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Setup and positioning in robotic colorectal surgery

Anuradha R. Bhama, MD, Robert K. Cleary, MD*

Department of Surgery, St. Joseph Mercy Health System, 1914 Day St Ann Arbor, MI 48104

ABSTRACT

Preparation for robotic colorectal surgery is more complicated than open and laparoscopy approaches. The colorectal surgeon interested in robotic training should be familiar with and well prepared for robotic draping, positioning of the operating table, the patient cart, the vision cart, the surgeon console, and other operating equipment. Port placement requires more strategy than for the laparoscopic platform and differs depending on the type of robotic system utilized. Anesthesia personnel should be prepared for potential airway issues related to operating table and patient positioning. Robotic technology is complex and, though the system checks itself at an enormously rapid rate, there is a low incidence of robotic malfunction. All operating room personnel should be familiar with these malfunctions and how to resolve them.

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Introduction

Studies to date have demonstrated several advantages for the robotic platform in the field of colorectal surgery.[1–3] There are several key differences in setup and positioning when compared to open and laparoscopic surgery. Equipment setup, port placement, and docking depend upon the planned anatomic resection. Anesthetic protocols may be affected by these nuances and anesthesia personnel should be involved in the planning process. In addition, it is important that the surgeon and operating room staff have a clear understanding of how to identify and ameliorate malfunctions with regard to the instruments, the robot arms, and the robotic computer system. A dedicated robotics nursing staff well trained and well prepared in equipment setup, patient positioning, docking, and robot malfunction leads to decreased operative times and better operative experiences.

General robot setup

Prior to any operation, the general setup of the operating room needs to be conducive to performing a robotic operation. Consideration should be given to the position of each component in the room, keeping in mind the ability to reposition the operating room table as needed. The main components include the patient cart, the vision cart, the surgeon console, and all other operating room equipment.

The patient cart should be draped in a sterile fashion in a way that allows it to be maneuvered toward the patient without contamination, so that it can be united with the sterile field over the patient. The surgeon console should be positioned outside the sterile field in such a manner that the surgeon can visualize the operating table at all times and provide effective communication with the bedside assistant. The vision cart should be positioned outside of the sterile field, but visible to the bedside assistant. It is possible to drape the monitor in a sterile fashion to bring it closer to the sterile field. Cable connections, draping, camera assembly, and use of the touchscreen monitor should be familiar to all operating room personnel.

Docking and general port placement

Effective docking requires practice and preparation and depends on the operation to be performed. For the Si® system, many dock the robot over the left hip for sigmoid and low-anterior resections, and over the right side for right colectomies. The Xi® platform allows more docking options and total colectomies are possible without re-docking the robot. It is best to store the robot in a dedicated spot in the operating suite and position the operating table in a fashion that allows the robot to be simply moved straight forward to the operating table over the shortest possible distance. This habit decreases the risk of costly robotic cable damage that can occur with excessive transport. Anesthesia personnel should be familiar with these coordinated maneuvers so that positioning does not interfere with airway management.

* Corresponding author.
E-mail address: Robert.Cleary@stjoeshealth.org (R.K. Cleary).

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While there are no strict rules governing port placement, there are some basic guiding principles. These guidelines ensure an optimal camera view, minimal external collisions, and maximal reach of the operating instruments. All ports should be positioned in relation to identification of the target anatomy. After gas insufflation, the camera port is placed first and should be in line with and 10–20 cm away from the target anatomy. Instrument cannulas are then placed under direct laparoscopic or robotic camera vision. These additional ports should be triangulated toward or away from the target anatomy. Each instrument port should also be 10–20 cm from the target anatomy. Placing ports greater than 20 cm from the target anatomy may place the dissection field out of reach of the robotic instruments. Robotic cannulas should not be placed between the camera port and the target anatomy as this may result in internal instrument and external robotic arm collisions. Assistant ports (noninstrument cannulas) should be placed as needed. When docking, the camera port, target anatomy, and patient cart should be in a straight line to maximize range of motion of the robotic arms, though side docking is also a widely used option.

