Early experience with robotic mitral valve repair with intra-aortic occlusion

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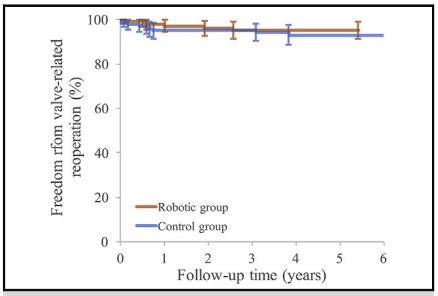
ABSTRACT

Objective: To report the learning curve and early results of robotic mitral valve repairs in comparison with propensity score–matched sternotomy controls after the adoption of a robotic mitral valve surgery program in a university teaching hospital.

Methods: A total of 142 patients underwent robotic mitral valve repair due to degenerative mitral regurgitation between May 2011 and December 2015. Control patients operated on via the conventional sternotomy approach were selected by the use of propensity score analysis resulting in 2 well-matched study groups.

Results: Valve repair rate was 98.6% and 97.9% in the robotic and sternotomy groups, respectively. Operation length, cardiopulmonary bypass, aortic cross-clamp, and ventilation times were shorter in the sternotomy group. All of these times were statistically significantly reduced within the robotic group during the learning curve. Even though there was no statistically significant difference in the rate of perioperative complications between the groups, 3 patients in the robotic group required postoperative extracorporeal membrane oxygenation due to low cardiac output, and 1 patient in the robotic group died. In the robotic and sternotomy groups, 86.3% versus 84.7% of patients had grade $\leq$1+ mitral valve regurgitation at the latest follow-up visit, and there was no statistically significant difference in survival or reoperation rate between the 2 study groups during follow-up.

Conclusions: The present series reports the entire early learning curve related to the introduction of robotic mitral valve repair in our institution. In all, repair rate and early durability were acceptable, but more patients in the robotic group had serious complications. Early major robotic complications that occurred may have been related to the simultaneous use of intra-aortic occlusion. (J Thorac Cardiovasc Surg 2017;■:1-9)



Freedom from valve-related reoperation.

Central Message

We report the early learning curve related to the introduction of robotic mitral valve repair. Valve-related follow-up results were acceptable, but some major complications occurred in the robotic group. Early major robotic complications that occurred may have been related to the simultaneous use of intra-aortic occlusion.

Perspective

Excellent mid-term results after robotic mitral valve repair have been reported by high-volume centers. Our study reports the entire early learning curve related to the introduction of robotic mitral valve repair compared with propensity score–matched sternotomy controls. In all, repair rate and valve-related follow-up results were acceptable, but some major complications occurred in the robotic group. Early major robotic complications that occurred may have been related to the simultaneous use of intra-aortic occlusion.

See Editorial Commentary page XXX.

Advancements in robotic surgical instrumentation and cardiopulmonary bypass technologies have expanded the role of robotically assisted operations in cardiac surgery. Robotic methods are most widely adopted in mitral valve operations due to excellent visualization of the mitral valve using

Scanning this QR code will take you to a supplemental video for this article.

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Abbreviations and Acronyms
ECMO = extracorporeal membrane oxygenator
IQR = interquartile range
MR = mitral valve regurgitation
SD = standard deviation

the robotic approach. In robotic mitral valve surgery, access to the heart is obtained by the use of small ports in the right intercostal spaces, allowing surgery to be performed with minimal tissue trauma in comparison with the conventional sternotomy approach. Suggested benefits of the robotically assisted approach have been faster return to ordinary daily activities, shorter length of stay, reduced pain, improved cosmesis, and reduced need for blood transfusions. In high-volume centers, the short-term and long-term results of robotic mitral valve surgery have been excellent, and outcomes have been comparable with the conventional sternotomy approach.[1-8] Recently published expert opinion for practice guidelines of minimally invasive and robotic mitral valve surgery suggests that in the beginning of the learning curve only simple mitral valve pathologies should be operated via minimally invasive approaches.[9-11] However, in high-volume centers, the results of complex robotic leaflet repairs have been comparable with more simple operations with no increase in the need of reoperations.[7] Also, quality of life early after surgery improves faster after robotic operations when compared with the sternotomy approach, but this difference is reduced over time.[12,13]

The minimally invasive cardiac surgery program at the Helsinki University Central Hospital Heart and Lung Center was started in January 2009. The first minimally invasive operations were performed videothoracoscopically via a right mini-thoracotomy. Since May 2011, minimally invasive mitral valve operations have been performed with robotic assistance. In addition to robotic mitral valve surgery, robotically assisted coronary artery bypass grafting operations and robotically assisted operations for atrial septal defects and myxomas also have been performed at our institution.

