Direct myocardial revascularization was introduced by Favaloro et al. at the Cleveland Clinic in May, 1967. The first operation was on a 51-year-old woman; her right coronary artery was reconstructed by the interposition of a saphenous vein segment.

Shortly afterward, Favaloro changed the interposed vein technique with the coronary artery bypass with saphenous vein graft (CABG). At the beginning, they used only one coronary bypass graft to the “culprit artery” even in patients with multiple vessel disease (MVD). Since some patients later developed myocardial ischemia in another territory, the concept of multiple bypass evolved. In 1968, Green et al. introduced the direct internal mammary anastomosis as an alternative to the vein graft in coronary bypass surgery.

The concept of performing multiple bypass grafts on all the suitable coronary arteries with severe obstruction avoided repeated surgery in some patients, but at the same time, perhaps many others had “too many” unnecessary bypass grafts.

In the beginning, it was extremely difficult to convince many cardiologists that coronary bypass surgery could improve myocardial perfusion, perhaps by the fact that many previous surgical attempts at myocardial revascularization were a failure. Once the randomized and non-randomized studies (comparing CABG and medical treatment) showed that surgery, when properly indicated, improved survival and quality of life in the majority of patients with severe coronary artery disease, the indications for CABG grew exponentially.

Through the years, surgeons have improved the initial surgical techniques, introducing myocardial protection and the use of more arterial conduits (i.e., internal mammary, gastroepiploic, inferior epigastric and radial arteries) for coronary bypass. Anesthesia, extracorporeal circulation and post-operative care were also improved. In the last few years, the surgeons have introduced a less traumatic operative technique to perform coronary arterial bypass grafts without extracorporeal circulation through a small left anterolateral thoracotomy (mini-invasive cardiac surgery).

The purpose of this paper is to discuss the question of whether cardiac surgery is here to stay in coronary artery disease. After 33 years of surgical experience, my answer is yes, but not in all patients. During a period of 10 years (1967–1977), the only effective revascularization procedure able to increase blood flow to an ischemic myocardium was CABG, until September 1977, when Andreas Gruentzig introduced percutaneous transluminal coronary angioplasty (PTCA) as an alternative to surgery in the treatment of some patients with myocardial ischemia. Initially, coronary angioplasty was indicated only in “ideal lesions” (i.e., proximal, short, concentric and non-calcified). In the following years, the indications for PTCA expanded to patients with multivessel disease as a result of more operator experience, improvements in guiding catheters, balloons and wires, and the development of new devices (directional and rotational atherectomy, laser, cutting and suction devices, stents, etc.). Coronary stenting became a safe and reliable procedure that was very effective for tacking down coronary dissections and for optimizing sub-optimal balloon angioplasty results. The use of coronary stents allowed the cardiologist to become more aggressive with certain “high-risk” coronary artery lesions.

Several major randomized trials comparing angioplasty to coronary bypass surgery for multi-vessel disease showed that PTCA was associated with a greater need for additional revascularization procedures, but there was not a statistically significant difference in mortality or non-fatal myocardial infarction in favor of CABG.
The high procedural success rate and low complication rate, which associated with increased patient comfort and shorter hospital stay, were important factors in the continuous expansion of percutaneous coronary intervention. The cardiologist gradually and steadily changed the indications of surgery for PTCA.

Percutaneous coronary interventions have an Achilles heel: coronary restenosis, which is a response to vessel wall trauma produced by the balloon dilatation. We can identify at least three different components in coronary restenosis: elastic recoil, negative remodeling and neointimal growth. Conventional stents reduce stenosis, elastic recoil and pathological remodeling by compressing the atherosclerotic plaque or intimal flap and by scaffolding the vessel wall. However, the coronary stent has no beneficial direct effect on smooth muscle proliferation; on the contrary, stents exacerbate neointimal proliferation secondary to chronic vessel wall irritation, leading to in-stent restenosis.

In-stent restenosis therefore remains a significant medical problem. Balloon angioplasty, rotational and directional atherectomy and laser are being used to treat in-stent restenosis with variable results. Brachytherapy appears to be a promising technique, but still has to solve many associated problems, such as “geographical miss”, delayed healing and late thrombosis.

With the aim of preventing neointimal proliferation, the idea of a stent able to liberate drugs (that could inhibit smooth muscle cell proliferation) was raised. The reasoning was that in order to be more effective against proliferating smooth muscle cells, the drug should be delivered locally, directly to the cells in the coronary artery wall. It was thought that oral or parenteral delivery of the drug would not provide a sufficiently high concentration of the drug locally at the lesion site for an effective period of time.

**Initial experience with the Quanam drug delivery stent.** Eighteen patients underwent implantation of a Quanam drug delivery stent (QuaDDS) between February 1999 and May 2000. The QuaDDS system is made up of three components: the QueST stent (a 316 L stainless-steel metal stent), a polymer sleeve and a rapid exchange delivery system. The drug that is incorporated into the polymeric sleeve is a microtubule inhibitor. By interfering with microtubule function, smooth muscle cell migration and proliferation is profoundly suppressed. The pharmacological category is an anti-neoplastic drug. The stents have a circular cross-section and a moderate radio-opacity. The drug delivery stent (mounted on a balloon catheter) has a low profile (0.065 inches) and can easily re-cross deployed metal stents. The QuaDDS is also very trackable, allowing the stent to traverse highly tortuous and calcified vessels and reach distal lesions without the stent moving on the balloon.

