta and distally to the left coronary artery in a dog. Although the dog survived only two hours, Carrel stated that "In certain cases of angina pectoris, when the mouth of the coronary artery is calcified, it would be useful to establish a complementary circulation for the lower part of the arteries."

In all these efforts to improve myocardial circulacion, the effectiveness of the procedures was measured by sympcomacic relief of pain, incerval before another cardiac event, or histologic-pachologic change. Thus, in order to evaluate procedures used to improve the coronary circulation, it seemed logical that a test should be developed to measure myocardial blood flow accurately. In the laboratories of Baylor College of Medicine in Houston, che use of radioisotopes was proving promising.[30] The significance of these efforts was diminished when Mason Sones3[1] and coauchors were able co visualize the encire coronary arterial system by direct injection of radio-opaque dye into the major coronary arteries. Although he described this technique in 1959, several years passed before the true value of this procedure was recognized. Ar about this time, the late Paul R. Ellis Jr.,[32] working in the Baylor laboratory, was successfully repairing opened coronary arteries in dogs with aucogenous vein patches. The long-term feasibility of these patches had been proved by prior research on che face of such grafts.[33] We began using multiple small Dacron tubes co bypass all major coronary arteries (Figure 1). Because rhe dogs had difficulty surviving che heart-lung bypass, we devised techniques to place these grafts "off pump."[1] Aucogenous saphenous veins were being used successfully in patients as peripheral arterial bypasses. Thus, che stage was sec for the first successful vein aorcocoronary artery bypass.

On November 23, 1964, a patienc was scheduled for possible endartereccomy of the anterior descending coronary artery. The pacienc's arheromacous disease, however, was found to be too extensive and rhe contemplated procedure too hazardous. Garrett, Dennis, and DeBakeywrote in their published report that, based on the animal experiments, it was decided co perform aortocoronary bypass immediately using an autogenous saphenous vein. Forrunacely, che patient recovered unevemfully, became asymptomatic, and resumed normal activities. Seven years after operation, an arceriogram showed the bypass graft functioning well. This proved to be che first successful case of aorcocoronary (vein) bypass.[34] Experimental methods chat prepared che way for this first successful case are outlined in Table I.

In 1958, Longmire, Cannon, and

Kattus[27] anastomosed a mammary artery to the distal end of a patient's right coronary artery that had disintegrated after endarterectomy. On April 4, 1962, Sabiston[35] performed a coronary bypass on a patient, using a saphenous vein attached to the ascending aorta proximally and anastomosed ω che right coronary artery distally. A few days later, the patient had a stroke and died. Favaloro's[36] work in 1968 was followed by his report in 1969 of clinical experience in 100 patients with coronary artery disease operated on at the Cleveland Clinic.[37] That same year, Dudley Johnson and coworkers[38] published their bypass experience.

Table 1. Occlusive Disease of the Coronary Arteries
Direct Methods of Surgical Treatment

Experimental

1. Homograft carotid artery from descending aorta to branch of left coronary artery - Carrel 1910[29]
2. Resection and vein graft replacement - Murray 1953[28]
   Carotid-coronary bypass - Murray 1954[61]
3. Internal mammary to circumflex bypass - Thal et al. 1955[57]
4. Internal mammary & carotid artery to circumflex - Absalon et al. 1956[58]
5. Systemic to coronary artery - Baker & Grindlay 1959[60]
6. Systemic to coronary anastomosis - Moore & Riberi 1958[59]
7. Ascending aorta to coronary bypass - DeBakey & Henley 1961[1]

Clinical

1. Vein graft bypass ascending aorta to right coronary - Sabiston 1962[35]
2. Vein graft bypass ascending aorta to LAD - Garrett & DeBakey 1964[34]
3. Internal mammary - Kolessov 1967[62]
4. Resection and interposition vein graft - Favaloro 1968[36]
5. Autogenous saphenous vein bypass - Johnson et al. 1969[38]
6. Autogenous saphenous vein bypass ascending aorta to coronary arteries - Favaloro et al. 1970[64]
7. Internal mammary anastomosis - Green 1968[63]

