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SURGERY FOR ACQUIRED CARDIOVASCULAR DISEASE

EDITORIAL: ENDOSCOPIC ROBOTIC CORONARY SURGERY—IS THIS REALITY OR FANTASY?

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In this issue of *The Journal of Thoracic and Cardiovascular Surgery*, two unique articles describe the first coronary artery operations done with a computer-assisted robot.^{1,2} At present, most surgeons probably will consider robotic cardiac surgery as too daunting, too futuristic, or simply “overkill,” inasmuch as they now perform coronary anastomoses comfortably through traditional sternotomies with a 5-day or less hospital stay, decreasing costs, and excellent long-term clinical results. However, both surgeons and patients will continue to ask penetrating questions. Is this the emergence of robotic cardiac surgery or just another passing means of accessing the heart through smaller incisions? Do these expensive devices really facilitate surgeon accuracy, patient comfort, and faster recovery? Will the surgical costs justify the benefit of rapid recovery? Recently, *The Wall Street Journal* called into question the premature launching of new technology in car-

diac surgery.³ The article was critical of marketing new devices widely before select groups of surgeons have proved efficacy and patient safety. The article was not unexpected inasmuch as the introduction of completely new technology into any specialty always explodes with questions regarding suboptimal early clinical results, inadequate patient safety, and added expense. Are all these concerns enough to stop the progress toward what may be a new future for cardiac surgery, that is, truly endoscopic coronary and valve operations? These early articles on the subject should provide a springboard for critical thought and circumspect scientific evaluation of these new surgical devices.

During computer-assisted or robotic cardiac surgery, electronic sensors are manipulated by the surgeon to reproduce accurate movement of surgical instruments remotely within the chest. The robotic techniques used in both articles require a master and a slave unit. The surgeon sits at a master console located at a distance from the patient, and the slave unit provides “tele-presence” within the chest for micro-instrument manipulation. Hand and wrist motions are translated directly to the robotic instruments, which are inserted through transthoracic trocars. In actuality, there are 2 effector components common to all surgical robotic systems. Advanced *computer technology* has enabled direct translation of digitized data from the master console into filtered fine mechanical motion in the slave unit.

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Instrument tips are controlled by complex sliding internal cables within mechanical arms. Unfortunately, iterative miniaturization of the *mechanical effector* arms becomes self-limiting, owing to inherent material properties. In other words, complex instruments can be made only so small and still function well. Moreover, mechanical limitations and chest anatomic variations have caused intrathoracic instrument conflicts that have been the nemesis for both devices described in these articles. Despite these limitations, significant progress in robotic cardiac surgery has been made in the past 2 years.

In early May of 1998, Carpentier and associates^{4,5} performed the first robotic cardiac surgical operations, which included an atrial septal defect closure and several mitral valve repairs. Later that month, Mohr and Falk⁶ performed additional mitral operations, carrying the valve operation to a near-endoscopic technique. Also, the latter group performed the first robotic coronary anastomosis, albeit through an open incision. Both groups used prototypes of the same surgical device (daVinci; Intuitive Surgical, Inc, Mountain View, Calif). In this article, the Broussais group¹ describes the world's first 2 totally endoscopic coronary operations (June 1998). Both patients recovered well and were discharged without complications. These operations were done with the use of a single camera site and 2 instrument ports. A robotic wrist provided articulated motion with a full 7 degrees of freedom of motion inside the chest cavity. This feature was most advantageous when performing the internal thoracic artery (ITA) harvests and the coronary anastomosis. Other advantages of the articulated wrist include motion scaling and artifact filtration, as well as a degree of ambidexterity. Simultaneous 3-dimensional visualization provides "topographic immersion" in the operative site with excellent resolution. Lack of tactile feedback is a limitation inherent in all surgical robotic systems at present.

Despite the elegance of the robotic device, Loulmet and associates¹ emphasize the difficulty in ITA dissection and preparation. Correct port placement for the robotic instruments was difficult, inasmuch as variations in chest wall contour and body habitus influence cardiac access much more dramatically than with traditional incisions. Variations in distance between the chest wall and anterior pericardium were problematic during ITA dissection. As only 3 port incisions are desired, repositioning or adding ports would defeat the purpose of the technique. Because of an intramyocardial vessel and inability to balloon-clamp the aorta in 2 patients, the anastomosis was done directly through a minithoracotomy. Thus, in these patients, the utility of

robotic surgery was limited to conduit preparation. Falk in Leipzig has found also that the ITA harvest presents a greater challenge than the actual anastomosis.

In Reichenspurner's article,² 2 patients underwent videoscopic ITA harvest with subsequent anastomosis to the left anterior descending coronary artery with the use of a different robotic device (ZEUS; Computer Motion, Inc, Santa Barbara, Calif), which incorporated a voice-activated 3-dimensional camera system. Although these surgeons added a minithoracotomy for "safety," 3 ports were used for thoracic cavity camera and robotic instrument arm insertion. Part of each procedure was done through the incision and not totally endoscopically. However, each anastomosis was done by the robotic method. Their device appears to have the advantage of less overall equipment size and smaller diameter instrument arms (3.9 vs 11 mm) compared with the Intuitive daVinci system. Moreover, the authors suggest that the device is more user friendly. Reichenspurner's robotic device provided similar motion scaling and tremor filtration as an articulated device but with the added advantage of instrument tip tracking of the camera via voice activation. However, the major difference between these robotic devices is the lack of articulated motion at the instrument tip in the ZEUS system. This seems to be a major disadvantage, especially for dissecting the ITA along the chest wall. Despite this limitation, satisfactory coronary anastomoses were performed, although they required more time than was needed by the Broussais group, who used the articulated wrist device.

Does the work done by these 2 groups answer the fundamental questions regarding the future of robotic coronary surgery? Clearly the answer is no. Both groups have had a great deal of experience with video-assisted cardiac surgery and have made progressive steps toward truly endoscopic coronary operations. The next step was robotic coronary surgery. Both groups were able to perform excellent coronary anastomoses with different systems. However, ITA preparation and anastomotic times were long, and other expensive technology was required in all of these cases. At present, few centers can justify this level of expense or use of human resource to robotically perform multivessel coronary surgery, let alone a single-vessel graft, as done here. However, both Loulmet's and Reichenspurner's groups have provided a look into what could be the future of tele-microaccess heart surgery. Both groups have addressed the difficulties and concerns of beginning what may be a new age. Both articles warrant a "good read" with digestion of the contents. Many of us expect that this work will eventuate in subsequent devices and new techniques that will provide truly endoscopic cardiac surgery. However, for

future surgeons to adopt these robotic operations, cost reduction, minimal patient risk, more rapid recovery, long-term graft patency, and operative facility must be shown. Mechanical size, cavitary access, tactile feedback, and visualization still remain concerning issues and must be solved before these methods are established widely. However, we should follow this pioneering work enthusiastically, *as the nod seems to be going toward reality...rather than fantasy*. The next century promises to be really exciting for our specialty.

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