Technical and operational modifications required for evolving robotic programs performing anatomic pulmonary resection

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As the number of thoracic robotic-assisted operations continues to grow, more hospitals are acquiring robots, and newer models such as the da Vinci Xi® surgical system are replacing older models such as the da Vinci Si® surgical system. Therefore, the demand to understand the technical modifications required for port placement, robotic arm numbering, operating room set-up, and the different instruments used is increasing.

The goals of this study were twofold: first, to specifically identify the precise clinical modifications that were implemented and the lessons learned during the transition from a da Vinci Si system to a da Vinci Xi system for lobectomy and segmentectomy. Second, to share measured operational differences between models.

Methods

The authors reviewed a prospective database of a consecutive series of patients who intended to undergo robotic lobectomy or segmentectomy by one surgeon (Cerfolio) from January 2015 to December 2016 on the da Vinci Si and da Vinci Xi models.

Operations were divided into three groups based on the robotic system used: (1) Si, which comprised all segmentectomies and lobectomies on the da Vinci Si system from January 2015 -January 2016; (2) Early Xi, defined as robotic-assisted lobectomies and segmentectomies performed on the da Vinci Xi system during the first 6 months after system acquisition (January -June 2016); or (3) Late Xi, representing surgeries performed in the second half of the year (July -December 2016).

There were 126 operations (101 lobectomies and 25 segmentectomies) performed in 2015–2016 on the da Vinci Si system, and 123 operations (95 lobectomies and 28 segmentectomies) performed on the da Vinci Xi system in 2016. Among these, 52 operations occurred in the Early Xi group (January–June 2016), and 71 in the Late Xi group (July–December 2016). All patients were similar in age, body mass index, height, pulmonary function tests, and co-morbidities.

Operative parameters measured include: docking time (defined as the time from incision to moving the robot to bedside with portal anchorage); operation duration (defined as skin incision to skin closure); and skin closure to room exit.

The authors also surveyed the anesthesiologists, surgical residents, and nursing staff familiar with the da Vinci Si and da Vinci Xi systems on parameters of performance including ease of robotic maneuverability in docking, intraoperative mobility and visibility, patient access, and overall satisfaction.

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Results

Notable technical changes with the da Vinci Xi® system (relative to the da Vinci Si® system) included the following:

Turning the patient bed is generally unnecessary with the da Vinci Xi system. This system can approach the patient from the left side or right side, and the arms together can be rotated into the proper position so that the arms holding the camera and instruments will be directed towards the operating target. The patient can remain with their head oriented towards the anesthesia station, and the da Vinci Xi system can be driven in perpendicular to the patient's body.

Specific port positioning differs depending on what operation is being performed. In general, using the da Vinci Xi system requires a minimum distance of 8 cm, and preferably 9 cm, between ports to avoid collisions between instruments.

Certain key concepts to emphasize during the teaching/learning phase include:

- At all times, maintaining a clear line of sight to instruments which are in motion.
- Clearly stating the instrument to remove and the instrument to use in exchange.
- Ensuring the assistant verifies the surgeon's request by verbal confirmation prior to implementing.

Operative differences with the da Vinci Xi system (relative to the da Vinci Si system) were reported as follows:

The Early Xi group (January–June 2016) was similar in all operative parameters to the Si group (see table).

Operative parameters were significantly shorter in the Late Xi group compared to the Si group (see table). Among these, median docking time was significantly shorter (7.5 versus 10 min, $p = 0.003$), as was operation duration (114 versus 119 min, $p = 0.041$).

The time from skin closure to room exit was shorter in the Late Xi group, although not statistically significant (12 versus 13 min, $p = 0.081$).

On survey, anesthesiologists expressed greater comfort with the da Vinci Xi system, because the patient's head was not covered by the robot allowing improved access to the airway.

Surgical outcomes between all groups were similar. Outcomes for da Vinci Si and da Vinci Xi operations such as median blood loss (20 cc versus 20 cc), transfusion rate (0 versus 0), major complication rate (3.2 versus 3.3%), and the 30- and 90-day mortality were no different (one 30-day death in the Si group).

Operative parameters in da Vinci Si and da Vinci Xi surgical efficiency

Parameter	Si Group n = 126 (95% CI)	Early Xi Group n = 52 (95% CI)	Late Xi Group n = 71 (95% CI)	*p* Value
Docking time (min)	10 (9 - 12)	—	7.5 (6–8)	0.003
Operation duration (min)	119 (116–126)	117 (109–128)	—	0.395
Operation duration (min)	119 (116–126)	—	114 (104–123)	0.041
Skin closure to room exit (min)	13 (12–15)	—	12 (10–14)	0.081

Data are presented in medians with 95% confidence intervals. Significance level was set at $p<0.05$.

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Conclusion

The authors demonstrate that there is no increased risk in transitioning from the da Vinci Si® system to the da Vinci Xi® system with an experienced thoracic robotic-assisted surgeon. In fact, with continued experience on the da Vinci Xi model, operative parameters such as operation duration may improve. The operating room staff, including the anesthesiologist, is more satisfied with the da Vinci Xi platform due to improved head access.

Study limitation

These results were based on data generated by a single surgeon at a single institution.

FINANCIAL DISCLOSURE

Dr. Cerfolio has received compensation from Intuitive Surgical for consulting and/or educational services.

IMPORTANT SAFETY INFORMATION

Serious complications may occur in any surgery, including da Vinci® Surgery, up to and including death. Examples of serious or life-threatening complications, which may require prolonged and/or unexpected hospitalization and/or reoperation, include but are not limited to, one or more of the following: injury to tissues/organs, bleeding, infection and internal scarring that can cause long-lasting dysfunction/pain.

Risks specific to minimally invasive surgery, including da Vinci® Surgery, include but are not limited to, one or more of the following: temporary pain/nerve injury associated with positioning; a longer operative time, the need to convert to an open approach, or the need for additional or larger incision sites. Converting the procedure could result in a longer operative time, a longer time under anesthesia, and could lead to increased complications. Contraindications applicable to the use of conventional endoscopic instruments also apply to the use of all da Vinci instruments.

For Important Safety Information, indications for use, risks, full cautions and warnings, please also refer to **www.davincisurgery.com/safety** and **www.intuitivesurgical.com/safety**.

Individual surgical results may vary.

DA VINCI XI® PRECAUTION STATEMENT

The demonstration of safety and effectiveness for the specific procedure(s) discussed in this material was based on evaluation of the device as a surgical tool and did not include evaluation of outcomes related to the treatment of cancer (overall survival, disease-free survival, local recurrence) or treatment of the patient's underlying disease/condition. Device usage in all surgical procedures should be guided by the clinical judgment of an adequately trained surgeon.

The friable nature of pulmonary tissue enhances the risk of vascular, bronchiolar or other injury that will be difficult to control when using this device. Published clinical experience as well as clinical studies performed to support this marketing clearance have demonstrated that even surgeons considered expert in laparoscopy/thoracoscopy have substantial learning curves of 10 to 12 cases (Falk, et al., Total endoscopic computer enhanced coronary artery bypass grafting, Eur J Cardiothorac Surg 2000; 17: 38-45).

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