Robotic Approach to Transhiatal Esophagectomy

24

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Introduction

The first transhiatal esophagectomy (THE) was performed in 1933 by Turner, but quickly replaced by the thoracic approach [1]. Orringer and Sloan re-popularized the transhiatal technique in their 1978 series, bringing about a change in the approach to treating esophageal disorders [2]. The transabdominal route requires no thoracic incisions and thus avoids the drawbacks associated with trans-thoracic esophagectomy: mainly postoperative pulmonary complications and mediastinitis from intrathoracic leak. Failure of the cervical anastomosis in transhiatal esophagectomy results in a fistula easily managed with open drainage. Consider this in contrast to the devastating sequelae of a thoracic anastomotic leak resulting in mediastinitis with a mortality rate up to 42% [3].

The oncologic appropriateness of the transhiatal approach has previously been questioned and remains a point of contention. Critics argue that a complete thoracic lymphadenectomy cannot be performed adequately with the transhiatal approach [4, 5]. Orringer and others argue, however, that long-term survival is based upon the status of the disease at the time of resection with 46% of patients with Stage III or IV disease at the time of operation and 35% of patients with occult lymph node metastasis [6]. There are no randomized control studies which show a superior survival benefit of either approach. A recent meta-analysis looking at over 200 papers with five randomized trials concluded that overall mortality was equivalent in both operative techniques except for a possible survival benefit with the transthoracic

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approach in a subgroup of limited node-positive patients [7]. The analysis also concludes that, short-term, the transhiatal approach is associated with reduced perioperative morbidity as evidenced by a shorter hospital stay and decreased in-hospital mortality rates. For gastroesophageal junction tumors, there may even be a survival advantage for Type III tumors [8].

The first series of laparoscopic transhiatal esophagectomy was described by DePaula in 1995 and, since that time, the literature has showed improvement in length of stay, postoperative morbidity and mortality of minimally invasive techniques over open esophagectomy [9, 10]. Recently, the advances in robotic technology have allowed surgeons to approach the hiatus with this new technology. Since first being described in 2002, robotic transhiatal esophagectomy has found its place among minimally invasive techniques [11]. Advanced robotic techniques such as recurrent laryngeal nodal dissection and extensive transhiatal thoracic nodal dissections including those as described by Mori et al. are pushing the boundaries of robotic surgery [12, 13]. The robot offers several advantages over traditional laparoscopy for hiatal work including stereoscopic vision, improved camera and operator stabilization, wristed instruments resulting in greater mobility, and improved surgeon ergonomics. On the other hand, diminished haptic feedback, increased cost of individual operations, and a steep learning curve have all been criticisms aimed at the platform. Regardless, the robot has been proven a powerful tool for esophageal surgery.

Indications/Patient Selection

All patients with benign and malignant disease should be considered candidates for robotic transhiatal esophagectomy. Patients with benign disease including caustic injuries, chronic strictures from previous anti-reflux surgeries, complications relating to achalasia, and sigmoid esophagus should all be considered for resection. The debate regarding the transhiatal approach in advanced stage carcinoma has been previously addressed, but there is no clear evidence that there is a survival benefit from one technique over another. Absolute contraindications to robot surgery parallel those of laparoscopic surgery, including the inability to tolerate abdominal insufflation and advanced stage/metastatic disease. Relative contraindications include extensive previous surgery or a hostile abdomen.

Preoperative staging is a necessity for all esophageal neoplasms. It is the authors' practice to obtain preoperative computed tomography of the chest, abdomen, and pelvis along with positron emission tomography scans. Endoscopic evaluation with tissue biopsy is necessary for determination of tumor location and biology. Endoscopic ultrasound (EUS) allows for improved tumor staging including presence of local invasion and nodal status. The authors' use of EUS is mostly for early stage lesions. The use of neoadjuvant chemotherapy and radiation in any lesions greater than T2 or node-positive lesions decreases the importance of EUS. Locally advanced tumors and invasion into the trachea-bronchial tree or surrounding tissues represent a contraindication to THE. Patients with neoplastic disease routinely receive neoadjuvant chemoradiation. While it would seem that morbidity would increase with surgery after neoadjuvant therapy, this has not been shown in the literature.

Room Setup

Patient Positioning

The patient is placed on the operating table in a supine position with arms tucked. There are some groups that place the patient in "French" position with the legs split. This is especially useful when there is a bedside assistant with an additional port. This is not the authors' preference as a bedside surgeon is not utilized. A foam padding is placed around the upper extremities and under the patient to assist in patient comfort as well as providing a non-skid surface to keep the patient in position when placed in severe reverse Trendelenburg. These pads are specifically used to both provide cushioning and prevent sliding of the patient. If the patient's body habitus is too large, plastic sleds may assist in keeping the arms at the patient's side. When using the Si system, it is important to keep patient as close to the head of the bed as possible, otherwise there may not be enough reach with the camera arm. Foam padding and goggles are placed over the patient's face to avoid undue pressure from the robot on the eyes or other facial structures. A shoulder roll can be used to improve neck extension for the cervical portion of the dissection and anastomosis. A foot board is placed at the feet with padding under the heels and soles in order to provide support when positioned steeply.

