Comparison of Anterolateral Minithoracotomy Versus Partial Upper Hemisternotomy in Aortic Valve Replacement

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Background. **In aortic valve replacement, a comparison between the anterolateral minithoracotomy and the partial upper hemisternotomy approach has not been reported to date.**

Methods. **From 2006 to 2012, isolated aortic valve replacement was performed in 1,118 consecutive patients. Aortic valve replacement was performed through a anterolateral minithoracotomy in 166 patients (14.9%) and through a partial upper hemisternotomy in 245 patients (21.9%). A propensity score–matched analysis was performed in 160 matched pairs.**

Results. **Conversion to median sternotomy was significantly higher in the anterolateral group (n = 22, 13.1%) than in the hemisternotomy group (n = 7, 4.4%) (p = 0.004). A second cross-clamp was significantly more often necessary in the anterolateral group (n = 14, 8.8%) than in the hemisternotomy group (n =2, 1.3%) (p = 0.003). The median cross-clamp time was significantly longer in the anterolateral group, 93 minutes (range, 43 to 231 minutes) than in the hemisternotomy group, 75 minutes (range, 46 to 137 minutes) ($p < 0.0001$). The median perfusion time was significantly longer in the anterolateral group, 137 minutes (range, 81 to 456 minutes) than in the hemisternotomy group, 113 minutes (range, 66 to 257 minutes) ($p < 0.0001$). Significantly more groin adverse events occurred in the anterolateral group (n = 17, 10.8%) than in the hemisternotomy group (n = 0, 0%) ($p < 0.0001$). No significant difference in 90-day mortality was seen in the anterolateral group (n = 6, 3.8%) than in the hemisternotomy group (n = 2, 1.3%) (p = 0.16).**

Conclusions. **The anterolateral minithoracotomy is associated with more perioperative adverse events. The partial upper hemisternotomy is an excellent surgical technique for minimally invasive aortic valve replacement in the daily routine for every staff surgeon.**

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According to the database of The Society of Thoracic Surgeons, perioperative mortality in isolated aortic valve replacement (IAVR) has decreased considerably in the past decade [1]. The IAVR is routinely performed through a median sternotomy [2]. Recently, other alternative options for minimally invasive surgical access for IAVR have been developed and compared with median sternotomy [3]. So far, the partial upper hemisternotomy (HS) is the most common minimally invasive surgical approach for IAVR and has been suggested as a routine surgical technique for that procedure [4]. However, the anterolateral minithoracotomy (RT) has been proposed as an even less invasive approach for minimally invasive IAVR with complete preservation of the sternum [5]. It has been reported that RT for minimally invasive IAVR is associated with lower perioperative morbidity, shorter hospital stay, and better patient satisfaction compared with median sternotomy [6]. So far, techniques for minimally invasive IAVR have been compared with median sternotomy. At our institution, we introduced RT in 2006 and the HS in 2009 for minimally invasive IAVR. A direct comparison of two different techniques for minimally invasive IAVR—surgical access through RT or HS—has not been reported so far.

Therefore, it was the aim of this study to compare perioperative results and mortality between the right anterolateral minithoracotomy and the partial upper hemisternotomy for minimally invasive IAVR in a propensity score–matched patient population.

Material and Methods

The local ethics committee approved the study. This was a retrospective cohort study of prospectively collected data from 1,118 consecutive patients receiving an IAVR at our institution from January 2001 until December 2012. In

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2006, minimally invasive IAVR was introduced at our department and performed by all staff surgeons. Until 2012, 411 patients received a minimally invasive IAVR. Initially, all patients eligible for a minimally invasive approach were operated through the RT (n = 166). This surgical access was abandoned in 2011 after internal surgical outcome revisions. In 2009, the HS was introduced as an alternative minimally invasive approach for IAVR at our department. Since 2011, the HS has been the surgical access of choice for all IAVR at our department. So far, IAVR with use of the HS technique has been performed in 245 patients by all staff surgeons. In 2012, the HS technique was performed in 78.7% of all patients receiving IAVR.

