Total robotic radical rectal resection with da Vinci Xi system: single docking, single phase technique

Anup Sunil Tamhankar1
Sudhir Jatal1
Avanish Saklani2*

1Department of Surgical Oncology, Tata Memorial Hospital, Mumbai, India
2Department of Gastro-Intestinal Surgery, Department of Surgical Oncology, Tata Memorial Hospital, Mumbai, India

*Correspondence to: Avanish Saklani, Department of Gastro-Intestinal Surgery, Department of Surgical Oncology, Tata Memorial Hospital, Mumbai, India. Email: asaklani@hotmail.com

Abstract

Objective This study aims to assess the advantages of Da Vinci Xi system in rectal cancer surgery. It also assesses the initial oncological outcomes after rectal resection with this system from a tertiary cancer center in India.

Introduction Robotic rectal surgery has distinct advantages over laparoscopy. Total robotic resection is increasing following the evolution of hybrid technology. The latest Da Vinci Xi system (Intuitive Surgical, Sunnyvale, USA) is enabled with newer features to make total robotic resection possible with single docking and single phase.

Methods and results Thirty-six patients underwent total robotic resection in a single phase and single docking. We used newer port positions in a straight line. Median distance from the anal verge was 4.5 cm. Median robotic docking time and robotic procedure time were 9 and 280 min, respectively. Median blood loss was 100 mL. One patient needed conversion to an open approach due to advanced disease. Circumferential resection margin and longitudinal resection margins were uninvolved in all other patients. Median lymph node yield was 10. Median post-operative stay was 7 days. There were no intra-operative adverse events.

Conclusion The latest Da Vinci Xi system has made total robotic rectal surgery feasible in single docking and single phase. With this new system, four arm total robotic rectal surgery may replace the hybrid technique of laparoscopic and robotic surgery for rectal malignancies. The learning curve for the new system appears to be shorter than anticipated. Early perioperative and oncological outcomes of total robotic rectal surgery with the new system are promising. Copyright © 2016 John Wiley & Sons, Ltd.

Keywords Total robotic rectal resection; Carcinoma Rectum; Multiquadrant Surgery; Single Docking and single phase resection

Introduction

Minimal invasive surgery for rectal cancers has gained acceptance over open surgery. Results from MRC CLASICC and COLOR-II have shown no inferiority of laparoscopic rectal resection compared with an open approach. Laparoscopic surgery is associated with better short-term outcomes with less pain and blood loss and is associated with early return of bowel activity and decreased hospital stay (1,2). However, it was associated with high
conversion rates to open surgery (up to 29%), and patients who were converted, showed suboptimal outcomes. Weber et al. were the first to perform a robotic-assisted colorectal procedure in 2002. It involved mobilization of the right and sigmoid colon (3). Since then, many studies have shown the feasibility and safety of robotic colorectal surgery (4–7). Recently, three meta-analyses comparing robotic rectal cancer surgery with laparoscopic surgery have shown lower conversion rates (8–10). Robotic pelvic dissection has shown better preservation of sexual function (11). All other outcomes including early recovery, safety, and oncological outcome were similar (8–10). Robotic surgery has certain advantages over open and laparoscopic surgery such as a stable operating platform, fine motion scaling, three-dimensional imaging, articulated instruments providing superior dexterity, and a stable surgeon-controlled camera. These benefits of robotic surgery are essential in areas where access is problematic such as the pelvis in which laparoscopic operations and visualization are technically difficult and less accurate (4,5,7). It may facilitate ultralow dissection (intersphincteric plane) and improve functional outcome (urogenital) while maintaining oncological safety.

The Da Vinci robotic system is the pioneer in this field. Recently, it introduced its latest version, Da Vinci Xi (Intuitive Surgical, Sunnyvale, USA) in April 2014. We are the first center to install this latest version in India. We present our initial experience with the use of this new system at a tertiary referral cancer center (Tata Memorial Center, Mumbai, India).

Materials and methods

We operated 36 rectal cancer cases from 6 October 2014, to 14 June 2015, robotically. Total robotic technique was used in all the patients. The data were evaluated prospectively. The demographic details, body mass index (BMI), perioperative outcomes, pathology results, and postoperative complications were noted.

