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How the field of cardiovascular surgery is changing in light of new technology and its ever-increasing coordination with interventional cardiology.

How would you describe the evolution of the cardiovascular surgeon in treating patients via minimally invasive means?

The minimally invasive evolution began some 20 years ago with cardiovascular surgeons being appropriately skeptical. A big surgery requires a big incision and that is how we were trained. There is very little margin for error in open heart surgery, and thus we equated access to safety and optimal outcomes; the better the access, the better the outcomes. At that time, this dogma was pretty accurate. The technology simply was not there to treat heart patients via a small incision. As laparoscopic technology improved, our patients had observed these successes in other fields and thus CV surgeons were dragged to the minimally invasive altar kicking and screaming.

Minimally invasive direct coronary artery bypass grafting and other less invasive technologies began to develop. When Heartport (formerly Heartport, Inc., now a private subsidiary of Johnson & Johnson, New Brunswick, NJ) hit the market in the mid 1990s, patients wanted it, and administrators demanded it to stay competitive with other hospitals. Some of us embraced at least one of the first truly minimally invasive technologies that could be used to perform mitral repair/replacement, aortic valve surgery, and even coronary artery bypass grafting. But it was hard to use and not universally adopted.

Simultaneously, angioplasty and stenting took the world by storm. Cardiac surgeons were initially resistant; however, during the past 15 years, cardiac surgeons had begun pushing the envelope with a variety of less invasive technologies including robotics. The results of these new technologies were varied, and for data-driven heart surgeons, the changes were met with justifiable resistance. Any technique that is not equal to or surpassed the accepted maximally invasive results is subject to at least healthy skepticism—which I believe is good. I believe that our skepticism is fueled by conflicting data surrounding other technologies such as stents, which in many studies failed to show clear benefit over coronary bypass grafting for patients with three-vessel disease, left main disease, low ejection fraction, and diabetes, which are most of our patients these days. However, stents continue to be the mainstay of treatment for coronary artery disease. Stent technology too is an ever-evolving technology.

What are some of the practical issues of balancing your surgical and interventional practices?

One of the reasons that I am so involved in TAVI (transcatheter aortic valve implantation) is because of my interventional practice. As I finished my general surgery residency, I saw my attendings try to perform laparoscopic cholecystectomy procedures, which seemed relatively simple. In short, the younger generation arcade junkies could do it and the older generation struggled. I also saw the interventional train coming down the track with percutaneous angioplasty and stents, and I believed I should hitch a ride. However, I had no training to do so at that time.

I partnered with my senior mentors who were all doing open valve procedures. I volunteered to be the venous and arterial access guy to get the Heartport equipment in place. That was my first learning environment for catheter wire skills. It positioned me for the endovascular stent graft revolution that took place a few years later. I then partnered with an interventional radiologist who was involved with a large cardiology group. I hung around the catheterization lab at night, assisting whatever I could, if only to learn the names of all these crazy catheters and wires that I was totally unfamiliar with. As the stent graft market exploded, so did my abdominal aortic aneurysm (AAA) practice at Cardiac Surgery Associates in Chicago. We are at 25

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hospitals in several states including one of the academic centers in Chicago, so I received many referrals from varied sources including my own partners.

This arrangement allowed me to be a leading enroller in several abdominal and thoracic stent graft trials during the last decade. The natural extension of this was to expand my practice to a greater variety of catheter-based technologies. I started in the groin initially and worked my way proximally through the abdominal aorta, thoracic aorta, and ultimately to the aortic valve (TAVI) back to doing open heart surgery, but now all via that initial groin incision—I had come full circle. Balancing my interventional and surgical practices is not easy, but it is a great problem to have because I am busy doing both. I have not limited myself to one or the other.

What tips would you offer CV surgeons who are aiming to add more interventional components to their practice?

