Implications of Minimally Invasive Cardiac Surgery

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Virtually everyone concerned with cardiac anesthesiology has had involvement and experience with minimally invasive cardiac surgery in one form or the other recently. Yet before 1996, the topic was rarely if ever discussed in the journals or at meetings. What has caused this tremendous, recent explosion of interest and activity in this field, and how did it all get started? The term minimally invasive cardiac surgery actually encompasses a number of different techniques, each with its own rationale, origin, and development, but all focusing on limiting the physiologic trespass of cardiac surgery on the patient.

The history of attempts to treat coronary artery disease (CAD) surgically goes back further than many might suspect. In the 1920s several operations were developed that attempted to relieve angina by interrupting the afferent nerve flow from the heart by dividing cervical sympathetic ganglia, the vagus nerve, or spinal cord tracts. In the 1930s, subtotal thyroidectomy was used as a treatment of angina and received some popularity until the failure of newly developed thyroid blocking drugs as angina therapy discredited the operation’s theoretical basis. Techniques intended to increase blood flow to the heart began in the 1930s with the surgical creation of adhesions (hopefully with some blood vessels) between the heart and pericardium, an omental flap, or a pectoralis muscle flap. In 1946 Dr. Vineberg described the technique of tunneling the pedicle of the internal mammary artery (IMA) into the myocardium in the hope that anastomoses between its branches and the coronary arteries would form. This operation was more successful and accepted than the previous surgical treatments, and there are undoubtedly still patients walking around with patent Vineberg IMA implants in their hearts. Direct surgery to the coronary arteries began in the 1950s with atherectomies performed on beating hearts. But the first truly successful and broadly accepted operation for CAD was CABG, first performed by Dr. Sabiston in 1962 and successfully applied to a series of patients by Dr. Favaloro at the Cleveland Clinic in the late 1960s. CABG has been largely responsible for the tremendous increase in cardiac surgery over the past 30 years and is performed on over 300,000 patients a year in the United States alone.

CABG was developed and broadly applied using CPB with aortic cross clamping and cardiac arrest, a technique felt to facilitate performing delicate anastomoses on the relatively small coronary arteries. Nonetheless, surgeons have been performing CABG surgery without CPB since the inception of the operation. Ankeney informally reported on 143 patients having CABG without CPB at the 1972 meeting of the Society of Cardiothoracic Surgeons. Buffolo in Brazil and Benetti in Argentina, motivated in part by limited resources, continued to perform CABG without CPB on large numbers of patients throughout 1980s and reported large series in 1990 and 1991 with results comparable to conventional CABG with CPB. Their techniques were limited to easily accessible vessels, and their patients tended to have fewer grafts than those undergoing
conventional CABG. During this time, Benetti introduced the technique of performing CABG without CPB through a small, left anterior thoracotomy. In 1992, however, a bucket of cold water was thrown on the growing flame of beating heart CABG during a discussion of a paper reporting on 220 off CPB CABG cases presented by Dr. Pfister from Washington, DC. Dr. Steven Gundry of Loma Linda, CA, related that his institution had abandoned the procedure because of a high incidence of late deaths and post operative angiographic abnormalities of grafts and coronary arteries. This highlighted the persistent, primary concern for off pump CABG: that the quality and long term patency of a graft performed on a beating heart may be less than that performed with the quiet, clear field provided by CPB.

Another important development in the impetus towards beating heart surgery occurred in 1977 when Dr. Gruentzig introduced the technique of coronary angioplasty and began performing it regularly at Emory University in Atlanta. This was an alternative and competing means of revascularizing patients with CAD. In the 1980s and 1990s, head to head comparisons of angioplasty to CABG revealed that although the two procedures had similar results in relieving angina short term, CABG had a higher initial cost but produced more long lasting relief, while angioplasty required more frequent interventions in the ensuing years but had a lower initial cost. The data at three years follow up gave angioplasty a slight advantage in terms of cost. Surgeons were interested in developing a procedure that could provide patients with the most durable revascularization of the LAD, an IMA CABG, at reduced cost and length of stay in order to compete with angioplasty. CABG without CPB through a small anterior thoracotomy fit the bill.