General anesthesia concerns

All patients should be thoroughly evaluated with attention to identifying comorbidities with appropriate interventions prior to the administration of general anesthesia. Consideration should be given in preparing for the possibility of conversion to open from the minimally invasive approach. Additionally, patients should have enough cardiopulmonary reserve to tolerate carbon dioxide pneumoperitoneum of 15 mmHg. The laparoscopic risks of air embolism, bradycardia with gas insufflation, subcutaneous emphysema, hypercarbia, and potential cardiovascular collapse are also potential complications to be aware of during robotic colorectal surgery[4] (Fig. 1).

During pelvic operations, the patient is often placed in steep Trendelenburg tilt while in lithotomy position, with both arms tucked at the sides. These patients are at risk to slide off the table, so efforts to minimize this problem are crucial. Padding specifically designed to prevent slippage is available for these procedures. In addition, extra safety straps, bean bags, and taping of the patient to the table around the chest should be utilized strategically. Care should be taken to ensure that the patient is able to ventilate if the chest is taped. Extremities should be padded to prevent neurovascular injuries.

The steep Trendelenburg position decreases the length of the trachea by approximately 1 cm and, in conjunction with a retroperitoneal dissection, increases the absorption of carbon dioxide.[5] Increased pressure on the thoracic cavity by intraabdominal organs in this position reduces lung compliance and functional residual capacity.[6] Strategies employed to ameliorate these deleterious effects include maintaining tidal volumes of 6–8 ml/kg, positive end expiratory pressure (PEEP) of 4–7 cm H_2O, and maximum airway pressures of less than 35 cm H_2O.[7] Epidural analgesia, pressure control ventilation, and prolonging the inspiratory:expiratory ratio may decrease maximum airway pressure and improve oxygenation and ventilation.[8,9]

Central venous pressure, pulmonary artery pressure, and pulmonary capillary wedge pressure increase with increasing degrees of Trendelenburg tilt.[10] In addition, cardiac output and cardiac index are decreased due to decreased venous return and increased systemic vascular resistance, which may result in increased myocardial oxygen demand.[11,12] Increases in intraocular pressure resulting in blindness and increased intracranial pressure have been reported with steep Trendelenburg positioning during minimally invasive surgery.[13–16] The robotic colorectal surgeon should be aware of these potential complications.