One of the most important factors in the authors' experience with robotic foregut surgery was the acquisition of a properly adjustable sliding operating table. The table should be able to slide in both cephalad and caudal directions and achieve extreme reverse Trendelenburg with the patient nearly "standing up" (Fig. 24.1). Positioning should be checked in conjunction with anesthesia in order to assure proper patient security. Once the patient is positioned satisfactorily, waist straps are applied and the rails on the patient's right side are cleared of any obstruction, as the liver retractor will be placed here.

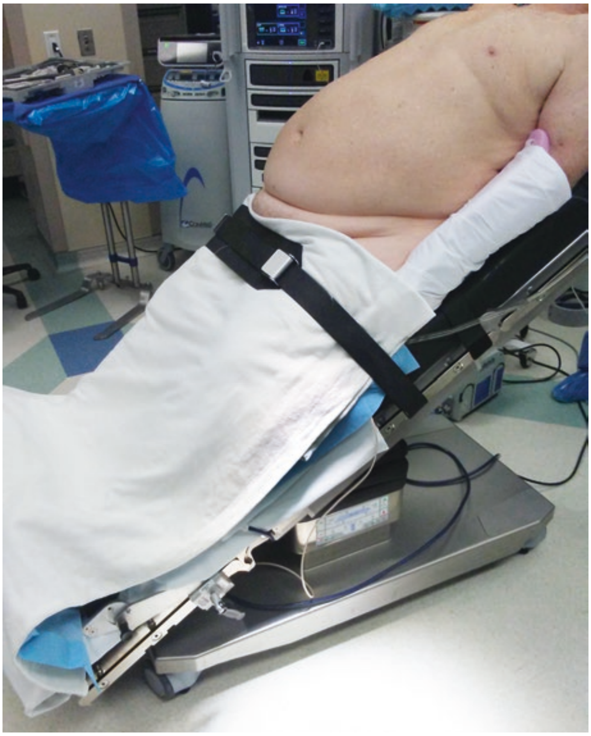
Robot Positioning

When using the Si system, the table will likely need to be positioned at an oblique angle to the anesthesiologist to allow the robot to dock in a linear fashion over the patient's head (Fig. 24.2). The surgeon should ensure that the Si robot, which will dock from above the head, will leave enough room for the anesthesiologist to access the airway and face. In addition, there must be enough space for the cervical anastomotic portion of the case. When using the Xi system, the robot can approach from a lateral position with the arms turned 90° to facilitate easier docking (Fig. 24.3). The table is placed in maximal reverse Trendelenburg, then lowered as far down to the ground as possible. Sometimes it is necessary to adjust the sliding position of the table up or down. This is especially important because, unlike the Xi system, the Si boom cannot be raised or lowered. Once the positioning is confirmed, the patient may be prepped and draped.

Key Points

See Table 24.1.

Fig. 24.1 Positioning patient in steep reverse Trendelenburg on sliding operating table



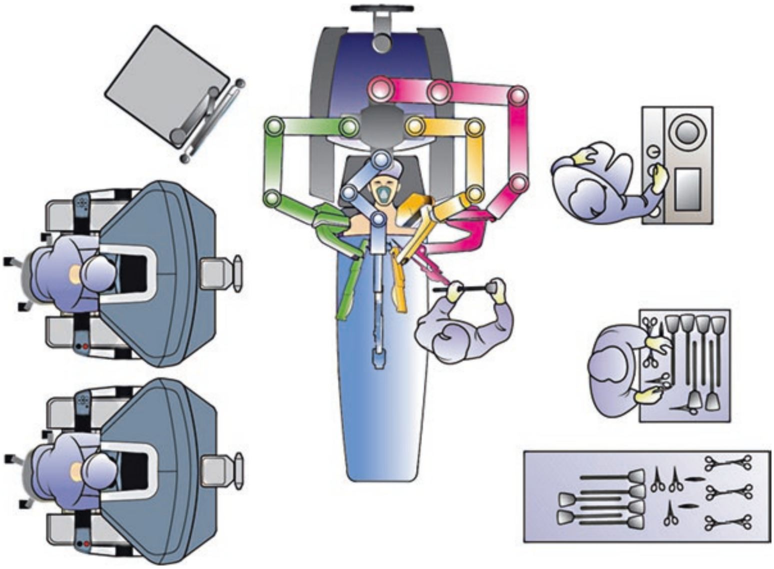


Fig. 24.2 Room setup for Si system. The robot approaches and docks from above the patient's head