There are a number of programs for surgeons who wish to increase their interventional footprint. Medtronic (Medtronic, Inc., Minneapolis, MN), for example, sponsors an academia aortic boot camp that helps you sharpen your interventional minimally invasive skills. It directly educates heart surgeons using various didactic and hands-on workshops. This type of program is available at almost every national meeting. There are also 1:1 programs that allow you to work with and observe experienced surgeons who do a lot of interventions. If cardiac surgeons take the time to learn these techniques now, they will have plenty of time to succeed in the future. Otherwise, they are going to be left behind by the next generation of hybrid surgeons or structural heart interventionists. They must get engaged now, and how they do it is up to them, but the tools are there: the simulation suites, courses, hands-on programs, networking, Internet, and even videos. There are enough programs available so that they can get up to speed quickly and succeed in using these new technologies in their practices.

Can you tell me about some of the devices that you have developed or are currently working on?

I have been fortunate to be on the front end of this new technological wave since my Heartport days, and I have worked with a lot of bright people in the medical industry. I recently shared in one of the patents for Medtronic's next generation of percutaneous valves. I have been working on that project for the last several years, even before CoreValve was purchased. I spend a lot of time working on different solutions to various aortic problems, including bare-metal stent technology in dissections. Some of that technology is being investigated in Europe right now. I worked on fenestrated devices for arch pathology, and a few of these companies are developing branch devices specifically based on some of the work of heart surgeons experienced in endovascular therapies. I had been doing a lot of research with CardioMEMS pressure sensors (CardioMEMS, Inc. Atlanta, GA), which I use to follow all of my AAA patients, and it is now being evaluated for use in treating heart failure.

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I think a lot of the designs and techniques that we use for abdominal and thoracic stents have helped us learn that it is not so much the destination but the journey getting there. Our experience in using AAA and thoracic stent graft technology has helped us get to the aortic valve for TAVI, and now we are using many of these same delivery system concepts that we developed for stent grafts and applying them to percutaneous valves. It is a natural extension.

What are some of the device trials that you are currently enrolled in and are there any that you are particularly excited to see the results of?

Because our practice is so far reaching, my ability to enroll in trials is equally broad. In all of these trials, there were only a few cardiovascular surgeons participating, yet they were consistently the largest enrollers in every one of the abdominal and thoracic stent graft trials, which says a lot about our catheter wire skills and our overall presence in the endovascular marketplace. Cardiac surgeons still have a lot to offer in the catheter wire dominated realm of abdominal and thoracic stent grafting. The Medtronic Endurant device will probably be approved in the very near future, and I am especially proud to be involved in that trial because it will be a game-changing stent graft that was built from the ground up using everything we have learned from years of various stent graft implants and designs. Medtronic took what was best about its previous devices, techniques, and technologies, and put them into the Endurant device. It has one of the smallest device outer profiles, but it can expand up to 36 mm in diameter. It

is the most flexible and has the most active fixation on the market, which should all but eliminate migration. I suspect that it will dominate all other grafts as it seems to be doing in Europe.

I am also excited to get the CoreValve (Medtronic, Inc.) trial started and get updates about the PARTNER trial from Edwards (Edwards Lifesciences, Irvine, CA). Hopefully that will not be too far down the road because it is long overdue that we get several percutaneous valve technologies on the market (Sapien). Edwards Lifesciences just finished their enrollment and announced some of their initial results, and CoreValve is going to be starting soon. These technologies are going to make a cataclysmic splash for doctors and most importantly patients. We are going to be treating very high-risk patients who otherwise would simply not be treated.

I don't know how the trial results will ultimately compare to the standard valve treatments that we have today (which have great 20-year results), but it is going to be a fascinating journey to see the new technological advances that will spring from these first-generation percutaneous TAVI devices. TAVI technologies will be a game changer. This singular lightening rod technology will divide or galvanize CV surgeons as a specialty. It may define our very specialty. Unlike most minimally invasive heart surgery, which has been an iteration on a theme, small incremental improvements in technology and techniques, TAVI is a truly disruptive technology. It may by its very nature turn standard open heart surgery on its head. How cardiac surgeons embrace (or fight) this technology will define their practice, their reputations, the way they train future heart surgeons, and how they take care of patients in the future. Its overall impact cannot be underestimated. ■