All patients receiving an aortic valve replacement through RT underwent preoperative 64-multislice computer tomographic (CT) imaging (GE Healthcare, Chalfont St Giles, UK) for evaluation of the anatomic topography of the aortic valve, the ascending aorta and thoracic diameters. The RT approach was performed with a 6-cm-long skin incision above the second or third intercostal space on the right hemithorax, as described by Glauber and colleagues [7]. Direct arterial cannulation of the ascending aorta was abandoned after the first 15 patients because of technical challenges regarding surgical access to the aorta. In all other patients, arterial cannulation was performed through the femoral artery. Venous cannulation was performed through the femoral vein in all patients [8].

The HS technique was performed with a J incision: a 6- to 8-cm-long midline skin incision 2 cm above the angle of Louis until 4 to 6 cm below the angle. The sternum was incised with an oscillating saw midline from the cranial aspect to the level of the third or fourth intercostal space, depending on the anatomic topography [4]. Arterial cannulation was performed in the distal ascending aorta with a standard arterial cannula. Venous cannulation was performed in the superior vena cava by use of a right-angle single venous cannula [9].

This study was based on an all-comers design of patients receiving a minimally invasive IAVR at our department. It included all IAVRs performed during the learning curve of these two different minimally invasive access approaches. All patients were assigned to the two groups (RT or HS) by preoperative intention to treat. Exclusion criteria were infective endocarditis, redo operations, need for additional cardiosurgical procedures, aortic valve repair, emergencies, and intubation of patients before their arrival to the anesthetic suite. For this study, we evaluated baseline patient characteristics, including age, female gender, body mass index, creatinine clearance (Cockcroft formula), preoperative documented atrial fibrillation, diabetes mellitus, New York Heart Association class III/IV functional status, impaired left ventricular ejection fraction less than 51%, aortic stenosis or regurgitation. We evaluated intraoperative and postoperative data. Intraoperative data were the following: prosthesis–patient mismatch (defined by an effective orifice area $\leq$0.85 cm^2/m^2 body surface area), intraoperative conversion to median sternotomy, second pump run, second cross-clamp, cross-clamp time, perfusion time, and intraoperative use of red blood cell units. Postoperative data were the following: surgical revision due to postoperative bleeding, length of intensive care unit stay, groin adverse events (lymphatic fistula formation, surgical revision necessary for infectious reasons, bleeding or vessel stenosis), pneumonia (diagnosed by roentgenography, CT, or positive bacterial culture), hemodialysis, intraoperative or postoperative implantation of an intra-aortic balloon pump, intraoperative or postoperative use of extracorporal membrane oxygenation, pacemaker implantation because of postoperative atrioventricular block verified by a 12-lead electrocardiogram, sternal dehiscence, and stroke, verified by a new neurologic deficit with a morphologic substrate diagnosed by cranial CT-scan. Postoperative mortality was evaluated 90 days after aortic valve replacement.

Statistical Analysis

Continuous data are presented as median (minimum–maximum range) and categoric data as frequencies and percentages. For the unmatched analysis, continuous data were compared with the Mann-Whitney *U* test. Fisher's exact test was applied to compare categoric data. To diminish the effect of selection bias and potential confounding, we used a propensity score matching model to approximate a randomized trial [10]. The propensity scores were estimated with a logistic regression. A greedy, nearest-neighbor matching algorithm was applied by making "best" matches first and "next-best" matches next in a hierarchic sequence until no more matches are available. We performed a 5-to-1 digit match as described by Parsons [11]. Balance on covariates was assessed by computing the standardized differences. A standard difference indicated an important imbalance when it was greater than 0.1 [10]. For the matched analysis, differences between matched pairs were evaluated by the signed-rank test for continuous data and McNemar's test for categoric data. A two-sided value of $p \leq 0.05$ was considered to indicate statistical significance. The Mann-Whitney *U* test and Fisher's exact test were performed with SPSS 12.0 (SPSS Inc. Chicago, IL). The propensity score matching, McNemar's test, and signed rank test were performed with SAS 9.1 (SAS Institute Inc., Cary, NC) statistical software.

Results

All the detailed results are shown in Tables 1 through 6. Important results are summarized as follows:

More intraoperative conversions to median sternotomy and second cross-clamps occurred in the RT group. The reasons for conversion to median sternotomy in the RT group were bleeding (n = 9), paravalvular leakage (n = 4), access issues (n = 3), myocardial infarction (n = 2), and others (n=4). In the HS group, the reasons for conversions were access issues (n = 6) and aortic dissection (n = 1). A higher trend of conversion-associated second cross-clamps was observed in the RT group than in the HS group. Conversion-associated mortality was 14.3% in the