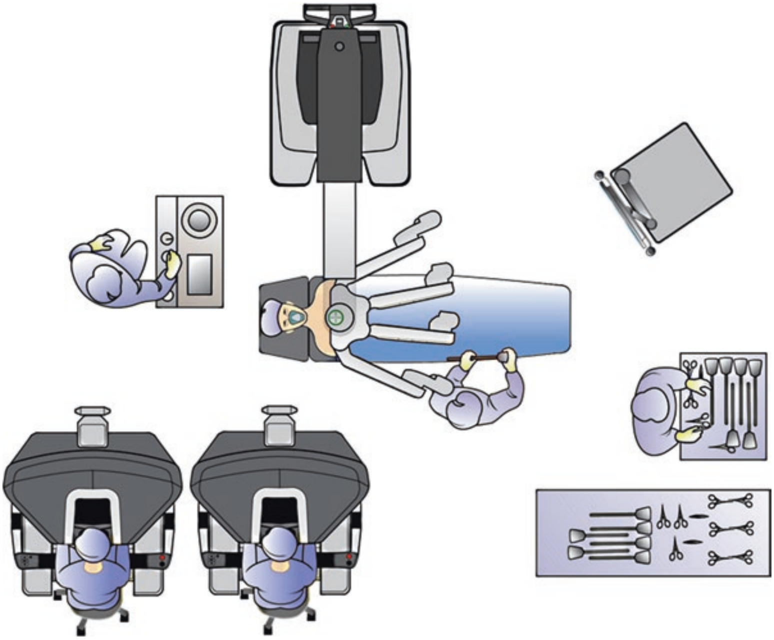


Fig. 24.3 Room setup for the Xi system. The robot approaches and docks from the patient's side

Table 24.1 Docking key differences

Si	Xi
Dock from above patient's head	Dock from patient's left
Turn table	Table position unchanged
Patient in steep reverse Trendelenburg	Patient in steep reverse Trendelenburg

Console Setup/Third Arm Approach

At the authors' training institution, the use of a dual-console system is advocated in order to facilitate the involvement of trainees. The dual-console setup allows several advantages over a single-console setup. Once the trainee has fulfilled the requisite number of docking and instrument exchanges at the bedside, it is imperative that they participate in the surgery. Taking their place at the console allows involvement and graduated responsibility. Traditionally, using the "3rd arm" has referred to the utilization of the unused arm on the Si system by the assistant on the second console. The arm numbering has been changed on the Xi system and thus the term "assistant arm" will be used in place of the term third arm on the Si and fourth arm on Xi.

The use of the assistant arm allows seamless swapping of instruments between surgeon and assistant. The trainee is able to start with a single arm in order to become more familiar with the mechanics of the robot controls and gradually move to the primary arms with the acquisition of more experience. Placing a trainee bedside with an additional assistant port places emphasis on laparoscopy rather than robotics and does nothing to increase the robotic skillset. The dynamic interchange between robot arms allows the surgeon to take over the main arms during more difficult portions of the case. This technique enhances interplay between surgeon and trainee while facilitating education. It also overcomes the "loneliness" of the robot which can occur when the surgeon is isolated in the console without any other human contact. There may be some surgeons that gravitate towards robotics as a means to be alone and escape human interaction. The authors are not in this group and would encourage the more "social" surgeon to use the assistant arm as a technique of training. It is more convenient to position the two consoles near each other for ease of communication, but is not a requirement and operating room space limitations may preclude this arrangement. The voice communications system within the console may be inadequate for some, and the use of a separate hands-free wireless communication system for improved voice communication has been suggested.

It is important to customize the console settings for the individual surgeon. On both the Si and the Xi, surgeons are able to log in using unique profiles and adjust ergonomics and other settings as needed. In our experience, it is convenient to switch off the Firefly quick switching option to avoid inadvertent camera switching when finger clutching. We also use normal (1:1) motion scaling.

Key Points

- Use dual-console setup
- Trainee should use assistant arm until proficiency shown
- Trainee should then advance to using primary arms (1 and 2 for Si, 1 and 3 for Xi)

Operative Technique

Port Placement

The abdomen can be entered by any manner in which the surgeon is comfortable. The authors prefer to use a 5 mm direct entry optical entry through a supraumbilical stab incision. The abdominal wall is grasped laterally by the surgeon and the assistant and elevated as the trocar and camera are slowly advanced through the layers of the abdominal wall under direct visualization. Once the abdomen is entered, pneumoperitoneum of 15 mmHg is achieved. The underlying bowel and omentum is visualized to rule out inadvertent injury. In the authors' practice, no documented complications or injuries over hundreds of procedures using this technique have occurred. A thorough exploration of the abdomen with the laparoscope should be undertaken in the patient with malignancy. It is very easy to proceed mechanically without this step and overlook metastatic disease.

A 12 mm robotic trocar is placed in the left upper abdomen which will be used for the energy device and stapler (Fig. 24.4). The location will vary depending on the energy device used. A more cephalad position along the mid-clavicular line (MCL) towards the costal margin is required for the ultrasonic dissector in order to

