Current era minimally invasive aortic valve replacement: Techniques and practice

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Background: Since the first aortic valve replacement through a right thoracotomy was reported in 1993, upper hemisternotomy and right anterior thoracotomy have become the predominant approaches for minimally invasive aortic valve replacement. Clinical studies have documented equivalent operative mortality, less bleeding, and reduced intensive care/hospital stay compared with conventional sternotomy despite longer procedure times. However, comparative trials face challenges due to patient preference, surgeon bias, and the lack of a standardized minimally invasive surgical approach.

Methods: Twenty cardiothoracic surgeons from 19 institutions across the United States, with a combined experience of nearly 5000 minimally invasive aortic valve replacement operations, formed a working group to develop a basis for a standardized approach to patient evaluation, operative technique, and postoperative care. In addition, a stepwise learning program for surgeons was outlined.

Results: Improved cosmesis, less pain and narcotic use, and faster recovery have been reported and generally accepted by patients and by surgeons performing minimally invasive aortic valve replacement. These benefits are more likely to be verified with standardization of the procedure itself, which will greatly facilitate the design and implementation of future clinical studies.

Conclusions: Surgeons interested in learning and performing minimally invasive aortic valve replacement must have expertise in conventional aortic valve replacement at centers with adequate case volumes. A team approach that coordinates efforts of the surgeon, anesthesiologist, perfusionist, and nurses is required to achieve the best clinical outcomes. By first developing fundamental minimally invasive skills using specialized cannulation techniques, neck lines, and long-shafted instruments in the setting of conventional full sternotomy, the safest operative environment is afforded to patients. (J Thorac Cardiovasc Surg 2014;147:6-14)

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Disclosures: Edwards Lifesciences provided reasonable travel, lodging, and honorarium for participation by many of the authors in a medical advisory board meeting where, as one of the agenda topics, initial concepts for the minimally invasive aortic valve replacement manuscript were validated. Authors were not compensated for any time spent writing or reviewing this manuscript and claim full responsibility for the integrity of this work. S. Chris Malaisrie reports lecture fees from Edwards Lifesciences and Medtronic. Glenn R. Barnhart reports consulting fees from Edwards, and lecture fees from Edwards and Atricure. R. Saeid Farivar reports consulting fees from Edwards. John Mehall reports consulting fees from Edwards. Brian Hummel reports consulting fees from Edwards, St. Jude, and Estech. Evelio Rodriguez reports consulting fees from Cardionet, Edwards, and Atricure and lecture fees and grant support from Medtronic. Mark Anderson reports consulting fees from Abiomed and Edwards. Clifton Lewis reports consulting fees from Edwards. Clark Hargrove reports consulting fees from Edwards and Sorin. Gorav Ailawadi reports consulting fees from Edwards, Atricure, Mitralign, and Abbott and lecture fees from St. Jude. Scott Goldman reports consulting fees from Edwards, St. Jude, and LSI. Junaid Khan reports consulting and lecture fees from Edwards. Michael Moront reports consulting fees from Edwards, Medtronic, and Terumo and lecture fees from Medtronic. Eugene Grossi reports consulting fees from Edwards and Medtronic. Eric E. Roselli reports consulting fees from Edwards and Medtronic. Arvind Agnihotri reports consulting fees from Edwards and lecture fees from Intuitive Surgical. Michael J. Mack reports consulting fees from Edwards. J. Michael Smith reports consulting fees from Atricure. Vinod H. Thourani reports consulting fees from Edwards. Francis G. Duhay is a full-time employee of Edwards Lifesciences. Mark T. Kocis is a full-time employee of Edwards Lifesciences. William H. Ryan reports consulting fees from Edwards and Medtronic.

Received for publication June 3, 2013; revisions received Aug 21, 2013; accepted for publication Aug 29, 2013; available ahead of print Nov 4, 2013.

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0022-5223/$36.00

http://dx.doi.org/10.1016/j.jtcvs.2013.08.086

Abbreviations and Acronymns

CPB	= cardiopulmonary bypass
CT	= computed tomography
MIAVR	= minimally invasive aortic valve replacment
RAT	= right anterior thoracotomy
TEE	= transesophageal echocardiography
UHS	= upper hemisternotomy

In 1993, the first minimally invasive aortic valve replacement (MIAVR) was performed through a right thoracotomy.[1] By 1996, techniques encompassed a wide variety of incisions, including partial lower and transverse sternotomies as well as a parasternal approach.[2] Today, the right anterior thoracotomy (RAT) and upper hemisternotomy (UHS) are the predominant MIAVR approaches.