ADDRESSING SURGICAL CHALLENGES

With the bypass principle now firmly established, cardiac surgeons began trying to solve emerging problems associated with the new procedure. An advantage for the Methodist/Baylor team was the number of capable cardiac surgeons, assembled under the leadership of Dr. DeBakey, who helped develop the bypass operation into the safe and effective procedure that is now done every day in The Methodist Hospital in Houston.

An initial technical problem was the conduit-coronary connection. Under the microscope, in che experimental laboracory, che fine anerial silk sutures were seen to be unsatisfactory fur precise anastomoses. F. Coghill Usher, a hernia surgeon, was working in the Baylor laboratory with high-density polyethylene (Marlex®) to determine its tissue reaction. From these efforts ultimately came the fine Prolene® sutures chat make small anastomoses easier, secure, hemostatic, and long-lasting. A second technical matter was the performance of a precise connection of the graft to a small artery 1-3 mm in diameter. J. Alex Haller of Johns Hopkins had remarked ω a Houston surgeon that he was performing all of his operations on children using optical loops fur magnification. This comment resulted in immediate use of loops in the surgical laboratory, where they proved so helpful chat chey soon appeared routinely on every surgeon in every operating room.

During initial coronary bypasses, anoxic cardiac arrest was used in order to permic precise anastomosis. This technique was associated with 10-20% perioperative myocardial injury, which often adversely affected the surgical outcome. This complication diminished with use of mild body hypothermia (30°-32° C) and local cardiac cooling with iced-saline slush. Insulating pads were placed within che pericardia! sac ω prevent permanent injury to the phrenic nerves. To prevent perioperative myocardial damage relating ω ischemic arrest, some surgeons used electrically induced/sustained ventricular fibrillation. This reduced cardiac injury but produced new technical problems relating to cardiac motion and maintenance of coronary flow during anastomosis. The effect of potassium on the heart has long been known ω cardiac physiologists. Melrose and associaces[39] introduced potassium-induced cardiac arrest in London around 1955. This technique was slow to disseminate through the cardiac surgery world, but with the addition of cold blood-potassium-induced arrest, myocardial protection significantly improved. Further improvement occurred when surgeons, recalling Beck's coronary sinus operation, began retrograde coronary sinus perfusion by inserting a catheter into the sinus through the right atrium. With these newer myocardial protective techniques, speed of anastomosis gave way to precision - with significantly improved resulcs.

THE USE OF MAMMARY ARTERIES FOR GRAFTING

Reversed autogenous saphenous veins in extremities seemed to function satisfactorily over time. Whether chis would be the case for veins used as heart conduits was not known. Indeed, some of these venous bypasses were found m have occluded soon after insertion. Experimental work in our laboratory had shown chat small tubes of Dacron (4 mm) and ocher synthetic materials tended to be associated with early thrombosis. Logic suggested a more suitable conduit. The internal mammary artery had been used many times, initially by Vineberg,[23] as a pedicle graft placed in a myocardial tunnel. It was natural that this vessel be considered an alternative to veins as a suitable bypass conduit. Ir is not clear who first used chis vessel experimentally or clinically for coronary flow augmentation. Even though the mammary artery proved an acceptable graft, its use was slow co become popular, perhaps because of che increased time needed to prepare the vessel for bypass. In our institution, Garrett early recognized che significance of the mammary artery as an excellent conduit. On his departure for Memphis, he remarked to an associate: "Continue to employ mammaries for bypass, and you will be doing a superior operation." Although controversial at that rime, this vessel has proved to be the cornerstone of bypass surgery. In order to extend the effectiveness of cardiac revascularizacion, arterial conduits have been used to bypass all major coronary vessels. Mammary arteries, radial arteries, and gastroepiploic arteries are now used with all arcerial grafts to provide revascularization. These grafcs are considered superior co veins, but it is not unusual for a cardiologist to report co the surgeon that he scudied a patient operated on years before and the veins "look new."