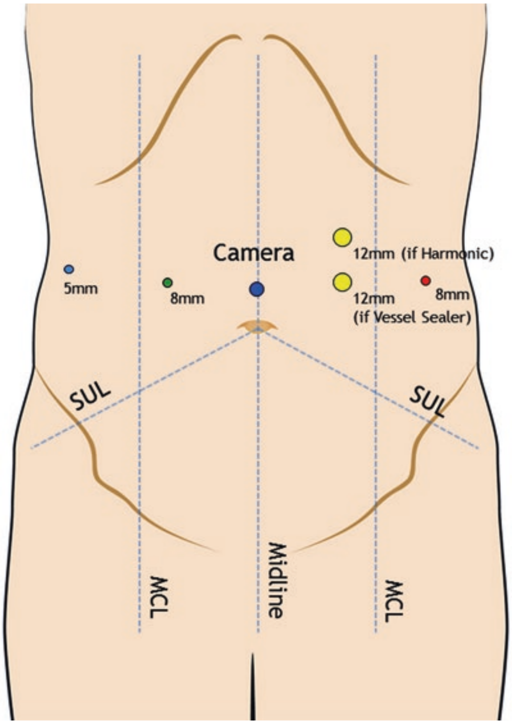


Fig. 24.4 Port placement for the Si and Xi system. If using the Harmonic device, the 12 mm port will be placed more cephalad than if using the Vessel Sealer. The camera port will be a bariatric length 11 mm trocar for the Si, or an 8 mm robotic trocar if using the Xi

maximize the extent of its reach. It is the authors' preference to use the Harmonic ACE™ ultrasonic dissector device in this position. If using the robotic vessel sealer, the port can be placed in a more caudal position just superior to the horizontal level of the midline camera port. The ultrasonic dissector is shorter than the vessel sealer and so the left mid-clavicular port must be placed more cephalad if the former device is being used. An 8 mm robotic port will be used to "piggyback" through the 12 mm port. The 8 mm robotic port is placed inside the 12 mm port and the arm is docked to the robotic port in the normal fashion. In order to gain more reach when using the ultrasonic shears, the 12 mm port may be "burped" by the assistant which involves retracting the shears and clutching the arm and advancing the port in order to gain more distance for the instrument. Regardless of the robotic system used, this trocar should be spaced at least 10 cm away from the camera port.

An 8 mm trocar is then placed in the far left abdomen, below the costal margin at least 10 cm from the energy device port. This port should be placed far laterally while safely avoiding bowel. If the trocar is placed too far laterally, however, docking of this port can be challenging and there can be external collisions with the patient's left arm. A ProGrasp™ instrument will be used through this port and will be controlled by the assistant if using a dual-console setup. This port will be placed at the same location on the abdomen regardless of whether the Si or Xi system is used.

An 8 mm port is placed in the right abdomen on the right MCL at the level of the camera port. This will be the surgeon's right hand and a fenestrated bipolar grasper will be used. In order to maximize the effectiveness of the bipolar instrument, the tips must be slightly open when coagulating tissue; otherwise the electrocautery will not be as effective. This port will be placed in a more caudal position resulting in a more linear angle if using the Xi system.

A liver retractor system is set up by securing the clamp to the rails of the table in cooperation with the anesthesiologist to avoid clamping any of the patient lines. A flexible triangular liver retractor (Snowden-Pencer®) is placed in the abdomen and, under direct visualization, is positioned under the left lobe of the liver to expose the hiatus. This is secured in place by the assistant using the Fast Clamp system.

The 5 mm camera port is then upsized to a robotic port under direct visualization. In the Si system, a bariatric length 12 mm trocar is placed and a 12 mm camera is used. In the Xi system, an 8 mm trocar is placed and an 8 mm scope is used with the advantage of being able to use any of the 8 mm ports as the camera port. A disposable 5 mm port is placed in the far right abdomen in a subcostal position. A 5 mm AirSeal® port can be placed for improved insufflation and evacuation. If using the AirSeal® system, the surgeon should place this port last. Once AirSeal® is initiated, placement of ports becomes very difficult as the system will maintain the pressure of 15 mmHg and not allow for elevated pressures associated with trocar placement. The authors prefer this system as this is very efficient at steam evacuation without affecting pneumoperitoneum.

Docking

Once the liver retractor is placed, the patient is placed in reverse Trendelenburg. It may be necessary for the table to be lowered and slid down towards the floor in order to achieve the correct height to accommodate the robot.

Si System

For the Si system, the patient is approached in a linear manner from the head of the bed, i.e., dock from above the head. The robot should be advanced with the bed in the flat position. Once the camera arm appears to be in good position, the table is then placed in steep reverse Trendelenburg position and, with the surgeon watching carefully, ensures that the camera arm is still dockable. The robot will likely need to be advanced once the table position is achieved. The robot should be centered in line with the center camera port. Once the robot is positioned, the brake is applied and the camera arm is docked to the midline port, with the arm indicator in the blue "sweet spot". With a very tall patient, the surgeon may have to dock with the camera arm in the straight position. This is not a major concern, but the robot must be advanced as close to the head of the bed as possible. Use of a bariatric 12 mm trocar at the midline position helps achieve greater mobility and decreases the likelihood of port slippage. Once the camera arm is docked, the remaining arms are docked. Arm three should be positioned to the patient's left side. If there are external collisions, the arms may need to be adjusted. A 12 mm camera is placed through the camera port and the remaining instruments are placed under direct visualization. All four arms are used.

