Function of the Respiratory System in Elderly Patients after Aortic Valve Replacement

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Objective: **To compare the function of the respiratory system after aortic valve replacement through median sternotomy (AVR) or the minimally invasive right anterior minithoracotomy (RAT-AVR) approach among elderly (aged ≥75 years) patients.**

Design: **Observational cohort study.**

Settings: **University hospital.**

Participants: **The study included 65 elderly patients scheduled for RAT-AVR and 82 for standard AVR.**

Interventions: **Pulmonary function tests (PFT) were performed preoperatively, 1 week, 1 month, and 3 months after surgery. In addition, respiratory complications were analyzed.**

Measurements and Main Results: **Respiratory complications occurred in 12.3% of patients in the RAT-AVR group and 18.3% of patients in the AVR group ($p = 0.445$). Mechanical ventilation time in the intensive care unit was 7.7 ± 3.6 hours for RAT-AVR patients and 9.7 ± 5.4 hours for AVR patients ($p = 0.003$). Most PFT were worse in the AVR group than in the RAT-AVR group when performed 1 week after surgery. After 1 month, forced expiratory volume in the first second, vital capacity, and total lung capacity differed significantly in favor of the RAT-AVR group ($p = 0.002$, $p < 0.001$, and $p = 0.001$, respectively). After 3 months, the PFT parameters still had not returned to preoperative values, but the differences were no longer significant between the RAT-AVR and AVR groups. The multivariable median regression analysis demonstrated that RAT-AVR surgery was a key factor in a patient's higher postoperative PFT parameter values.**

Conclusions: **RAT-AVR surgery resulted in shorter postoperative mechanical ventilation time and improved the recovery of pulmonary function in elderly patients, but it did not reduce the incidence of pulmonary complications when compared with surgery performed through a median sternotomy.**

KEY WORDS: minimally invasive aortic valve surgery, respiratory function after cardiac surgery, cardiac surgery in elderly patients

THE MEDIAN STERNOTOMY has been the gold standard approach to aortic valve replacement surgery for many years and still remains the preferred method in most cardiac surgical centers.[1-3] On the other hand, modern cardiac surgery has seen the rapid development of various minimally invasive, video-assisted techniques that allow for reduced perioperative trauma.[4-7]

Partial upper hemisternotomy and right anterior minithoracotomy (RAT-AVR) currently are the most frequently used minimally invasive approaches to aortic valve surgery.[6-9] For a number of years, RAT-AVR (which allows entry to the thoracic cavity without splitting the sternum) was the preferred technique of performing aortic valve replacement by numerous cardiac surgery centers, with very good results.[8,9] The standard full sternotomy approach, which allows for excellent heart visualization and shorter surgery times, now is being reserved in most centers for emergency surgeries, combined procedures, reoperations, and complex cases.[2,3,10] It has been reported that avoiding the standard median sternotomy (AVR) in cardiac surgery provides better preservation and integrity of the thoracic cage.[10,11] However, there still are not enough data describing pulmonary function of patients undergoing cardiac surgery with use of less-invasive methods. In addition, to the authors' best knowledge, there has been no analysis of the respiratory system function of elderly patients after aortic valve replacement when comparing those undergoing surgery via conventional AVR with those undergoing surgery with a RAT-AVR approach.

The aim of this study was to analyze pulmonary functional status and respiratory complications in elderly patients who underwent minimally invasive aortic valve replacement surgery through RAT-AVR compared with the results of a control group, for whom aortic valve replacement was performed through the standard AVR approach. The authors sought to determine whether minimally invasive surgical technique could prevent postsurgery pulmonary functional status from worsening or minimize pulmonary complication rates.

PATIENTS AND METHODS

The study was performed in accordance with the Declaration of Helsinki and with the consensus guidelines expressed by the STROBE statement.[12] Institutional Review Board (Jagiellonian University of Cracow, Regional Medical Chamber 10/10/2010) approval was obtained as was written informed consent from each patient. The authors conducted an observational cohort study of elderly patients who were scheduled for isolated aortic valve replacement between January 2013 and December 2014. Patients eligible for study enrollment were 75 years or older and required aortic valve replacement because of isolated aortic valve stenosis and/or

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insufficiency. Exclusion criteria included previous cardiac surgical procedures, emergency surgeries that included infective endocarditis, and patients with a left ventricle ejection fraction below 30%. Patients fulfilling exclusion criteria were considered to be of higher risk and therefore underwent surgery via conventional AVR without further study.[13]

The presence of preoperative lung disease was not an exclusion criterion. Chronic obstructive pulmonary disease (COPD) was the only preoperative lung disease recognized in this cohort of patients. Severity of lung disease was not determined preoperatively; no computed tomography scan was performed to define the severity of lung disease. During the study period, 68 consecutive patients underwent RAT-AVR surgery and 86 consecutive patients underwent conventional AVR surgery. Contraindication for RAT-AVR surgery was based on a preoperative multidetector computed tomography examination (MDCT). One criterion for rejection was the expectation of difficult access to the aortic valve in patients in whom more than half of the diameter of the ascending aorta was positioned on the left of the right sternal border.[9] Right pleural adhesions also were considered a contraindication for RAT-AVR surgery.[9]