Technique

Four 8-mm robotic ports were used for the procedure. The camera port was placed 2 cm above the umbilicus on mid-line (open access). After creating pneumoperitoneum, we used a 30° robotic camera to place the remaining ports under direct vision; the three ports were placed along a straight line joining the right anterior superior iliac spine (ASIS) and the camera port, extending toward the left costal margin. Average distance among ports was 7 cm to avoid clashing of the robotic arms. The farthest ports were positioned at least 2 cm away from the bony landmarks (i.e., right ASIS and left costal margin) (Figure 1). An assistant port was placed on the right side, in triangulation with right side ports at 7 cm distance. We used an Air-seal cannula (Surgiquest, Intuitive Surgical) as an assistant port. This port was used for suctioning, pelvic traction, and occasionally for stapling the bowel. The patient was positioned in lithotomy with a 30° Trendelenburg position and 15° right tilt (left up). The position was not changed throughout the procedure. Robotic camera (lighter and less bulky than the previous Si version) was used initially to place the small bowel in the supracolic compartment and to expose the duodenaljejunal (DJ) flexure with the help of laparoscopic instruments.

Before docking, the settings on the patient cart were set to lower abdomen, left side, and the robotic arms were deployed. The patient cart was brought in from left side. With use of the laser pointer, the overhead boom was centered on to the camera port (Figure 2). The camera was attached to Arm 2, although it can be introduced through any of the arms. The camera was pointed toward the inferior mesenteric artery, and ‘targeting’ was used to align the other arms (automatic) (Figure 3). We used monopolar scissors in Arm 3, fenestrated bipolar forceps in Arm 1, and prograsp forceps in Arm 4 (Intuitive Surgical). Dissection of the inferior mesenteric (artery and vein) pedicles was done initially with transection of vessels (using robotic hem-o-lock clip applicator, using hem-o lock clips) after nodal dissection. This was followed by standard medial to lateral dissection preserving ureter and gonadal vessels up to...
most of the time and was instrumental in providing precise and tireless retraction. We used tape around the recto sigmoid junction to allow additional traction by the assistant through the air-seal port. Total mesorectal excision was completely satisfactorily. Visualization of autonomic nerves was excellent with the 3D camera, and they were safeguarded in all patients. Air-seal mode was instrumental in avoiding fogging of the camera and blurring of vision. It was also useful in saving insufflation gas.

For transection of the rectum, the robotic arms were used to guide the stapler through the assistant port (high stapling). However, for low stapling, the fourth port was replaced with a 12-mm laparoscopic port. Specimen extraction and anvil placement for the stapled anastomosis were performed through left iliac fossa incision. Hand-sewn coloanal anastomosis was performed in patients requiring intersphincteric resection. Visualization of the intersphincteric space was better with robotic than our prior laparoscopic experiences.

Results

The demographic profile of the cohort is shown in Table 1. Among the cohort, 28 of 36 cases were given preoperative chemoradiotherapy as they showed clinicoradiologically locally advanced disease (Stage III) at initial evaluation. One case of rectosigmoid carcinoma

### Table 1. Demographic details and clinic-pathological outcome

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number</td>
<td>36</td>
</tr>
<tr>
<td>Age (Median)(years)</td>
<td>51 (23–75)</td>
</tr>
<tr>
<td>Sex (Male:Female)</td>
<td>1.76:1 (23:13)</td>
</tr>
<tr>
<td>BMI (Median)</td>
<td>22.7 (15–30.1)</td>
</tr>
<tr>
<td><strong>Surgery Type</strong></td>
<td></td>
</tr>
<tr>
<td>APR</td>
<td>13</td>
</tr>
<tr>
<td>ISR</td>
<td>5</td>
</tr>
<tr>
<td>AR</td>
<td>16</td>
</tr>
<tr>
<td>Docking time (Median, Min)</td>
<td>9 (4–14)</td>
</tr>
<tr>
<td>Robotic procedure time (Median, Min)</td>
<td>280 (100–380)</td>
</tr>
<tr>
<td>Blood loss (Median, mL)</td>
<td>100 (400–600)</td>
</tr>
<tr>
<td>Distance from AV (Median, cm)</td>
<td>4.5 (0.5–15)</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td></td>
</tr>
<tr>
<td>Upper 3rd</td>
<td>5</td>
</tr>
<tr>
<td>Middle 3rd</td>
<td>8</td>
</tr>
<tr>
<td>Lower 3rd</td>
<td>23</td>
</tr>
<tr>
<td>Lymph node yield (Median)</td>
<td>10 (8–52)</td>
</tr>
<tr>
<td>Distal resection margin (Median, cm)</td>
<td>2.5 (0.8–8)</td>
</tr>
<tr>
<td>Circumferential resection margin (CRM, mm)</td>
<td>1/36 (2.77%)</td>
</tr>
<tr>
<td><strong>Quality of mesorectal excision</strong></td>
<td></td>
</tr>
<tr>
<td>Complete</td>
<td>35/36 (97.2%)</td>
</tr>
<tr>
<td>Incomplete</td>
<td>1/36 (2.8%)</td>
</tr>
<tr>
<td>Post-operative stay (Days)</td>
<td>7 (3–26)</td>
</tr>
</tbody>
</table>

needed conversion to open approach (locally advanced) as it had invaded ureter and presacral fascia. Other demographic and clinical parameters are illustrated in Table 1. One patient showed post-operative ileus. One patient, who was converted to open approach due to locally advanced disease, died owing to pulmonary thrombo-embolism. This patient had involved circumferential resection margin (CRM). CRM and longitudinal resection margins (LRM) were not involved in all the other patients. Median distances of tumor from proximal and distal resection margins were 14 and 2.5 cm respectively. The median lymph node yield was 10. The median post-operative stay was 7 days.