Xi System

For the Xi system, the patient is approached from either the right or left side (see Fig. 24.3), depending on the room setup. The driver will input the location of the surgery (upper abdomen) and the direction of the approach (right or left). The green laser guides are then aligned with the midline camera port and arm 2 is docked to the 8 mm robotic port. The 8 mm camera is inserted and the targeting sequence is initiated by aiming the camera towards the hiatus and pressing the target button on the camera while holding the trocar firmly in place. The remaining free arms will move as the boom rotates. Once the targeting sequence is completed, the remaining arms are docked. Arm 3 will be docked to a free 8 mm port and "piggybacked" into a 12 mm left mid-clavicular line port.

Key Points

See Table 24.2.

Instrumentation

For the purpose of this section, the authors will use the arm terminology for the Si robot. Arm 1 is the right MCL port; arm 2 is the left MCL port; arm 3 is the left abdominal port.

The surgeon will use arms 1 and 2, while the assistant will use arm 3. The fenestrated bipolar instrument is used in arm 1 in the right abdomen. It is less traumatic than the ProGrasp™ and has the ability to apply bipolar energy. In order to maximize the effectiveness of the bipolar instrument, the tips must be slightly open when coagulating tissue, otherwise the electrocautery will not be effective. The surgeon uses the energy device in arm 2, which can either be an ultrasonic dissector or a bipolar vessel sealer. The Vessel Sealer is a wristed instrument which can effectively seal vessel up to 7 mm in diameter. It exhibits minimal thermal spread without any active blades. It is possible to perform blunt dissection and has a longer reach and more mobility than the harmonic dissector. The activating sequence is more complex and requires three pedal presses for each complete cycle. The ultrasonic dissector has no "wrist" ability and less overall mobility. In addition, it has an exposed active blade, so care must be taken not to cause any inadvertent thermal tissue damage. The activating mechanism requires a single pedal press and tissue dissection and vessel coagulation proceed at a much more accelerated rate. If additional length is needed for the ultrasonic dissector, the 12 mm trocar may be "burped" in farther for a longer reach.

Table 24.2 Port placement key differences

Si	Xi
Midline 12 mm bariatric port	Midline 8 mm robot port
Bring robot in then position patient	Position patient first
Arm 3 swings to the left	No need to rearrange arms

The assistant arm 3 will use the ProGrasp™ instrument. It exhibits the most gripping power of the graspers, but in turn is the most traumatic to tissues. Care must be taken to limit tissue trauma by avoiding direct manipulation of hollow-viscous organs. The flexible triangular liver retractor is used in the far-right abdominal 5 mm port and held in place using the Fast Clamp system on the right-sided bed rails. A 12 mm linear-lipped vascular load-powered stapler is used through the left upper abdominal 12 mm port when transecting the right gastric vessels. Finally, if the pyloroplasty is performed intracorporeally, large cutting needle drivers can be placed through the 12 mm port along with suture.

Operative Details

After docking the robot and placing the instruments, the right gastroepiploic vessels are identified. It is important not to manipulate or place excessive retraction around this area as it will serve as the vascular pedicle for the gastric conduit. In our practice, we prefer a left-sided approach wherein the short gastric vessels are divided and the crus is approached from the greater curvature before moving on to the right crus via the pars flacida.

Once the right gastroepiploic vessels are identified, the greater curvature is grasped and elevated by the surgeon, while the assistant retracts the gastrocolic ligament using arm 3 in the Si system (4 for Xi). The lesser sac is entered using the energy device and the short gastric vessels are divided, continuing the dissection towards the lefts crus. It is helpful for the surgeon to grasp the posterior wall of the stomach and retract medially and towards the abdominal wall. This will allow dissection and division of the posterior gastric attachments. Short gastric vessels up to 5 mm can be divided using the ultrasonic dissector or up to 7 mm using the bipolar Vessel Sealer. The authors propose an unusual approach to the left crus: they start along the greater curvature and then work more medially. Effectively, the assistant lifts the stomach up towards the ceiling in line with the left edge of the aorta (Fig. 24.5). The energy device is used to take the vessels to the left of this area. The maneuver allows for lengthening of the short gastric vessels at the spleen by taking the posterior short gastric vessels that emanate off the splenic artery first. This allows for little chance of injury to spleen itself. Once the left crus is identified, the phrenoesophageal ligament is incised. The right crus is then approached from the lesser curvature of the stomach. The gastrohepatic ligament is divided using an energy device, being careful to identify the presence of an accessory or replaced left hepatic artery. Once the right crus is identified, the phrenoesophageal ligament is divided (Fig. 24.6). Care must be taken in patients who have a hiatal defect as the left gastric vascular bundle can be elongated and enter the chest via the defect. It is possible to injure these vessels in this case.