Clinical studies of MIAVR have documented less bleeding, shorter duration of mechanical ventilation, and reduced intensive care unit and hospital stay despite longer operative, cardiopulmonary bypass, and crossclamp times.[2-9] Although definitive clinical evidence is lacking, advantages of less pain, faster recovery, and improved cosmesis are generally accepted by MIAVR patients and surgeons.[10-16]

Randomized trials comparing conventional sternotomy to MIAVR face formidable challenges because of patient preference, surgeon bias, and, importantly, the lack of a standardized surgical approach. Recognizing this need, 20 cardiothoracic surgeons from 19 institutions across the United States formed a MIAVR Working Group to document intraoperative steps as well as key preoperative evaluation and planning and postoperative considerations based on their combined experience of nearly 5000 MIAVR operations. The purpose of this report is to provide the basis for a safe, standardized approach, as well as a stepwise learning program to achieve proficiency.

PREOPERATIVE EVALUATION AND PLANNING

When evaluating a patient for MIAVR, several preexisting conditions warrant emphasis: peripheral and cerebrovascular disease, chronic obstructive lung disease, chest wall irradiation or deformity, and previous cardiac surgery. In a patient with a history of stroke or transient ischemic attack, duplex scanning of the carotid and vertebral arteries is obtained. Severe chronic obstructive pulmonary disease may alter the anatomic relationship between the chest wall and aortic valve, and a chest x-ray and computed tomography (CT) provides a roadmap, as well as information about the lungs and pleural spaces.

Peripheral vascular disease elevates the risk of stroke or systemic embolization with retrograde arterial perfusion. CT angiography of the chest, abdomen, and pelvis is performed routinely when retrograde perfusion is considered. Severity, location, and nature of atherosclerosis are assessed.[17] Smooth, calcified plaque is less hazardous than soft or irregular plaque. Size and tortuosity of the iliofemoral vessels are important factors in selecting the appropriate arterial cannula.[18]

In patients with previous cardiac surgery or chest wall irradiation, a chest CT conveys the distance between the posterior sternal table and right ventricle.[19] The presence of patent coronary bypass grafts crossing the midline is particularly hazardous. For RAT, previous pneumonia, pneumothorax, recurrent lung infections, or right lung resection may be associated with dense pleural adhesions. MIAVR should be approached cautiously in patients with severe chest wall deformities, such as pectus excavatum and kyphoscoliosis, and may be avoided depending on the severity of the abnormality.

Preoperative evaluation for coexistent coronary artery disease is similar to sternotomy patients. Concomitant coronary disease does not preclude MIAVR, and isolated lesions can be managed percutaneously either before or after MIAVR depending on clinical presentation. Importantly, iatrogenic dissection of the iliac artery during cardiac catheterization may be occult, and usually is confined to a tortuous segment as it emerges from the pelvis. If not recognized, acute dissection into the aorta can be induced by retrograde arterial perfusion. For this reason, CT angiography should be performed after cardiac catheterization, if possible (Glenn R. Barnhart, MD, personal communication, November 2012) (Figure 1).

For UHS with direct ascending aortic cannulation, a noncontrast chest CT is used to evaluate the severity and distribution of aortic atherosclerosis, and to formulate cannulation and crossclamp strategies. In bicuspid aortic valve disease, the aortic root and ascending aorta are evaluated to determine if concomitant replacement is indicated. Also, a noncontrast CT confirms to which intercostal space to extend the *J*.

For RAT, chest CT facilitates preoperative planning in 2 ways. First, by conveying the location of the aortic valve, CT identifies those patients best suited for RAT. In particular, if more than one-half of the ascending aorta is positioned to the right of a vertical line drawn from the right sternal border to the ascending aorta in the axial CT view, RAT is appropriate[20] (Figure 2, *A*). Second, by noting which intercostal space is closest to the tip of the right atrial appendage, the preferred intercostal space is identified (Figure 2, *B*).

INTRAOPERATIVE

MIAVR requires a coordinated effort by the surgeon, anesthesiologist, perfusionist, and nurses to achieve the