The experience of surgeons such as Dr. Subramanian in New York City, Calafiore in Italy, and Magovern in Pittsburgh led to further refinement in techniques and has encouraged many other surgeons to add CABG without CPB to their armamentarium. In the latter half of the 1990s industry responded enthusiastically by providing increasingly sophisticated instrumentation designed to improve the effectiveness of beating heart surgery and the ease with which it can be performed. Sternal retractors with coronary stabilizers attached can now provide a motionless field without resorting to pharmacologic stabilizers such as esmolol and adenosine, which often compromise hemodynamic stability. Most recently, techniques of cardiac retraction that maintain stable hemodynamics has been developed that provide access to all of the coronary arteries without CPB, making all CABG patients potential candidates for beating heart surgery. In recent years, randomized trials comparing off pump to conventional CABG are indicating that the two techniques probably achieve similar mid term results with probably less bleeding and transfusion for off pump CABG.

Heart surgery with conventional CPB through limited thoracic incisions was pioneered in the late 1990s primarily by Dr. Gundry at Loma Linda, CA, Dr. Cosgrove at the Cleveland Clinic, and Dr. Chitwood at East Carolina University. The technique essentially involves a small (6 to 10 cm) parasternal or partial sternotomy incision providing access to the ascending aorta for cannulation and clamping, to the right atrium for venous cannulation, and to either the aortic or the mitral valve for repair or replacement. Smaller instruments and cannulae have been designed for these purposes. These workers suggest that their approach results in quicker and less painful recovery.
without compromising the quality of the valve surgery. They have accumulated considerable experience with this method. These techniques often require one lung ventilation and hence a double lumen endotracheal tube or a bronchial blocker.

Another unique approach to minimally invasive cardiac surgery has been the development of a technique to provide CPB including aortic occlusion, administration of cardioplegia, and cardiac venting entirely with percutaneously inserted catheters. This is usually referred to as port-access heart surgery and was developed by Heartport, Inc. of Redwood City, California. Dr. Wesley D. Sterman and Dr. John H. Stevens, a heart surgeon from Stanford University School of Medicine, founded Heartport in 1991. The company completed its initial public offering in April 1996 raising $111 million. The instrumentation and techniques were worked out at Stanford and New York University using animal models by 199616,17, and the first application to patients came from these centers in 1997, for both CABG18 and mitral valve surgery19. In that year the Port Access System became commercially available from Heartport for use in patients. It currently is being used in over 120 centers around the world. The company established a voluntary registry for its users in 1997, and its first report was published in 1999 in the Annals of Thoracic Surgery including over 1000 patients20.

Two other technological developments were important in the rise of minimally invasive cardiac surgery. First was the miniaturization of video equipment to the point that high-resolution cameras can be mounted on small scopes to provide excellent images of the cardiac structures through small, port-like stab incisions. Second was the introduction of transesophageal echocardiography (TEE) into cardiac surgery in the early 1980s. Port access surgery requires the precise positioning of multiple catheters within the heart and great vessels, a process greatly facilitated by TEE. Also, TEE provides a view of the heart during limited incision surgery otherwise not available and has proven useful as a means of assisting cannulation, de-airing, and assessment of adequacy of valve repair or replacement surgery. It is doubtful whether surgeons would have been as bold as they have been in the area of minimally invasive cardiac surgery if they had not had the safety net provided by TEE during these cases.

As approaches to cardiac surgery become less and less invasive, the expectation for quick extubation following the procedure increases as well. A generally reasonable approach is to tailor the anesthetic in these cases to permit emergence and extubation at the end of the procedure if all the other considerations do not make early extubation imprudent.

What does the future have in store for minimally invasive cardiac surgery? As techniques improve and experience grows, undoubtedly more surgeons will incorporate these procedures into their practice, and as a result, more anesthesiologists will need to be familiar with them. I would hope that all these techniques are evaluated with sufficient scientific scrutiny to truly determine whether or not the benefits claimed by the protagonists are valid and to better define which patients may benefit from minimally invasive cardiac surgery.

References