The left gastric artery is then identified and a window is made by dissecting caudad to this vascular bundle in order to place the stapler. The cephalad dissection of the left gastric vascular bundle is created by developing the plane in the pars flaccida. A lipped vascular-load linear stapler is placed through the left upper abdominal 12 mm

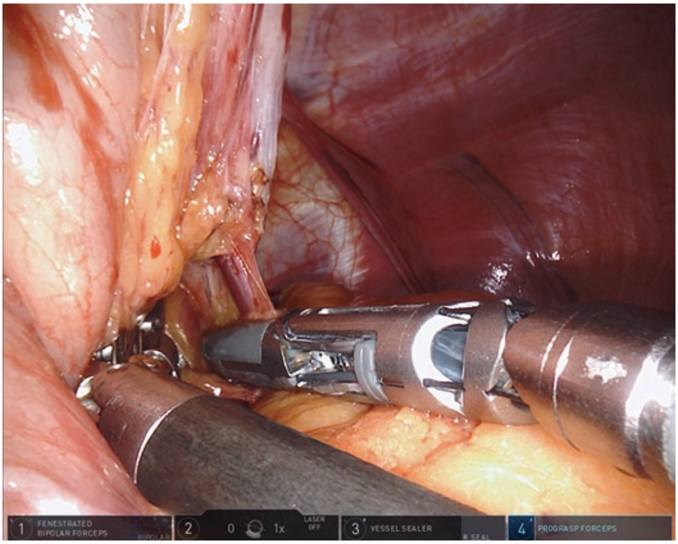


Fig. 24.5 The initial left-side first approach is demonstrated. The stomach is retracted towards the ceiling, lengthening the posterior short gastric vessels and minimizing injury to the spleen

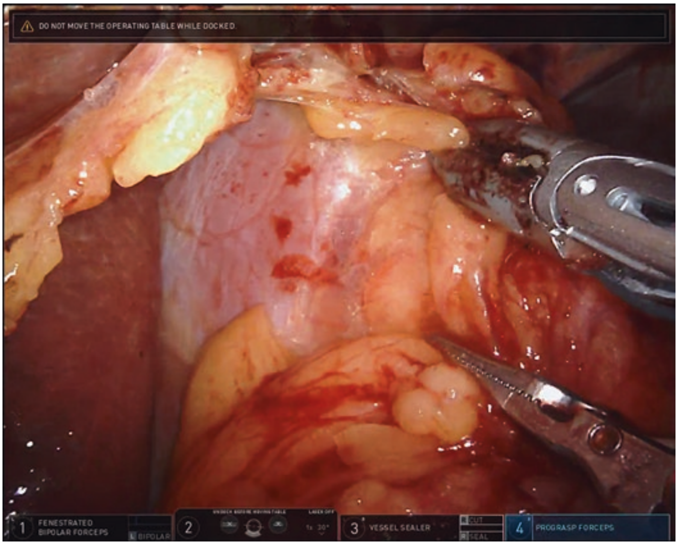


Fig. 24.6 Approaching the right crus from the lesser curvature. The right crus and phrenoesophageal ligament are shown

port by the bedside assistant and the left gastric vessels are taken near their origin, including the celiac and common hepatic nodal basins (Fig. 24.7). Some surgeons perform an extensive celiac nodal dissection; it is the authors' preference to place the stapler as flush with the hepatic artery to capture these nodes.

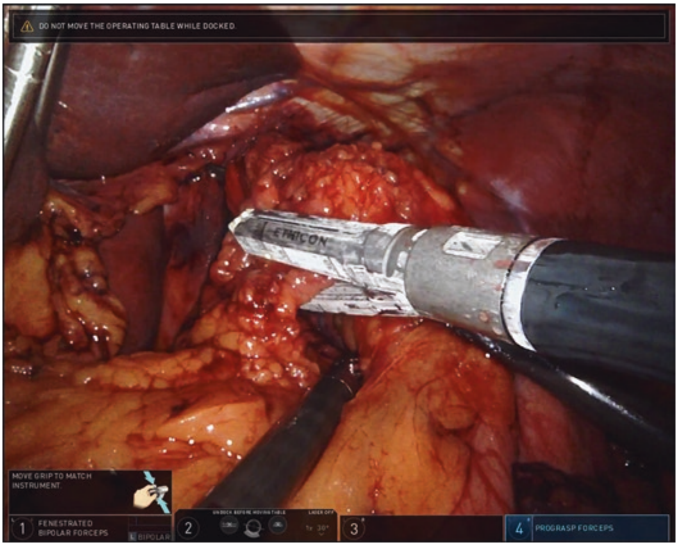


Fig. 24.7 The left gastric vessels are isolated by the assistant and divided using a linear vascular load stapler

The esophageal hiatal mobilization and dissection begins, maintaining en bloc lymphatics. The assistant (arm 3 on the Si) will retract caudad using the esophageal fat pad, while the operating surgeon retracts the hiatus to the left and right (Fig. 24.8). In this manner, each can provide counter-traction and allow for use of the energy to divide the esophageal attachments. One of the advantages of the robotic system is the ability to gain improved hiatal visualization by placing the scope in the mediastinum and continuing the dissection. It is helpful for the assistant to retract the gastroesophageal fat pad caudally, while the surgeon retracts the crus and dissects with the energy device. Care must be taken to avoid entering the pleural spaces on each side, as the pleura are very intimately associated with the esophageal tissues. Magnification with the robotic camera allows for visualization of a thin white line that is the pleural edge. Entering the pleura does not mandate placement of a chest tube; it is rare that a post-operative clinically relevant pneumothorax will need intervention.

