Should less-invasive aortic valve replacement be avoided in patients with pulmonary dysfunction?

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Objective: In patients with pulmonary dysfunction, it is unclear whether a less-invasive approach for aortic valve replacement is well tolerated or even beneficial. We investigated whether a partial upper J-incision for aortic valve replacement leads to more favorable outcomes than a full sternotomy in patients with chronic lung disease by using forced expiratory volume in 1 second as a surrogate.

Methods: From January 1995 to July 2010, 6931 patients underwent primary isolated aortic valve replacement; 655 had forced expiratory volume in 1 second measured and expressed as percent of predicted (FEV1%; 368 via J-incision, 287 via full sternotomy). Postoperative outcomes were compared among 223 propensity-matched pairs.

Results: Patients diagnosed with chronic lung disease had longer median intensive care unit (41 vs 27 hours, $P = .001$) and postoperative (7.1 vs 6.1 days, $P < .0001$) lengths of stay than those without chronic lung disease. At normal values of FEV1%, little difference was observed in either of these times for J-incision versus full sternotomy; however, at progressively lower FEV1%, these times lengthened, with increasing benefit for J-incision. Among propensity-matched patients, other postoperative complications were similar. Early survival (93% vs 89% at 1 year, $P = .07$) was possibly higher in matched patients with J-incision, but late survival was similar ($P = .9$). Patients with FEV1% less than 50 who underwent J-incision had the greatest survival advantage, which persisted for 5 years.

Conclusions: In patients with preoperative respiratory dysfunction, a less-invasive partial upper J-incision for aortic valve replacement can lead to more favorable outcomes than a full sternotomy, including shorter intensive care unit and postoperative lengths of stay and better early survival, which are amplified with decreasing pulmonary function. (J Thorac Cardiovasc Surg 2014;147:355-61)

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Patients with severe respiratory dysfunction and chronic lung disease (CLD) are being seen more frequently, particularly for various types of transcatheter aortic valve replacement (AVR).[1] Whether these patients would tolerate or even benefit from a surgical AVR via a less-invasive J-incision rather than a full sternotomy is unknown. Even among our own group of surgeons, the less-invasive approach has not been adopted universally.

A paramedian incision for AVR was introduced in 1996[2]; subsequently, a partial upper J-incision (hereafter referred to simply as ''J-incision''), introduced in 1997,[3] has been gaining acceptance.[2-5] We[5] and others[1-3,5-10] have reported that the J-incision has multiple benefits compared with a standard median sternotomy, including less surgical trauma, less pain, shorter ventilation time, and shorter intensive care unit (ICU) and hospital lengths of stay.[2-10] Because of these possible advantages, a J-incision might

Abbreviations and Acronyms

AVR = aortic valve replacement
CABG = coronary artery bypass grafting
CLD = chronic lung disease
FEV1 = forced expiratory volume in 1 second
FEV1% = forced expiratory volume in 1 second, percent of predicted
ICU = intensive care unit

be beneficial for high-risk patients, such as those with pulmonary dysfunction, a well-established risk factor for mortality and morbidity after cardiac surgery.[5,11,12]

The J-incision may stabilize the sternum and thoracic cage, resulting in better postoperative pulmonary function.[3-5] Furthermore, it is believed that less spreading of the incision, not interfering with the diaphragm, and less tissue dissection might facilitate earlier postoperative respiratory recovery.[5,13] Yet these perceived benefits have not been studied in the specific high-risk group of patients with pulmonary dysfunction.[3,4,6-14]

Such a study is challenging because pulmonary dysfunction comprises a broad spectrum of lung diseases and is complex to define. Spirometry is the most common pulmonary function test used to assess severity and operative risks in these patients.[15] It is not influenced by observer bias and provides markers for degree of lung function impairment. Therefore, we investigated whether a J-incision for AVR leads to more favorable outcomes in patients with pulmonary dysfunction, using forced expiratory volume in 1 second, percent of predicted (FEV1%), as a surrogate.