The objective of this study was to report the learning curve after the adoption of a robotic mitral valve surgery program in a university teaching hospital and to report the early results of robotic mitral valve repair in comparison with propensity score–matched sternotomy controls. Notably, in our series the use of an endoaortic balloon was initiated at the same time with the robotic instrumentation, which resulted in overlapping learning curves. Also, myocardial protection methods evolved during the learning curve.

PATIENTS AND METHODS

Patients and Data Collection

A total of 145 consecutive patients underwent robotic mitral valve surgery at our institution between May 2011 and December 2015. Operations were performed with the da Vinci Si Surgical System (Intuitive Surgical, Inc, Sunnyvale, Calif). Altogether, 3 patients who underwent a robotically assisted operation were excluded from this study, 2 due to a planned mitral valve replacement and 1 due to active endocarditis. This resulted in a study group of 142 patients who were scheduled for robotic mitral valve repair for degenerative mitral regurgitation.

Careful patient selection was carried out when selecting patients for robotic surgery. Exclusion criteria for robotic mitral valve surgery are listed in Table 1. Patients with significant comorbidities or high surgical risk were mostly operated on via the conventional sternotomy approach. To reduce selection bias, propensity score matching was used to create 2 study groups with similar preoperative risk profiles.[14] The medical records of all patients who underwent isolated mitral valve surgery or mitral valve surgery with concomitant tricuspid valve annuloplasty or an atrial fibrillation ablation procedure from the conventional sternotomy approach in our institution between 2005 and 2015 were reviewed for the propensity score analysis. A total of 317 sternotomy patients were included in the analysis after we excluded patients who underwent urgent surgery, surgery for active endocarditis, or planned mitral valve replacement. Of these patients, a control group of 142 patients was selected using the propensity score analysis. Patients included in the study are depicted in a flow chart (Figure 1).

Preoperative patient characteristics of the robotic group and the propensity-matched control group are shown in Table 2. The majority of patients had isolated posterior leaflet pathology, but isolated anterior leaflet and bileaflet pathologies also were present in both study groups with no statistically significant difference between the 2 groups. All control patients and 141 patients in the robotic group had grade 3+ or 4+ mitral valve regurgitation (MR) preoperatively, and 1 patient in the robotic group who underwent concomitant myxoma excision had grade 2+ MR preoperatively. A total of 19 (13.4%) patients in the sternotomy group and 7 (4.9%) patients in the robotic group had chronic lung disease preoperatively ($P = .022$). Patients with chronic obstructive pulmonary disease were excluded from robotic surgery, which may in part explain the observed difference. Preoperatively, all patients underwent a computed tomography scan of the aorta and femoral vessels to exclude patients unsuitable for robotic surgery. Echocardiographic follow-up visits were performed mostly at 3 months and 1 year postoperatively, and all available data from the latest follow-up visits were included in this study.

The patient data were collected from intensive care, cardiac surgery, and cardiology databases retrospectively. Medical records related to preoperative and postoperative care were retrieved from other hospitals when needed. This study was approved by the local institutional board and the local ethics committee.

Surgical Technique

All robotically assisted operations were performed with the da Vinci Si Surgical system (Intuitive Surgical, Inc). Cardiopulmonary bypass was established by groin cannulation and aortic occlusion was performed primarily with an endoaortic balloon. A double-lumen endotracheal tube or a bronchial blocker was applied to allow isolated left-lung ventilation. The camera port was placed near the mammilla, mostly in the fourth intercostal space. The service port was placed laterally from the camera port to the same or adjacent intercostal space. The ports for the second, first, and third robotic arms were positioned using the 4-finger distance rule in the third, fifth, and sixth intercostal spaces, respectively.

Bicaval venous cannulation was performed via the right femoral and jugular veins with Medtronic, Inc (Minneapolis, Minn), Estech Systems Inc (Plano, Tex), or Edwards Lifesciences (Irvine, Calif) venous cannulas. Usually right-sided femoral arterial cannulation was preferred with a 21- or 23-F side branch arterial cannula (EndoReturn; Edwards Lifesciences). An endoaortic balloon (EndoClamp or IntraClude; Edwards Lifesciences) was positioned in the ascending aorta under echocardiographic control. The patient's right side was elevated 30° from the horizontal plane, and the