Specific circumstances that may cause difficulty with hiatal dissection are:

1. Preoperative Chemoradiotherapy

   In this circumstance, the esophagus can be quite thick and there can be dense adhesions to adjacent structures. Indeed, the majority of cases in the authors' experience are post-chemoradiation; as such, this has become commonplace in the esophagectomy procedure. It is important to note that the surgery should occur in the 6–12 week time frame post-radiation. After the 12 week mark, there is dense scarring that can make the surgery more challenging. The authors use the analogy of a lasagna: when fresh, all the layers can be seen. However, when

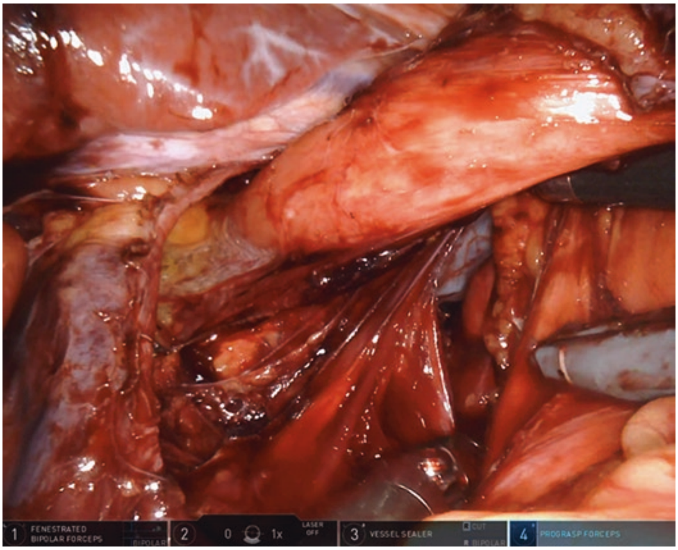


Fig. 24.8 The decussation of the crural fibers is identified and hiatal dissection is performed. The assistant elevates the esophagus, while the surgeon uses a combination of energy and blunt dissection

frozen (akin to long interval from radiation), there are no visible planes. Similarly, the anatomy becomes very tough the further one operates from the end of radiation therapy.

2. Presence of a Stent
   While this is becoming more commonplace, a bulky stent can lead to substantial issues when manipulating the esophagus. The stent can be rather rigid and make the traction/counter-traction more challenging than necessary. Presence of a stent should not preclude robotic surgery, but the surgeon should be prepared for a more challenging surgery.

Once the proximal extent of the hiatal dissection is completed, a pyloroplasty can be performed. The gastric antrum is identified and followed distally towards the pylorus and duodenum. Kocherization of the duodenum is achieved by dividing the peritoneum laterally using blunt and sharp dissection. The precise location of the pylorus is confirmed by the presence of the vein of Mayo. Stay sutures (the authors' preference is 2-0 silk on an SH needle) are placed and a longitudinal gastrotomy is made either using electrocautery or ultrasonic shears. This is extended through the pylorus and onto the duodenum, creating a generous 4–5 cm incision. This is then closed in the manner of Heineke-Mikulicz using interrupted 2-0 braided permanent sutures. A suture-cut needle driver is convenient in order to avoid frequently switching instruments in and out of the port. Once completed, the stay sutures are removed and the instruments withdrawn from the abdomen and the robot undocked. If an intracorporeal pyloroplasty proves unfeasible, an open approach can be performed or endoscopic botulinum toxin can be injected.

The authors have experience with a fully robotic approach, but have found that the use of a mini-laparaotomy saves time and has no consequences on postoperative recovery or pain. Therefore, the authors have evolved to the following technique that some may call "hybrid" as there is a small laparotomy scar. In fact, the authors would argue that this incision is needed to extract the specimen and there are no retractors placed. As such, there has been no difference noted in postoperative recovery.

An upper midline mini-laparotomy is made that is enough to permit a hand into the abdomen and chest. This is generally just 10 cm with a fascial undercut. Anterograde blunt hiatal dissection is then performed. The hand in placed into the abdomen and the hiatus is manually dilated. The entire hand must be placed into the mediastinum and the esophagus should be grasped from within the palm of the hand. The dissection proceeds from posterior to lateral and finally anteriorly. Much like in the pelvis, the key structures are anterior and therefore this should be left for last. The left mainstem bronchus should be palpable anterior to the esophagus. Care is taken not to enter the pleura or disrupt the bronchus.

At the same time, the neck dissection can be performed and mobilization of the cervical esophagus is achieved. A limited anterior sternocleidomastoid incision is made. The carotid is retracted laterally and the thyroid medially. Care should be taken in using energy in the tracheoesophageal groove as the recurrent laryngeal nerve is in this location. Despite careful dissection, there is a risk of palsy of this nerve of at least 10% in the authors' experience. The esophagus is mobilized from above into the thoracic inlet again working posteriorly first. The hand from above can then meet the hand from below and complete the dissection.