Discussion

Laparoscopy has proven its value over the open technique for rectal cancer surgery in terms of better short-term outcomes (1,2). However, it is fraught with certain problems such as lack of 3D vision, poor ergonomics, limited dexterity, restricted degrees of movements (only four) and amplification of physiologic tremor. This significantly hampers the performance of surgeons, especially in small confined spaces such as the narrow male pelvis or in those patients with a high body mass index (BMI). Laparoscopic surgery has been shown to have a longer learning curve than robotic surgery (12,13). The development of robotic systems such as the da Vinci has made it possible to overcome these difficulties (14).

Robotic technology has evolved over a period of time. It started with a hybrid technique of laparoscopic colonic mobilization and robotic pelvic dissection. Later, total robotic techniques evolved. But, they required dual docking and involved cumbersome changes of position of the patient cart (11). Single docking and dual phase technique was described with the Da Vinci S version. However, it required multiquadrant port placement and port hopping (change of ports for instruments) (15). Fortunately, the recently developed Xi system empowers the surgeon to perform the whole robotic multiquadrant procedure with a single docking and single phase mode, thereby avoiding the requirement for port hopping or alteration of the operating arms.

The new Da Vinci Xi system

The Xi system has particular advantages over its prior versions. The advancement in the design of the overhead boom provides greater liberty for accessing organs from all positions. The facility of a rotating boom in the patient cart has made multiquadrant surgery possible without the need for re-docking of the robot. In addition, a laser pointer present in the cart centers the camera port enabling optimal positioning of the arms. The system’s preset organ-centered settings enable targeting and alignment. While prior systems warranted a 90° angle at the proximal joints, a more compact positioning is adopted by the robotic arms. This positioning of proximal joint provides better patient clearance and makes the surgery safer for the patient and aids in avoiding recurrent dockings for patient clearance. This system makes docking user friendly for less experienced users. A similar decrease in docking time using the new Xi system was seen in the urology department when less experienced nurses were docking (16). The automatic alignment of arms decreases arm collisions. The arms are enabled with yellow and gray trackers for active and inactive instruments. This helps in finding instruments in the restricted field easier and safer. For a novice, losing sight of the robotic arms inside the abdomen can cause potential bowel injuries and this new tracking feature can avoid such mishaps. Placement of all ports along a straight line reduces external collisions of arms and aids in smoother multiquadrant surgery. The endoscopic digital architecture is revised to create a more compact design with better visual definition and clarity. An endoscope can be attached to any of the robotic arms. This provides flexibility for visualization of the surgical site. The arms are smaller and thinner with newly designed FLEX joints that provide a wider range of motion than the earlier versions and make the multiquadrant procedures easier. Instrument shafts are longer than before for greater operative reach. The new system is also compatible with Intuitive Surgical’s Firefly™ Fluorescence Imaging System. It provides the surgeon with additional visual information in the assessment of vessels, bile ducts and tissue perfusion.

We did not have any untoward complications intraoperatively. But on a few occasions we faced difficulty in handling redundant sigmoid colon owing to a narrower field of vision. Operative time in our series is comparable with the world literature and series of hybrid technique (217–383 min) (17–20). We needed splenic flexure mobilization in only five patients. In other patients, we did not require it as sigmoid colon was quite redundant and hence, reach of the colon for anastomosis was not a concern. Similar findings have been noted in Asian patients in other studies (21–23). This extra length of sigmoid colon makes the routine splenic flexure mobilization unnecessary. This makes multiquadrant colonic surgery less cumbersome. The number of lymph nodes retrieved was on the low side (10) in our study. But, this may be due to the majority of patients being offered neoadjuvant chemoradiotherapy. Retrospective studies have shown that the number of nodes retrieved tends to lose prognostic significance after neoadjuvant chemoradiation. Tumor
regression grade and lymph node status are more prognostic than the number of nodes retrieved after chemoradiation (24,25). Our perioperative outcomes were comparable with previous robotic series (15,17,26). Our results show that total robotic surgery for rectal cancer is technically feasible and oncologically safe.