The analysis, which was based on prospectively collected preoperative data from in-hospital and postdischarge outcomes, predominantly focused on pulmonary function and respiratory system complications. The time of discharge from the intensive care unit (ICU) or hospital was determined using medical judgment and the patient's suitability for discharge.[14]

Anesthesia

All preoperative medications were continued until the day of surgery, except for diuretics, potassium supplementations, and angiotensin-converting enzyme inhibitors. The authors specifically found beta-blockers to be especially beneficial, particularly in the context of aortic stenosis (majority of patients). All patients received standard oral premedication with 1.5 to 2.0 mg of lorazepam.

Routine monitoring was maintained during surgery, including 5-lead surface electrocardiography with automated ST-segment analysis, pulse oximetry, continuous urinary output, esophageal and rectal temperatures, arterial blood pressure measurement with a cannula positioned in the radial or femoral artery, central venous catheter, and transesophageal echocardiography (TEE). Anesthesia was started with intravenous fentanyl, 1 to 2 μ/kg, and propofol, 1.5 to 2.5 mg/kg, and was maintained with propofol, 4 to 12 mg/kg/h, and sevoflurane with inspiratory concentration between 1.0 to 2.0 vol%. Analgesia was provided with continuous fentanyl infusion, 0.1 μg/kg/min. Pancuronium, 0.1 mg/kg, or cisatracurium 0.15 mg/kg, was administered, and patients were intubated. Repeated doses of pancuronium were administered every 50 minutes, and cisatracurium, was given as a continuous infusion of 0.18 mg/kg/h. The last dose of pancuronium was given during the rewarming phase of cardiopulmonary bypass (CPB) to prevent shivering and excessive oxygen consumption.

For RAT-AVR surgery, tracheal intubation was performed with a double-lumen, and for conventional AVR surgery, a single-lumen tracheal tube was used. A TEE probe was inserted in all patients. A central venous line was inserted and fluids infusion of 12 to 15 mL/kg/h was administered to ensure hemodynamic stability. Decisions regarding fluid management were based on overall fluid balance, hemodynamic status, TEE findings describing contractility, and volume status. Use of inotropic support was based on clinical, laboratory (central venous saturation), and/or TEE criteria of low-cardiac-output syndrome. The authors did not routinely use pulmonary artery lines in all patients but only in those who experienced hemodynamic instability during the postoperative period. External defibrillation pads were placed on the thorax.

When the RAT-AVR surgery was finished, the double-lumen tracheal tube and TEE probe were removed and the patient was reintubated with a single-lumen tracheal tube and transferred to the ICU.

Surgery

For preoperative planning of the RAT-AVR surgery, patients underwent MDCT imaging (Siemens Healthcare, Erlangen, Germany). CPB was instituted with peripheral cannulation of the femoral vessels. The femoral artery usually was cannulated with a 19- or 21-Fr arterial cannula (Bio-Medicus; Medtronic, Minneapolis, MN) and the femoral vein with a 25-Fr venous cannula (QuickDraw; Edwards Lifesciences, Irvine, CA). Both cannulae were placed using the Seldinger technique under TEE control. In rare cases when significant peripheral vascular disease was present or femoral vessels were small in diameter, central ascending aortic cannulation was performed with the same arterial cannula.

For the RAT-AVR surgery, a 5-to-6 cm transverse incision was made, usually over the right third rib, and the chest was entered through the third intercostal space on the right side. An aortic cross-clamp was applied through the incision. Antegrade warm blood cardioplegia was delivered through a catheter placed in the ascending aorta with repeated doses given directly to coronary ostia. The aortic valve replacement surgery was performed in standard fashion. Thoracoscopic visualization was helpful in selected patients when the aortic valve was positioned deep with a long distance between the chest wall and the level of the aortic annulus.

For AVR surgery, a full-length median sternotomy was performed and CPB was established with standard cannulation of the ascending aorta and the right atrium. The ascending aorta was cross-clamped, and antegrade warm blood cardioplegia was administered through the aortic root in repeated doses directly to the coronary ostia. A transverse aortotomy and aortic valve surgery were performed using standard techniques.

Extubation

ICU extubation protocol was standardized: temperature of the patient $>36.5^{\circ}$C, partial pressure of oxygen (PO_2) equal to or above 80 mmHg on fraction of inspired oxygen 50% or less, postoperative drainage below 100 mL/h and less than 500 mL over the previous 4 hours, patient understanding comments and without postoperative delirium, hemoglobin concentration >7.0 g/dL, hemodynamic stability with or without mild or moderate inotropic support, no metabolic derangements, potassium levels within normal limits, no metabolic or respiratory acidosis, and exclusion of residual neuromuscular blockade with use of nerve