The nasogastric tube is pulled back and the esophagus is divided in the neck using a linear thoracic anastomosis 30 mm stapler with a blue load. The esophagus is transected leaving the staple line in the distal (specimen) side of the esophagus. A sterile nasogastric tube is sewn to the distal esophagus and the specimen is retrieved from the abdomen and laid on the abdominal wall. It is necessary to complete the antral dissection by dissecting the right gastroepiploic vessels to their origin from the gastroduodenal artery in order to gain maximal mobilization. The surgeon should not skeletonize this origin too much as it can tear when the conduit is pulled up into the neck. The conduit is then created by dissecting and stapling the lesser curvature of the stomach. The authors do not tubularize the stomach, but rather resect the proximal stomach. The staple line is oversewn using 2-0 silk in the manner of Cushing. The sterile nasogastric tube which is lying in the posterior mediastinum is then sewn to the greater curvature of the stomach and the conduit is guided into the hiatus and pulled up into the neck. Stay sutures of 3-0 silk are used to tack the stomach to the posterior wall of the esophagus. A gastrotomy is made and the anastomosis is created using a blue intestinal load linear stapler. The enterotomy is then closed using interrupted absorbable braided suture (3-0 Vicryl). A flat drain placed to bulb suction is left in the cervical wound until patient tolerating soft diet. A feeding jejunostomy tube is then placed using a jejunal loop 30 cm distal to the ligament of Trietz. A nasal gastric tube is placed at the level of the pyloroplasty and bridled into place at the nares. The fascia is closed using a running absorbable barbed fascial closure suture with one full-thickness external retention sutures.

Postoperative Care

Postoperatively, all patients are sent to the Intensive Care Unit for close monitoring. A nasogastric tube (NGT) is left bridled in place, and special care is given to ensure proper fluid management and avoidance of hypotension. One of the most feared early postoperative complications is conduit necrosis. This presents as early tachycardia, hypotension, leukocytosis, and respiratory failure. Adjunct pain medications are maximized including parenteral formulations of acetaminophen and ibuprofen to minimize opiates. Patients with an uncomplicated post-op course are transferred to a surgical bed on the floor after the first postoperative day. Continuous trickle tube-feeding is started early and advanced to full tube feeds as tolerated.

The authors regularly obtain a water-soluble upper gastrointestinal series on the fifth postoperative day to assess the esophagogastric anastomosis as well as the pyloroplasty. Once cleared, the NGT is discontinued and a clear liquid diet is started with advancement to soft mechanical as tolerated. The cervical incision staples are removed and the drain is discontinued. Continuous tube feeds are changed to nocturnal feeds and if the patient is tolerating per os diet, the patient can be discharged on a soft diet without home tube feeding. A multi-disciplinary approach to postoperative care is recommended and members from physical therapy, nutrition, speech therapy, and social work are included.

Complications to Avoid

With the use of the robot come additional complications one must be aware of in order to avoid. The docking process can be complicated to the uninitiated and care must be taken to avoid external arm collisions with each other as well as with the patient. When using the Si, the camera arm lies directly over the patient’s head and can inadvertently cause injury if not positioned correctly. When initially placing instruments in the abdomen and with each subsequent replacement, extreme care must be taken to visualize the instrument in order to avoid blunt injury to the intraperitoneal organs. When using energy, especially electrocautery, care must be taken not to arc with other instruments. The lack of haptics (force feedback) can be challenging for the beginner robotic surgeon who is used to laparoscopy. Care must be taken to avoid undue traction on the tissues as it is much easier to damage soft tissue without the “feel” of the instruments.

Current Data/Outcomes

Perioperative outcomes of robotic transhiatal esophagectomy in the literature have been favorable. The first series of robotic THE was presented by Galvani et al. in 2008 with 18 patients [14]. The mean operative time was 267 min, no early mortality, and minimal postoperative complications. The average ICU stay and total hospital length of stay was 1.8 and 10 days, respectively. Another series was presented by Dunn et al. in 2013 with 40 patients undergoing robotic THE [15]. The indication for the majority of the patients was esophageal carcinoma. Mean operative time was 311 min and length of stay was similar to the Galvani series. Complication rates were higher than average with a postoperative stricture rate at 68% and leak rate of 25%. Early postoperative mortality was only 2.5%.

A new robotic technique described by Mori et al. as the Non transthoracic esophagectomy (NTTE) shows promise [13]. This technique first described in 2013 with a follow-up series combines a "video-assisted cervical approach for the upper mediastinum and a robot-assisted transhiatal approach for the middle and lower mediastinum". The technique claims the benefit of an improved transhiatal nodal dissection without the disadvantages of a thoracic approach.

In the authors' own experience, outcomes from a single institution's experience with laparoscopic versus robotic THE are currently in publication. Eighteen consecutive patients who underwent robotic esophagectomy were included in the study. All procedures were performed for malignancy and mean operative time was 168 min. There was one anastomotic leak which required no further invasive intervention and no early mortalities. Mean hospital and ICU length of stay was 10 and 1.7 days, respectively. An average of 14.2 lymph nodes were harvested with no gross positive margins and 94.4% disease-free microscopic margins.

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