Robotic Mitral Valve Repair: A Review of Anesthetic Management of the First 200 Patients

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Objective: **The aim of this study was to describe the evolution in anesthetic technique used for the first 200 patients undergoing robotic mitral valve surgery.**

Design: **A retrospective review.**

Setting: **A single tertiary referral academic hospital.**

Participants: **Two hundred consecutive patients undergoing robotic mitral valve surgery using the da Vinci Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA) at Mayo Clinic Rochester.**

Interventions: **None.**

Measurements and Main Results: **After obtaining institutional review board approval, surgical and anesthetic data were recorded. For analysis, patients were placed in 4 groups, each containing 50 consecutive patients, labeled Quartiles 1 to 4. Over time, there were statistically significant decreases in cardiopulmonary bypass and aortic cross-clamp times. Significant differences in the anesthetic management were shown, with a reduction of intraoperative fentanyl and midazolam doses, and the introduction of paravertebral blockade in Quartile 2. There was a reduction of time between incision closure and extubation, and nearly 90% of patients were extubated in the operating room in Quartiles 3 and 4. Despite changes to the intraoperative analgesic management, and focus on earlier extubation, there were no differences seen in visual analog scale (VAS) pain scores over the 4 quartiles. Reductions were seen in total intensive care unit and hospital length of stay during the study period.**

Conclusions: **Changes to the practice, including efforts to limit intraoperative opioid administration and the addition of preoperative paravertebral blockade, helped facilitate earlier extubation. In the second half of the study period, close to 90% of patients were extubated in the operating room safely and without delaying patient transition to the intensive care unit.**

KEY WORDS: minimally invasive, cardiac surgery, robotic, mitral valve repair, paravertebral block, early extubation

THE CURRENT GUIDELINES for the management of patients with cardiac valve disease recommend early referral for mitral valve repair based upon the ability to complete anatomic correction with low morbidity and mortality with greater than 90% certainty.[1] Large clinical series of mitral valve repair for leaflet prolapse have demonstrated excellent late outcomes using standardized surgical techniques.[2–5] Asymptomatic or minimally symptomatic patients with mitral regurgitation (MR) may seek less invasive options. Despite some controversy within the cardiac surgical field, there is growing patient interest in minimally invasive mitral valve surgery. Minimally invasive mitral valve repair has been associated with reduced pain, time to extubation, and transfusion. Also, there is improved respiratory function postoperatively and equal or reduced postoperative length of hospital stay (LOS).[6–9] A recent review of 100 patients in this practice showed that robotic mitral valve repair using standard open repair techniques not only resulted in excellent surgical outcome, but also was associated with shorter duration of postoperative ventilation and intensive care unit (ICU) and hospital LOS when compared with patients who underwent traditional mitral valve repair via median sternotomy.[10,11]

Although robotic cardiac surgery presents new challenges to the surgical and anesthesia teams, there are several potential benefits that should facilitate early extubation and rapid recovery postoperatively. These include small incisions, avoidance of sternotomy, and reduced bleeding and surgical trauma.[12] As experience is gained performing these procedures, the management of these patients can become standardized.[13]

The purpose of this study was to review the intraoperative anesthetic management of the first 200 patients undergoing robotic mitral valve repair at Mayo Clinic Rochester. With increasing focus on early tracheal extubation and rapid recovery for these patients, the authors also wanted to confirm that the changes being made to achieve these goals did not compromise patient safety or analgesia.

PATIENTS AND METHODS

After obtaining institutional review board approval, the authors performed a retrospective review of medical records of the first consecutive 200 patients undergoing robotic mitral valve repair with the da Vinci Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA) at Mayo Clinic Rochester. The requirement for written informed consent was waived by the institutional review board. Procedures occurred between January 24, 2008 and January 28, 2011. Patients with isolated mitral leaflet prolapse and severe MR were offered surgery in accordance with American College of Cardiology and American Heart Association guidelines. Before robotic mitral valve repair, all patients underwent transthoracic echocardiogram and an electrocardiography gated volumetric computed tomography scan of the chest, abdomen, and pelvis. Patients with significant aortic or coronary atherosclerotic disease, lung disease, chest wall abnormalities, or previous right-sided thoracic surgery were not offered a robotic approach. There were no exclusions related to the anatomy of the mitral valve. Full description of

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the surgical and anesthetic techniques of the authors' institution has been published in detail.[10,11,14] There were 2 staff surgeons who alternated as primary surgeon for these 200 operations. Fourteen different cardiac anesthesiologists were involved in the care of these patients. No members of the surgical, anesthesia, perfusion, or nursing teams had any previous experience with robotic cardiac operations at another institution before the development of this practice.