Results of coronary bypass surgery have been gratifying.[40,46] The operative morcality race of patients under 64 years of age is less than 2%, about 5% at 79 years of age, and 8% at 80 years of age. A number of studies, including ours, have reported follow-up daca.[40-46] In general, they show a 5-year, 10-year, 14-year, and 25-year survival expectancy of about 92%, 78%, 50%, and 19%, respectively. Eighty percent of patients under 65 years of age have been able co continue working more than five years after operation. Angina is relieved in most patients, with almost 70% remaining asympcomacic. Graft patency has been found in 82% of patients at five years after operation and 50% at 10 years after operation.

In chis connection, we obtained coronary angiograms on a patient on whom we performed coronary bypass surgery 27 years ago for severe stenosis of the left main coronary artery, using saphenous vein homografts to the left anterior descending and obtuse marginal coronary arteries. It was gratifying that these grafts were functioning normally and the structure of the grafts looked good (Figure 1). The patient has remained asymptomatic.

MEDICAL VS. SURGICAL TREATMENT OF ATHEROSCLEROTIC CORONARY DISEASE

More than 25 years have passed since Griintzig, Senning, and Siegemhaler[47] performed che first percutaneous coronary arrerioplasty. Since then, che technique for nonsurgical treatment of acherosderotic coronary disease has improved significancly. Simple dilation of coronary stenoses and placement of seems of early design carried a significant restenosis race. Removal of lesions by lasers and rotoblades proved hazardous and shore-lived. The recent use of drug-eluting scents (DES), designed to prevent or reduce troublesome restenosis, is both exciting and encouraging. Recent randomized trials show little difference in postoperative stroke, myocardial infarction, and death races for bypass recipients and stem recipiems.[48] The advantage of bypass over angioplasty/scenting in preventing additional revascularization remains significant but has narrowed. Surgical patients with severe mulcivessel disease had better long-term survival and fewer repeat revascularizations than a comparable group of scent patients.[49] More recendy, Hannan[50] reported that patients with two or more blocked arteries live longer if they have bypass surgery than if they have angioplasry and stenting. At six years after operation, survival expectancy was 81% after coronary bypass and 66% after percutaneous dilation and stenting.48 The absolute value of improved scenting techniques is yet co be known. Scenting methods are currently being compared co the gold standard coronary artery bypass graft (CABG). The use of bare metal stems improved the results of percutaneous cransluminal coronary arterioplascy, and the more recent introduction of DES holds even greater promise.51 Yet co be determined, however, is whether treatment of severe disease by seeming matches or is superior to CABG. Randomized studies are in progress to learn if the newer scents and scenting techniques yield superior results to surgery. These studies compare not only mortality and morbidity rates but also consider subsequent revascularizarion efforts, cost effectiveness, and quality of life. The results may allow more valid decisions regarding optimal initial treatment of patients with the most severe disease.

A major complication plaguing patients placed on cardiopulmonary bypass has been unexpected neurologic deficits. In che beginning, insufficient cerebral perfusion may have been a factor, but most of these residual problems are now attributed to debris or air emboli. Surgeons have devised many techniques to minimize chis complication, including careful palpation of the aorta before aortic cannulacion, use of a closed-tip cannulation catheter, use of special atraumatic aortic clamps, single application of aortic clamp or no-clamp technique, correct positioning of aortic perfusion cannula, and careful removal of all air from heart, grafts, and aorta. Because this complication can turn a successful operation into tragedy, cardiac surgeons have begun to perform coronary grafts "off-pump." This technique, available in most hospitals, avoids aortic cannulation and cardiopulmonary bypass. Although there are technical advantages and disadvantages to bypass off-pump, statistical studies to date have failed to show chat this technique minimizes adverse neurologic changes.[52]