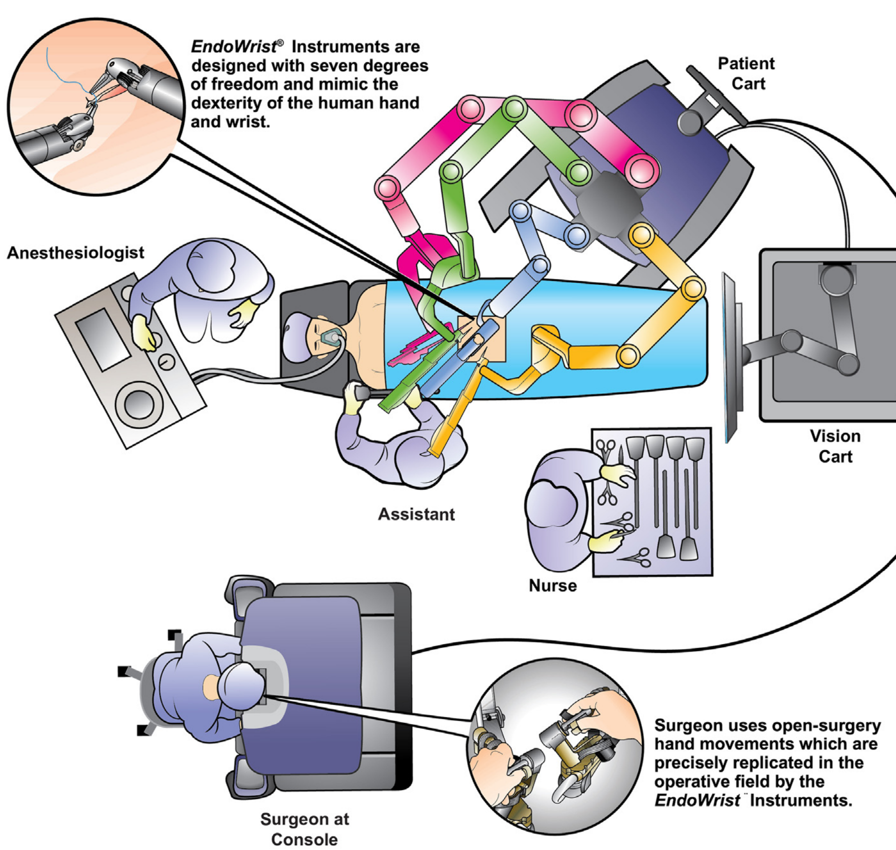

Fig. 1. Setup and docking for sigmoid resection/low-anterior resection/abdominoperineal resection.

Right colectomy

For robotic right colectomy, the patient is placed supine on the operating room table with the right or both arms tucked at the side. All pressure points should be padded appropriately. Urinary catheters and orogastric tubes are used at the discretion of the surgeon and anesthetist. The robotic patient cart is docked directly to the right side or between the right side and right shoulder (Fig. 2).

For the Si® system, a 12-mm camera port is placed at the umbilicus or a point halfway between the costal margin and symphysis pubis, using the Veress needle or Hasson technique. Many surgeons prefer to insert the camera port 2–3 cm to the left of the midline to decrease the incidence of incisional hernias related to the midline location.[17] Addition ports are placed under direct vision as follows: an 8-mm instrument cannula (D3) in the subcostal region just to the left of the midline typically used for the third arm for fixed retraction, an 8- or 13-mm instrument cannula (D1) in the left upper quadrant typically used for dissecting instruments, energy sources, and the robotic stapler, an 8-mm instrument cannula (D2) in the suprapubic region for coordinated micro-retraction and dissection with D1, and a 5-mm assistant port in the left lower quadrant. The patient is placed in slight Trendelenburg position and rotated to the left.

Because the latest upgrade in robotic technology (Xi®) has sleeker arms with an extra joint for movement, there are fewer issues with external arm collisions. Port placement for the robotic right colectomy with the Xi® system is in a diagonal line from a point to the left of the costal margin cephalad to the suprapubic region caudally. Most surgeons dock the Xi® robot directly over the right side of the operating table.

Sigmoid colectomy/low-anterior resection/APR

For robotic sigmoidectomy, low-anterior resection, and abdominoperineal resection, the patient is placed in lithotomy position with both arms tucked at the sides. A urinary catheter is placed and all pressure points are padded appropriately. Padding under the patient (the "Pigazzi Pink Pad"), safety straps, and bean bags may all be used to prevent patient movement on the table during steep Trendelenburg positioning. Most surgeons also employ table rotation to the right. These maneuvers serve to position the small bowel in the right upper quadrant away from the operating field. Intraabdominal carbon dioxide gas insufflation is conducted using Veress needle or Hasson techniques (Fig. 3).

For the Si® system, a 12-mm camera port is placed at or 2–3 cm to the right of a point halfway between the costal margin and symphysis pubis. Additional ports are placed under vision and include an 8-mm or 13-mm (if robotic stapler used) port (D1) in

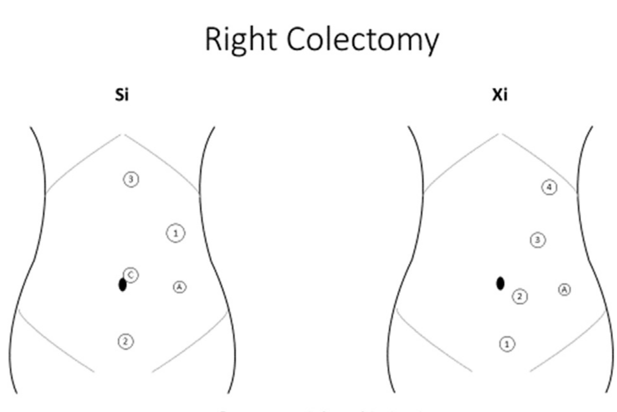

Fig. 2. Si and Xi port placement for right colectomy.