All procedures were performed under general endotracheal anesthesia with single-lung ventilation. Lung isolation was achieved with a left-sided double-lumen endotracheal tube, or endobronchial blocker through a single-lumen endotracheal tube. General anesthesia was induced with propofol, midazolam, and fentanyl. Isoflurane, fentanyl, and vecuronium were used for maintenance. As the practice evolved, efforts were made to limit total fentanyl dose to <5 to <7 μg/kg and to perform multi-level single injection right-sided ultrasound-guided thoracic paravertebral blocks (TPVBs) before surgery to supplement analgesia. Blocks were performed with dynamic ultrasound guidance in the sitting position before induction of anesthesia in the operating room (OR). A total of 25 mL to 30 mL of 0.5% bupivacaine with epinephrine (1:200,000) was injected through a 21-G regional block needle at 2 to 3 levels between T2 and T6.[15] Patients were monitored with left radial arterial and central venous catheters and transesophageal echocardiography (TEE). A second central venous catheter (5-Fr, 10-cm) was inserted in the right internal jugular vein to facilitate venous cannula placement by the surgical team.

Patients were anticoagulated with heparin, 350 units/kg, before cannulation. Additional heparin (5,000-10,000 units) was administered to maintain an activated coagulation time (Hemochron 401, ITC, Edison, NJ) >450 seconds. Aminocaproic acid, 100 mg/kg loading dose, was given, followed by an infusion of 30 mg/kg/hour. The cardiopulmonary bypass (CPB) circuit was primed with 1,500 mL of balanced salt solution, 10 mEq sodium bicarbonate, 12.5 gm of mannitol, 5 gm of aminocaproic acid, and 10,000 units of heparin. All patients underwent cannulation of the left femoral artery and vein through a 1.5- to 2-cm incision with advancement of a 21F to 25F multistage venous cannula (Edwards Lifesciences CardioVations, Irvine, CA) up to the junction of the superior vena cava and right atrium. A percutaneous 16F to 18F venous cannula also was inserted via the right internal jugular vein using the Seldinger technique to augment right atrial drainage. Transesophageal echocardiography was used to confirm the position of both venous cannulae. Cardiopulmonary bypass was maintained at 2.4 L/min/m^2. Patient temperature on CPB was allowed to drift to 34°C. Cardioplegia was delivered at 20-minute intervals through a long tack vent cannula placed in the ascending aorta. Aortic cross-clamping was performed with a transthoracic clamp inserted through the chest wall.

The surgical procedure was carried out through a total of 5 right thoracic ports: A working port, left atrial retractor and camera ports in the fourth intercostal space, and robotic arm ports 1 interspace above and 2 interspaces below the working port. Standard open-repair techniques were used for all robotic mitral valve repair procedures.[14]

At the conclusion of the procedure, local anesthetic (0.25% bupivacaine) was infiltrated at the femoral incision site and also at the surgical port sites if no thoracic paravertebral blocks (TPVBs) were performed. Neuromuscular blockade was reversed with neostigmine and the isoflurane was discontinued. Patients were extubated in the OR at the end of the procedure if standard extubation criteria were met and at the discretion of the responsible anesthesiologist. If prolonged ventilation was anticipated, a propofol infusion was started for sedation before leaving the OR. Regardless of extubation status, all patients were transported directly to the ICU on a monitored ICU bed.

Postoperative analgesia was not standardized and was prescribed by the primary surgical service. Patients were offered patient-controlled analgesia therapy using fentanyl or hydromorphone, in addition to a combination of acetaminophen, tramadol, and nonsteroidal anti-inflammatory agents. A modified Richmond Agitation Sedation Scale (RASS) was used to assess patient alertness by the ICU nursing team. Pain assessment was completed by the ICU and intermediate care unit nurses per standard protocol using numeric postoperative visual analog scale (VAS) pain scales ranging from zero (no pain) to 10 (worst possible pain).

For the initial analysis, patients were grouped into quartiles containing 50 consecutive patients to observe changes or trends in surgical, anesthetic, and recovery data as experience with robotic mitral valve repair was gained. Quartile 1 included patients 1 to 50 (January 24, 2008 to February 9, 2009). Quartile 2 included patients 51 to 100 (February 11, 2009 to November 30, 2009. Quartile 3 included patients 101 to 150 (December 10, 2009 to July 14, 2010). Quartile 4 included patients 151 to 200 (July 20, 2010 to January 28, 2011). Additional analysis was performed comparing patients extubated in the OR and patients extubated in the ICU. Surgical and recovery times, postextubation blood gas parameters, and postoperative sedation and VAS pain scores were compared between the groups.

Descriptive statistics for categoric variables are reported as frequency and percentage while continuous variables are reported as mean ± standard deviation (median) or median (interquartile range) as appropriate. Categoric variables were compared between quartile groups using χ^2 test or Fisher's exact test and continuous variables were compared using one-way ANOVA or Kruskal Wallis test where appropriate. Comparison of categoric variables between patients extubated in and out of the OR was performed by χ^2 test or Fisher's exact test, and comparisons of continuous variables were performed by two-sample t test or Wilcoxon rank sum test according to the normality of distribution of the variables.

RESULTS

All patients underwent successful mitral valve repair confirmed by intraoperative TEE assessment. Concomitant procedures included left-sided MAZE procedure in 5 (2.5%) patients and atrial septal defect or patent foramen ovale closure in 12 (6.0%) patients. Transfusion of any allogeneic blood product only occurred in 12 (6.0%) patients.

Surgical and anesthetic data for the quartile analysis are shown in Table 1. Over time, there were statistically significant decreases in operative time, CPB times, and aortic cross-clamp times ($p \leq 0.0001$). Significant differences in the anesthetic