Today, angioplasties outnumber bypass operations three to one. Although the number of coronary operations is decreasing, patients scheduled for operation are sicker and have atherosclerotic disease that is technically more difficult to treat. This is to be expected, and it is the challenge of tomorrow. As always, when surgical or interventional therapy is touted as successful in altering the natural course of coronary disease, critics arise. Nortin M. Hadler is quoted by John Carey[53] as stating that bypass surgery "should have been relegated to the archives 15 years ago." David Waters has also been quoted by Carey[53] as saying: "There is no evidence that opening chronically narrowed arteries reduces the risk of heart attacks." Such comments from the medical profession naturally prompt patients and insurance payors to ask: "ls it worth it?" Recent work by Han nan and associates,[50] comparing more than 37,000 patients treated in New York hospitals, provided convincing evidence that long-term survival rates of bypass operations in patients with mulrivessel disease are superior to those after scenting. The Hannan study underscores the value of clinical databases and questions the accuracy of results stemming from small series of patients. Herz and colleagues[54] have demonstrated that improved resulcs of percutaneous coronary intervention (PCI) can be obtained with DES, but mid-rerm clinical outcome of multivessel patients treated with bilateral internal thoracic artery grafting is even better.

David P. Taggart of Oxford suggested that trials touting PCI have included patients of very low risk and have excluded 95% of pocential patients. His data support the view that today CABG remains superior to PCI for treating certain types of coronary artery disease.[55]

Enthusiastic interventionists have suggested that DES will put bypass surgeons out of business. Shahzad G. Raja[56] of Glasgow has recently published a review of the effect of DES on CABG. He stresses that "...important safety issues such as thrombosis, late stent malapposition, aneurysm formation, edge effect, late inflammation due to choice of polymer used to bind the drug, the release of toxins, and potential interaction with brachytherapy have nor yer been completely addressed."[56] Nor included in this review is an evaluation of the cost-effectiveness of routine use of DES. Raja suggests that DES and CABG be considered as complimentary therapy. His review supports Taggart's argument chat every cardiac patient being considered for palliative treatment should have a multidisciplinary knowledge of che options and risks of treatment, specifically including counseling by a coronary surgeon.

CONCLUSION

Isolated single significant stenoses in the left main or proximal left anterior descending coronary arteries are termed "widow makers," indicating the importance of treating single-vessel and "less severe" disease. The proper question is: "What is a life worth?" And what will the quality of one's remaining life be? Certainly, there is little room for argument regarding the improved quality of life after successful surgery or scenting, as demonstrated in the patient described in the legend for Figure 1.

Efforts over the past fifty years to alter the coronary disease process cannot be ignored simply because some consider the mode of treatment too costly. Are there too many operations? Perhaps. Yet cardiologists and surgeons are still formulating indications for treatment. These answers most likely will come from analyses of larger databases such as from the Society of Thoracic Surgeons, and from current ongoing randomized studies such as SYNTAX, COMBAT, FREEDOM.

By definition, cure of coronary artery disease requires an understanding of the pathogenesis and prevention of plaque formation. Until that understanding comes, continued improvements in methods of paliation are essential. For patients with severe mulrivessel disease, our current operation of choice is the use of both internal mammary arteries as pedicle grafts to revascularize the front and right sides of the heart, and additional arterial graft or autogenous vein graft for the circumflex system. When the disease is extensive in the distal right coronary or in the left anterior descending artery, partial endartereccomy proximal co che coronary-mammary anastomosis may be indicated. This surgical plan is flexible, varying from case co case, and may change tomorrow.

The collaborative efforts of surgeons and cardiologists have changed the course of coronary artery disease in many patients. Young physicians today will undoubtedly be better informed and effect more successful outcomes than the current generation.

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