**Animal studies.** Animal studies in pigs and rabbits (implanted with the drug-delivery stent) showed that the stent provided site specific, local delivery of the drug over a prolonged period of time (up to 6 months). The histological findings showed no thrombosis or acute inflammation present. There was mild chronic inflammation and necrosis. No foreign body response or fibrosis were observed. Fibroblast/smooth cell proliferation and intimal hyperplasia were minimal. No medial hyperplasia or medial thinning were observed.

**Patient population.** The 18 patients consisted of 15 men and 3 women, with a mean age of 58.53 ± 11.32 years (range, 38–75 years). Five patients (27.7%) had previous infarction and 2 patients (11.1%) had a prior CABG.

The most common indication for PTCA was unstable angina in 10 patients (55.5%), and 2 patients (11.18%) with acute myocardial infarction (AMI) were treated within 6 hours after onset of clinical symptoms (primary PTCA). Glycoprotein IIb/IIIa inhibitors were not used in any of these patients. The only patients excluded were those with left main disease, bifurcation lesions involving a large sidebranch and small vessels (< 2.7 mm diameter) because the stents available were 3.0 mm and 3.5 mm in diameter. The drug delivery stent was deployed after recanalization of a total occlusion in three patients. The stent was implanted for in-stent restenosis in another 3 patients. In one patient with several stents previously placed in the left anterior descending artery (LAD), a drug delivery stent was placed in a new LAD ostial lesion.

Procedural success rate (successful stent placement in the absence of procedural death, Q-wave myocardial infarction, or emergency bypass surgery) was 100%. The first 10 patients had a clinical follow-up of over one year, while the other 8 patients had a follow-up of less than 6 months to date. In the first 10 patients, nine had angiographic follow-up; seven out of the 9 patients also had intravascular ultrasound studies. Two of the patients presented a total occlusion in the LAD; one of these patients (in the first hours of an AMI) had a successful recanalization and implantation of a drug-delivery stent. However, at 6 months he developed severe chest pain and an emergency angiography showed a total occlusion in the LAD, distal to the stent. The artery was again recanalized and two Nir stents (Boston Scientific/Scimed, Inc., Maple Grove, Minnesota) were deployed proximal and distal to the drug-delivery stent, because there was progression of the disease. However, the LAD at the level of the drug-delivery stent showed no evidence of angiographic obstruction (no intravascular ultrasound studies were performed). At the present time, 10 months after the last PTCA, the patient is asymptomatic.

The second patient with post-AMI angina had a proximal total occlusion of the LAD. The artery was
recanalized and a drug-delivery stent was implanted. A distal dissection was stented with a 2.5 mm GFX stent (Medtronic AVE, Santa Rosa, California). Three months later, the patient developed chest pain and angiogram showed a new total occlusion of the LAD. The artery was again recanalized and the ultrasound showed restenosis of the GFX stent and minimal intimal proliferation at the level of the drug-delivery stent. This patient developed chest pain again at 7 months and a new angiogram and intravascular ultrasound showed no restenosis in the LAD. However, the patient developed 2 severe lesions in the middle and distal segments of the right coronary artery (RCA). The RCA was dilated and 2 stents were deployed. The patient has been asymptomatic now for 10 months.

The angiographic studies on the other 7 patients showed no restenosis and intravascular ultrasound showed only minimal intimal hyperplasia, including the patient with in-stent restenosis in the circumflex artery (treated with the GFX stent). At the present time, all the patients are asymptomatic and have a negative exercise TI 201 or MIBI SPECT test. The other 8 patients are also asymptomatic with negative functional exercise; they await the six-month or one-year angiographic and intravascular ultrasound follow-up.

The results of this study demonstrate that this novel drug-delivery stent implantation in patients with coronary artery disease is safe and feasible, with very promising results thus far.

The fact that this stent has been used in any clinical situation (including acute myocardial infarction) and that the angiographic and intravascular ultrasound follow-up studies over 1 year show no restenosis and little if any intimal hyperplasia indicates that cardiologists have a new alternative to avoid in-stent restenosis and that the indications for the use of coronary stents will further expand.

**Conclusion.** Is cardiac surgery here to stay in coronary artery disease? At the present time, we have two kinds of indications for surgery in coronary artery disease: 1) absolute; and 2) relative indications.

**Absolute indications:**
- Left ventricular aneurysms: either acute or chronic (left ventricular failure, embolic episodes and/or ventricular arrhythmias).
- Rupture of the ventricular septum, papillary muscles or free wall of the ventricles in acute myocardial infarction.
- Multi-vessel disease with left main severe obstruction and unsuitable anatomy for PTCA.

**Relative indications:**
- Left main disease (unprotected).
- Multi-vessel disease with difficult anatomy for PTCA and severe left ventricular dysfunction.

**Addendum.** Since May 2000, we have implanted the Quanam drug delivery stent (QuaDDS) in 17 additional patients, with a procedural success of 100% (total: 35 patients).

Of the 35 patients cohort, the QuaDDS was implanted in 6 patients with acute myocardial infarction in the first hours (primary PTCA); GP IIb/IIIa inhibitors were not used in any of these patients. Also, the QuaDDS was implanted in 5 patients with in-stent restenosis. The first three patients with in-stent restenosis (1 GFX, 1 Angiostent, and 1 NIR stent) had angiographic and ultrasound follow-up, and the ultrasound showed only a minimal amount of intimal proliferation in the stented segment.

The follow-up of these 35 patients is from February 1999 to February 2001. At the present time, all the patients are alive and asymptomatic.