PATIENTS AND METHODS

Patients

From January 1995 to July 2010, 6931 patients underwent primary isolated AVR, of whom 655 had preoperative spirometry data available (J-incision in 368 and full sternotomy in 287). Patients undergoing concomitant mitral valve surgery or coronary artery bypass grafting (CABG) were excluded, as were those with active endocarditis. Mean age was 68 ± 13 years, and 54% were men.

Data

Data were retrieved from the prospective Cardiovascular Information Registry, supplemented with information from the Echocardiography database. Preoperative spirometry data were obtained from the institution's prospectively recorded Pulmonary Function Laboratory database. Preoperative forced expiratory volume in 1 second (FEV1) and forced vital capacity values were normalized to percent of predicted by the National Health and Nutrition Examination Survey algorithm.[16] All data were approved for use in research by the Institutional Review Board, with patient consent waived.

Surgical Technique

Conventional general anesthesia was used in all patients regardless of surgical approach. Patients who underwent less-invasive J-incision had an 8- to 10-cm skin incision. The upper sternum was divided in the midline, and this sternotomy was extended into the right fourth intercostal space forming a J.[3,4] The diaphragm was not interfered with, and spreading the incision was limited to approximately 5 cm, minimizing tension and flexing of the posterior rib attachments to the vertebral bodies. Approach to the aortic valve was via an oblique aortotomy carried into the noncoronary cusp or a transverse aortotomy above the sinutubular junction, and choice of valve type was at the discretion of the surgeon. AVR was then carried out according to the surgeon's standard technique.

Vacuum-assisted cardiopulmonary bypass with central cannulation was used in all patients. Intraoperative transfusions, anesthetic technique, and timing of extubation were at the anesthesiologists' and critical care team's discretion. Intraoperative and postoperative transfusions were not driven by protocolized transfusion triggers, except that Cleveland Clinic has long advocated blood-conservation practices.

Outcomes

Outcomes assessed included intraoperative support (myocardial ischemic time, cardiopulmonary bypass time), postoperative in-hospital mortality and morbidity (defined in accordance with the Society of Thoracic Surgeons National Database: http://www.ctsnet.org/file/rptDataSpecifications252_1_ForVendorsPGS.pdf), blood product use, time to extubation, ICU and postoperative lengths of stay, and long-term survival.

Survival was assessed by active follow-up at 2 years and then every 5 years using an Institutional Review Board–approved questionnaire with patient consent required. Vital status was supplemented with data from the Social Security Death Master File with a censoring date of February 15, 2011. A total of 2423 patient-years of combined active and passive follow-up for vital status were available for analysis, with a median follow-up of 2.7 years; 25% of survivors were followed more than 6.1 years, and 10% were followed more than 9.2 years. Thus, survival curves are truncated at 10 years. The seemingly short median follow-up is caused by a combination of an escalating volume of AVRs in recent years[5] and increased use of preoperative spirometry (Figure E1).

Data Analysis

All analyses were performed using SAS statistical software (v9.1; SAS Institute Inc, Cary, NC).

Spirometry and Chronic Lung Disease

Trends in spirometry values according to clinical diagnosis of CLD were estimated by logistic regression analysis, as were factors associated with performing preoperative spirometry.

Factors Associated With Surgical Approach

A number of patient characteristics differed between those receiving a less-invasive J-incision and those undergoing full sternotomy, including spirometry data (Table 1). Logistic regression analysis was used to identify statistically significant preoperative differences. A parsimonious model was developed using bagging.[17,18] Briefly, a patient is selected at random to begin building a new data set, and this random selection process is repeated until the new data set is the same size as the original. On average, approximately one third of patients are not selected, and therefore a number of patients are duplicated. This is known as a bootstrap sample; 1000 such bootstrap data sets were built. Each was then analyzed by automated stepwise regression with a P value criterion to retain of .05 using the candidate risk factors listed in Appendix E1. This resulted in 1000 regression models. These models were then aggregated by counting the frequency of occurrence of variables in the 1000 models. We consolidated counts of closely correlated variables such as linearizing transformations of scale. We then selected variables for the final model if they appeared in 50% or more of the analyses (a measure of reliability).