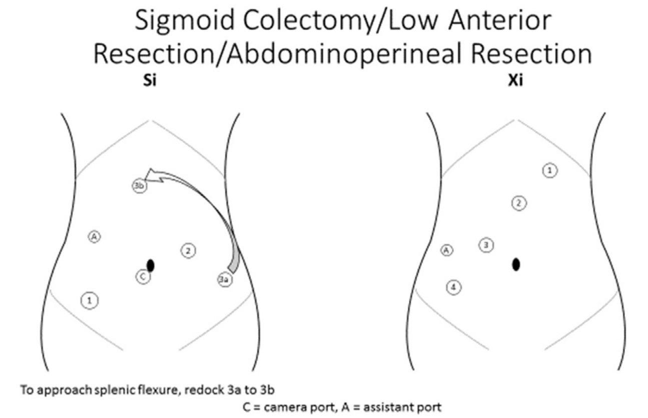

Fig. 3. Si and Xi port placement for sigmoid/LAR/APR.

the right lower quadrant for dissecting and energy instruments, an 8-mm instrument cannula in the subcostal region just to the right of the midline (D3) for coordinated dissection with the instruments passed through the right lower quadrant (D1), and an 8-mm instrument cannula (D2) in the left upper/mid quadrant for the third arm instrument for fixed retraction. For low-anterior resection and abdominoperineal resection, and additional 8-mm instrument cannula is placed in the left lower quadrant (additional D3). After mobilizing the sigmoid colon, descending colon, and splenic flexure, the robotic arm in the subcostal region (D3) is rotated to the left lower quadrant for the total mesorectal excision part of the operation. A 5-mm assistant port is typically placed in the right upper quadrant. Note that when the D3 robotic arm in the subcostal region is rotated to the left lower quadrant (D3), the assistant then has two assistant ports, one to grasp and deliver the rectum out of the pelvis, and one for pelvic side wall retraction or suction/irrigation.

The Si® robot is typically docked over the left hip though some surgeons dock between the legs. Some re-dock the robot over the left shoulder and place the patient in reverse Trendelenburg position for splenic flexure mobilization while others maximize use of the assistant for this part of the operation.

Port placement for the Xi® system may be in a diagonal straight line or a transverse straight line as illustrated in the figures. The latter option is especially useful when access to all quadrants is needed. The robot is docked over the left side and there is usually no need to re-dock the patient cart.

Malfunction of various elements of the robotic system

Because of the complexity of new robotic technology, there is the potential for malfunction for each element of the robotic system. It is important for robotic surgeons and nursing personnel to be familiar and prepared for these possibilities. This may include the patient cart, vision cart, surgeon console, instruments, optical system, and electric power. Analogous to a pilot preparing for takeoff, a stepwise inspection of the system should be carried out prior to the start of every robotic procedure.

System failures occur at a rate between 0.4% and 4.5%. The incidence has decreased with each robotic system upgrade and results in conversion in less than 0.2% of cases. The failures are typically due to instrument failures. There are two types of faults that may occur with instruments in the robotic system, recoverable and nonrecoverable. A recoverable fault stops operation of the system until the fault is addressed. After it is addressed, the procedure may continue. Typically there will be instructions on the monitor and console screens to indicate the manner in which the fault may be rectified. A hex wrench is available to manually ungrasp tissue in the instance in which an instrument experiences a fault while it is grasping tissue. A nonrecoverable fault may require rebooting the entire system.[18,19]

All operating room personnel should be familiar with the location of the stop button on the surgeon console should the system fail to respond to a command and be familiar with releasing robotic instruments from the robotic arms. Most system issues that are not immediately apparent are usually resolved by restarting the system.

Conclusion

The robotic platform continues to be applied to a wider range of colorectal operations. Operative planning, setup, patient positioning, and docking are unique to the robotic version of minimally invasive surgery. An experienced and dedicated robotic nursing team allows decreased operative times and maximal patient experiences. Anesthesia should be prepared for table and patient positioning that may impact their role in the operating suite, especially with respect to airway management. It is imperative for the entire operating room staff to be aware of potential system malfunctions and the best way to rectify these scenarios.

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