Robotic rectal surgery using the Da Vinci Xi system enables single docking, single phase rectal resection with fewer ports compared with the Si system. At the same time, the learning curve for the new system may be lower than anticipated owing to its surgeon-friendly nature.

Conclusion

The latest Da Vinci Xi (Intuitive Surgical) system has made total robotic rectal surgeries feasible in a single docking and single phase without changing the robotic arms. This technology may facilitate minimal access colorectal surgery by eliminating the problem of multiple docking steps. The port positions used by us have made multi-quadrant dissections and all varieties of rectal surgeries possible. Four-arm total robotic rectal surgeries may replace the hybrid technique of laparoscopic and robotic surgery for rectal malignancies in the near future in the wake of the new da Vinci Xi system. The learning curve for the new system appears to be shorter than anticipated. Early perioperative and oncological outcomes of total robotic rectal surgery with the new system are promising. Our technique will improve further as we gather more experience in this field.

Acknowledgements

Department of Gastro-Intestinal Surgery and Surgical Oncology, Tata Memorial Center, Mumbai, India.

Conflicts of Interest

The authors have stated explicitly that there are no conflict of interest in connection with this article.

Funding Information

No specific funding.

References


Dear Author,

During the copyediting of your paper, the following queries arose. Please respond to these by annotating your proofs with the necessary changes/additions.

- If you intend to annotate your proof electronically, please refer to the E-annotation guidelines.
- If you intend to annotate your proof by means of hard-copy mark-up, please use the standard proofing marks. If manually writing corrections on your proof and returning it by fax, do not write too close to the edge of the paper. Please remember that illegible mark-ups may delay publication.

Whether you opt for hard-copy or electronic annotation of your proofs, we recommend that you provide additional clarification of answers to queries by entering your answers on the query sheet, in addition to the text mark-up.

<table>
<thead>
<tr>
<th>Query No.</th>
<th>Query</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>AUTHOR: Please confirm that given names (red) and surnames/family names (green) have been identified correctly.</td>
<td></td>
</tr>
<tr>
<td>Q2</td>
<td>AUTHOR: Latest publishing info required.</td>
<td></td>
</tr>
</tbody>
</table>
USING e-ANNOTATION TOOLS FOR ELECTRONIC PROOF CORRECTION

Required software to e-annotate PDFs: Adobe Acrobat Professional or Adobe Reader (version 7.0 or above). (Note that this document uses screenshots from Adobe Reader X)
The latest version of Acrobat Reader can be downloaded for free at: http://get.adobe.com/uk/reader/

Once you have Acrobat Reader open on your computer, click on the Comment tab at the right of the toolbar:

This will open up a panel down the right side of the document. The majority of tools you will use for annotating your proof will be in the Annotations section, pictured opposite. We’ve picked out some of these tools below:

1. Replace (Ins) Tool – for replacing text.
   • Highlights a word or sentence.
   • Click on the Replace (Ins) icon in the Annotations section.
   • Type the replacement text into the blue box that appears.

2. Strikethrough (Del) Tool – for deleting text.
   • Highlights a word or sentence.
   • Click on the Strikethrough (Del) icon in the Annotations section.

3. Add note to text Tool – for highlighting a section to be changed to bold or italic.
   • Highlights text in yellow and opens up a text box where comments can be entered.
   • Click on the Add note to text icon in the Annotations section.
   • Type instruction on what should be changed regarding the text into the yellow box that appears.

4. Add sticky note Tool – for making notes at specific points in the text.
   • Marks a point in the proof where a comment needs to be highlighted.
   • Click on the Add sticky note icon in the Annotations section.
   • Click at the point in the proof where the comment should be inserted.
   • Type the comment into the yellow box that appears.
5. **Attach File Tool** – for inserting large amounts of text or replacement figures.

How to use it:
- Click on the Attach File icon in the Annotations section.
- Click on the proof to where you’d like the attached file to be linked.
- Select the file to be attached from your computer or network.
- Select the colour and type of icon that will appear in the proof. Click OK.

6. **Add stamp Tool** – for approving a proof if no corrections are required.

How to use it:
- Click on the Add stamp icon in the Annotations section.
- Select the stamp you want to use. (The Approved stamp is usually available directly in the menu that appears).
- Click on the proof where you’d like the stamp to appear. (Where a proof is to be approved as it is, this would normally be on the first page).

7. **Drawing Markups Tools** – for drawing shapes, lines and freeform annotations on proofs and commenting on these marks.

How to use it:
- Click on one of the shapes in the Drawing Markups section.
- Click on the proof at the relevant point and draw the selected shape with the cursor.
- To add a comment to the drawn shape, move the cursor over the shape until an arrowhead appears.
- Double click on the shape and type any text in the red box that appears.

For further information on how to annotate proofs, click on the Help menu to reveal a list of further options: