DAVINCI™

IVOR LEWIS

ESOPHAGECTOMY

Procedure Guide

Disclaimer

The following material has been reviewed and approved by the following independent surgeon, who is not an Intuitive Surgical employee:

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Surgeons of the Upper GI International Robotic Association (**UGIRA,** http://ugira.org/)
The 'Upper GI International Robotic Association' (UGIRA) was established in 2017 to facilitate the effective implementation and advancement of robotic esophageal and gastric surgery with evidence based guidelines. Currently 20 experienced robotic surgeons from 10 different countries in Europe (The Netherlands, Germany, United Kingdom, Denmark), Asia (Japan, Hong Kong, North-Korea, Taiwan), North-America (United States of America), and South-America (Brazil) are members of the UGIRA. To learn more about UGIRA visit http://ugira.org/.

Editor

Hubert Stein, Director Global Clinical Development
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Table of Contents

1. INTRODUCTION

da Vinci Esophagectomy maintains the oncologic principles of open esophagectomy while also providing the potential benefits of a minimally invasive approach for the patient.

The visualization, precision, dexterity and control provided by the *da Vinci* Surgical System offers the following potential surgeon benefits:

- Improved ergonomics[1]
- Autonomous control of the camera and instruments[1]
- May reduce overall complications with lower postoperative pain, better short term quality of life and better short-term postoperative functional recovery compared to open surgery[2]
- Dynamic exposure and retraction of tissues by utilizing all da Vinci instrument arms, which furthermore increases reproducibility and teachability[3]
- May reduce conversions and simplify minimally invasive thoracic surgery[3]

[1] Grimminger PP, van der Horst S, Ruurda JP, van Det M, Morel P, van Hillegersberg R. Surgical robotics for esophageal cancer. Ann N Y Acad Sci. 2018 May 9. doi: 10.1111/nyas.13676. PMID: 29741233

[2] Van Der Sluis PC, Van Der Horst S, May AM, Schippers C, Brosens LAA, Joore HCA, Kroese CC, Mohammad NH, Mook S, Vleggaar FP, Borel Rinkes IHM, Ruurda JP, Van Hillegersberg R. Robotic-assisted Minimally Invasive Thoracolaparoscopic Esophagectomy Versus Open Transthoracic Esophagectomy for resectablt Esophageal Cancer. A Randomized Controlled Trial. Annals Of Surgery (2018). DOI: 10.1097/SLA.0000000000003031

[3] Egberts JH, Stein H, Aselmann H, Hendricks A, Becker T. Fully robotic da Vinci Ivor-Lewis esophagectomy in four-arm technique – problems and solutions. *Diseases of the Esophagus* (2017) 30, 1-9. DOI: 10.1093/dote/dox098

2. INSTRUMENTS AND ACCESSORIES

2a. Recommended *EndoWrist* Instrumentation

Primary Instrumentation

Da Vinci Si	***Da Vinci Xi***
Monopolar Cautery Instruments	
420179 *Hot Shears*™ (Monopolar Curved Scissors)	470179 *Hot Shears*™ (Monopolar Curved Scissors)
Bipolar Cautery Instruments	
420205 Fenestrated Bipolar Forceps	470205 Fenestrated Bipolar Forceps
410322 *EndoWrist* Vessel Sealer	480322 Vessel Sealer
Graspers	
420049 Cadiere Forceps	470049 Cadiere Forceps
420093 ProGrasp™ Forceps *(for anvil grasping only)*	470093 ProGrasp™ Forceps *(for anvil grasping only)*
Needle Drivers	
420296 *Large SutureCut*™ Needle Driver	470296 Large *SutureCut* Needle Driver
Clip Appliers	
420327 Medium-Large Clip Applier	470327 Medium-Large Clip Applier
420230 Large Clip Applier	470230 Large Clip Applier
Stapling	
410298 *EndoWrist*® Stapler 45 Instrument	470298 *EndoWrist* Stapler 45 Instrument
-/-	470430 *EndoWrist* Stapler 30 Instrument
-/-	480460 *EndoWrist* Stapler 60 (Sureform™) Inst.

Alternative Instrumentation

Da Vinci Si	***Da Vinci Xi***
Monopolar Cautery Instruments	
420183 Permanent Cautery Hook	470183 Permanent Cautery Hook
Bipolar Cautery Instruments	
420172 Maryland Bipolar Forceps	470172 Maryland Bipolar Forceps
-/-	470400 Long Bipolar Grasper
Ultrasonic Energy Instruments	
420275 *Harmonic ACE*® Curved Shears	480275 *Harmonic ACE* Curved Shears
Graspers	
420343 **5mm** Thoracic Grasper	470347 Tip-Up Fenestrated Grasper
420139 **5mm** Schertel Grasper	-/-
Needle Drivers	
420006 Large Needle Driver	470006 Large Needle Drive
Clip Appliers	
420003 Small Clip Applier	470401 Small Clip Applier

2b. Recommended Specific Sutures[4]

Ethicon Endosurgery, Sommerville NJ, USA:

- Stratafix™ Spiral® PDS 4-0, RB-1 needle, 15 cm length, unidirectional, knotless
- Stratafix™ Spiral® PDS 3-0, SH needle, 15 cm length, unidirectional, knotless

Covidien (Medtronic),New Haven CT, USA:

- V-LOC™ 180 3-0, V-30 needle, 23 cm length
- V-LOC™ 90 4-0, V-20 needle, 15 cm length

3. PATIENT SELECTION

3a. Patient Selection

Patient Selection Criteria for cases *early* in the surgeons *da Vinci* experience

- Good performance status
- Non-obese patients (BMI < 30)
- Healthy: overall good performance status, few comorbidities
- No previous abdominal or thoracic surgery
- Tumor without infiltration in other structures
- No prior chemotherapy or radiotherapy (relative)
- Avoid patients with moderate to severe cardiopulmonary compromise. Prolonged operative times may be poorly tolerated by patients with cardiopulmonary disease.

Patient Selection Criteria for cases *later* in the surgeons *da Vinci* experience

- No BMI restriction (both obese and non-obese patients)
- No age restrictions, only performance status restrictions
- No tumor size restrictions up to 8 cm
- No restriction regarding prior chemotherapy or radiotherapy

Recommended for Patients with:

- Adequate pulmonary function tests, a stress test, and have adequate cardiopulmonary reserve
- Neither the size of the lesion, its location, presence of nodal disease or the use of pre-operative radiation and/or chemotherapy is a contraindication to offer *da Vinci* esophageal surgery.

Not Recommended for Patients with:

- Tumors invading into adjacent organs extensively or massive in size (10 cm or greater)
- Patients with contraindication to general anesthesia or the establishment of a single lung anesthesia
- Otherwise, no specific contraindications for *da Vinci* Surgery compared with open surgery

[4] *Please refer to the package insert for complete instructions, contraindications, warnings and precautions.*

3b. Recommended Preoperative Diagnostics

- Chest X-Ray
  - Assess chest size, relation of thoracic organs to each other, location of diaphragm
- CT scan and endoscopic ultrasound
  - surgeon dispensable, preoperative planning, assess lymph node involvement (N2), staging
- Pulmonary function and stress test
  - Assess adequate cardiopulmonary reserve

3c. Surgical Team Experience – Training Pathway

For surgical teams embarking on *da Vinci* Esophagectomy, a suggested minimum training protocol is recommended[5]. There are minimum training requirements for all members of the operating room staff, including the console surgeon, patient-side assistant (first assisting surgeon), scrub nurse and circulating nurse. All team members should go through basic system training provided by Intuitive Surgical. Progressive training takes the console surgeon through a series of tasks designed to expose and evaluate the skills necessary to proceed with *da Vinci* Esophagectomy. These include timed practice tasks in the lab, a minimum number of surgical procedures that are completed within an operating time limit, case observations, etc. and follow a specifically designed Clinical Pathway for *da Vinci* Esophagectomy. Published clinical experience as well as clinical studies performed to support the US FDA clearance of the *da Vinci* Surgical System have demonstrated that even surgeons considered expert in laparoscopy/thoracoscopy have substantial learning curves of 10 to 12 cases[6]. Therefore, only surgeons who have developed adequate skills on the *da Vinci* Surgical System platforms to perform the tasks associated with each procedure and who have received specific training provided by Intuitive Surgical should use the system. Use of the *da Vinci* Surgical Simulator may significantly shorten the learning curve. Figure 1 shows a proposed training pathway for surgeons to start *da Vinci* Esophagectomy procedures. To advance in the procedure it should be split up in parts and done one step at a time until full proficiency. Minimum yearly case volume to get over the learning curve is more than 20 cases[7].

5 Cerfolio RJ, Bryant AS, Skylizard L, Minnich DJ. Starting a robotic program in general thoracic surgery – why, how and lessons learned. *Ann Thorac Surg*. *In-press*.

6 Falk V, Diegeler A, Walther T, Banusch J, Brucerius J, Raumans J, Autschbach R, Mohr FW. Total endoscopic computer enhanced coronary artery bypass grafting. *Eur J Cardiothorac Surg.* 2000;17(1):38-45.

7 Hernandez JM, Dimou F, Weber J, Almhanna K, Hoffe S, Shridhar R, Karl R, Meredith K. Defining the learning curve for robotic-assisted esophagogastrectomy. *J Gastrointest Surg* 2013; 17: 1346-1351

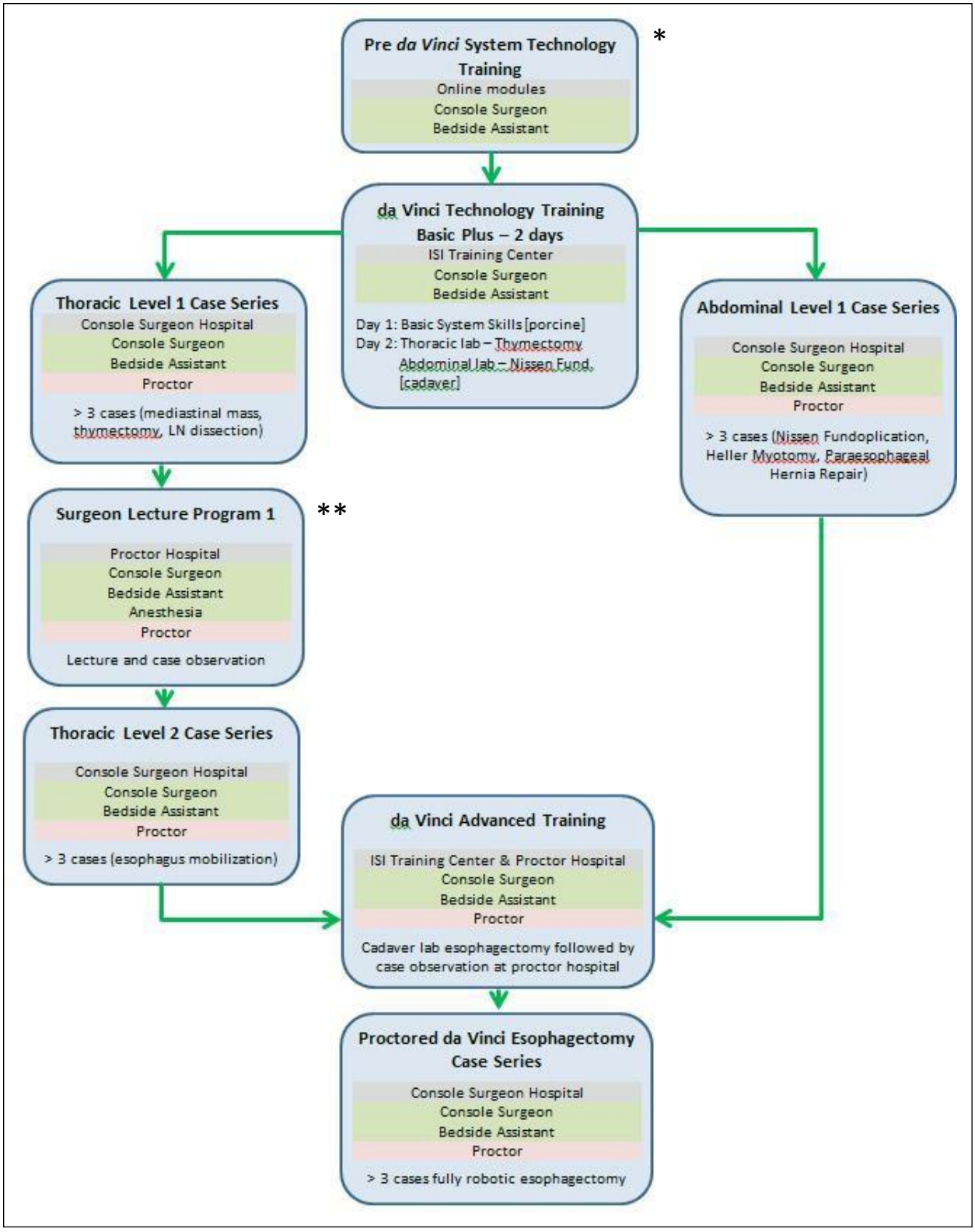


Figure 1: proposed Training Pathway for da Vinci Esophagectomy. * Surgeons without prior da Vinci experience would go through the training pathway performing the training steps of both the abdominal and thoracic parts. ** Surgeons with prior da Vinci case experience would start the esophagectomy training pathway at the Surgeon Lecture Program 1.

4. PATIENT POSITIONING AND SURGICAL PREPARATION

4a. Operating Room Configuration da Vinci Si/X System

- The following figure shows an overhead view of the recommended OR configuration for *da Vinci* Esophagectomy with the da Vinci Si & X system [Figure 2].

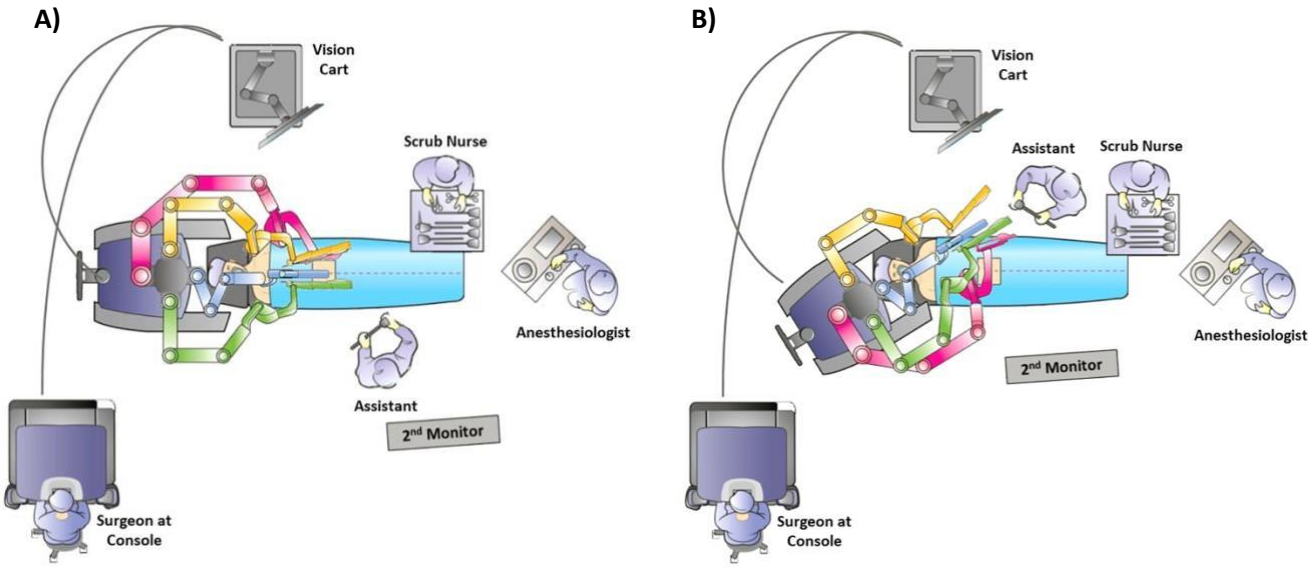


Figure 2: Operating room setup for esophagectomy with da Vinci Si System A) Abdominal Phase, B) Thoracic Phase

- To standardize operating room setup, consider keeping the Patient Cart opposite anesthesia and repositioning the operating table as needed for the procedure.
- Surgeon console is positioned so that good communication with the patient-side team canbe established. Ideally is direct eye contact.
- Assistant is on the patient's side opposite to the *da Vinci* Instrument Arm · port.
- Scrub nurse is at the patient's feet.
- At least one video monitor showing the endoscopic view is located opposite of the assistant.

NOTE: Configuration of the operating suite is dependent on the room dimensions as well as the preference and experience of the surgeon. Make sure console surgeon can communicate clearly with the patient-side team and has ability to establish direct eye contact.

4b. Operating Room Configuration da Vinci Xi System

- The following figure show an overhead view of the recommended OR configuration for *da Vinci* Esophagectomy with the da Vinci Xi [Figure 3].

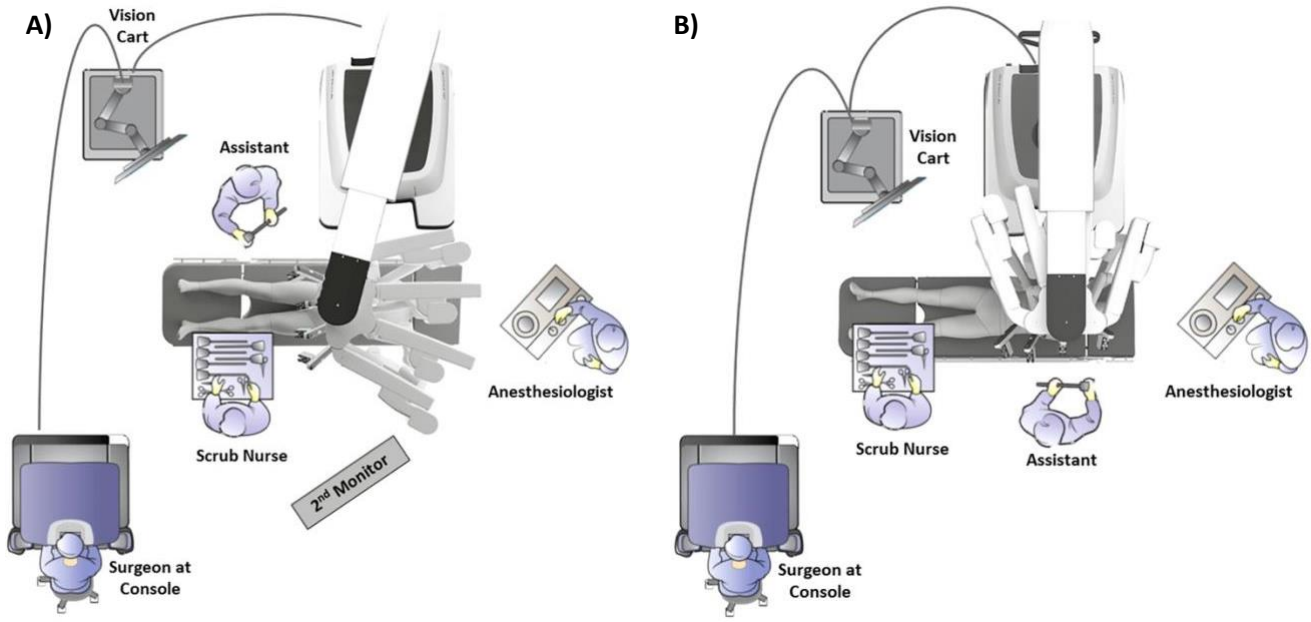


Figure 3: Operating room setup for esophagectomy with da Vinci Xi . A) Abdominal Phase, B) Thoracic Phase

- To standardize operating room setup, consider keeping the Patient Cart opposite anesthesia and repositioning the operating table as needed for the procedure.
- Surgeon console is positioned so that good communication with the patient-side team can be established. Ideally is direct eye contact.
- Assistant is on the patient's side that facilitates easy access to the placed assistant ports.
- Scrub nurse is at the patient's feet.
- At least one video monitor showing the endoscopic view is located opposite of the assistant.

NOTE: Configuration of the operating suite is dependent on the room dimensions as well as the preference and experience of the surgeon. Make sure console surgeon can communicate clearly with the patient-side team and has ability to establish direct eye contact.

4c. Patient Positioning and Surgical Preparation

Depending on the layout of your OR you might have to position anesthesia opposite the patient's head. Therefore, all monitoring cabling and tubing should be sufficiently long to allow for subsequent repositioning of the patient without lead disconnection. Patients receive a double lumen tracheal tube as well as a central venous catheter, and an arterial catheter. If indicated an extra peripheral venous catheter on the patient´s foot can be placed. To avoid any patient motions or increased stress on the patient due to low levels of anesthesia during the procedure, the intensity of the anesthesia and relaxation can be monitored by using the bi-spectral index (BIS).

- Patient placed in supine position under general anesthesia. Alternatively the patient can be placed in a
- "French" position for assistant access between the legs if preferred.
- Intubate with a double-lumen endotracheal tube.
- Perform complete bronchoscopy and confirm position of the double-lumen tube for single-lung ventilation. Secure tube to avoid displacement.
- Place Foley catheter (use selectively, not required)
- A body warmer to prevent patient hypothermia can be applied.

Patient Positioning Abdominal Phase

- Patient's arms are alongside the body to lessen possibility of shoulder injury.
- Pad pressure points and bony prominences.
- Carefully secure body position with gel pad or bean bag and apply a strap across the patient's thighs to avoid any shifting of the reverse Trendelenburg position.
- After positioning, padding, securing and preparing the patient in the supine position, the table is then placed in a reverse Trendelenburg position (~20°-25°) with a ~10° rotation to the right. [Figure 4]

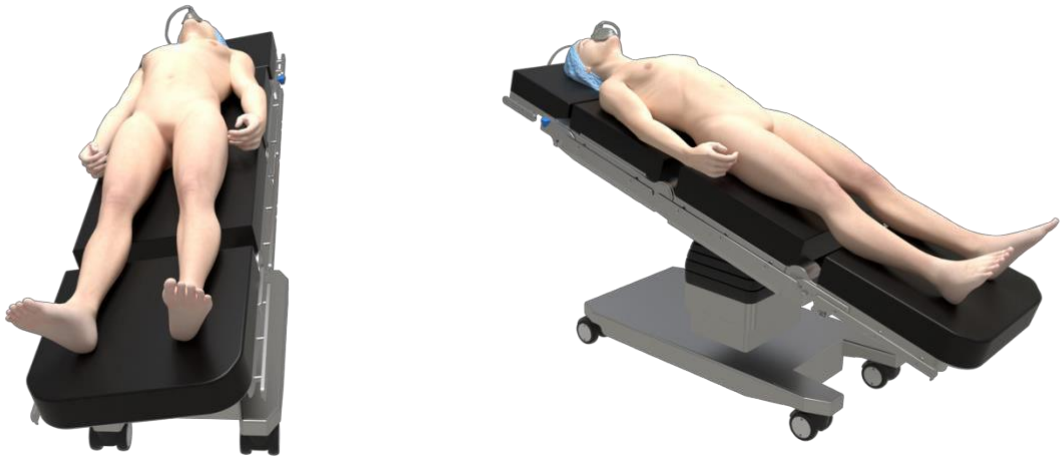


Figure 4: Patient positioning for abdominal phase

Patient Positioning Thoracic Phase

- The Patient is placed in a modified prone position to allow the lung and blood to fall away from the posterior mediastinum. Prone positioning is not used because of the added anesthesia and patient positioning time.
- Reposition patient to a left lateral decubitus position with the right side of the chest up.

NOTE: It is important to place the patient's flank (area between subcostal margin and iliac crest) exactly over the breaking point (flex or kidney break) of the table. We will utilize the table break/flex function to maximize rib separation.

- Arms in swimmer's position to display the axilla.
- Shoulder positioned higher than the hip
- Legs are positioned with the bottom leg bent and pillow in between to stabilize patient's lateral position.
- Break table (kidney bend/flex) and use additional reverse Trendelenburg to position the patient's lateral chest wall almost parallel to the floor and the legs are angled towards the floor [Figure 5].

NOTE: Best position is when the lateral chest is slightly upwards in a mild reverse Trendelenburg position so that the shoulder of the patient is higher than the hip portion to avoid collisions later during the case [Figure 5]. Make sure that OR table is low enough so that the *da Vinci* Patient cart can be driven in over the patient's shoulder during docking.

- Pad pressure points and bony prominences.

- Further rotate the patient ventrally so that a modified prone position (~ 45° rotation of the lateral chest) is reached. Goal is to position the right posterior axillary line as the highest part parallel to the floor. This can be done either by using a right tilt rotation of the OR table or a triangular "foam" positioning wedge under the patient's chest.
- Carefully secure body position and apply a strap across the patient's thighs to avoid any shifting of the reverse Trendelenburg position.
- A body warmer to prevent patient hypothermia can be applied.
- Area is prepped and draped in the usual sterile fashion.
- Single lung ventilation is introduced and moderate CO_2 insufflation of ~ 8 mmHg is applied creating the surgical workspace in the thorax.

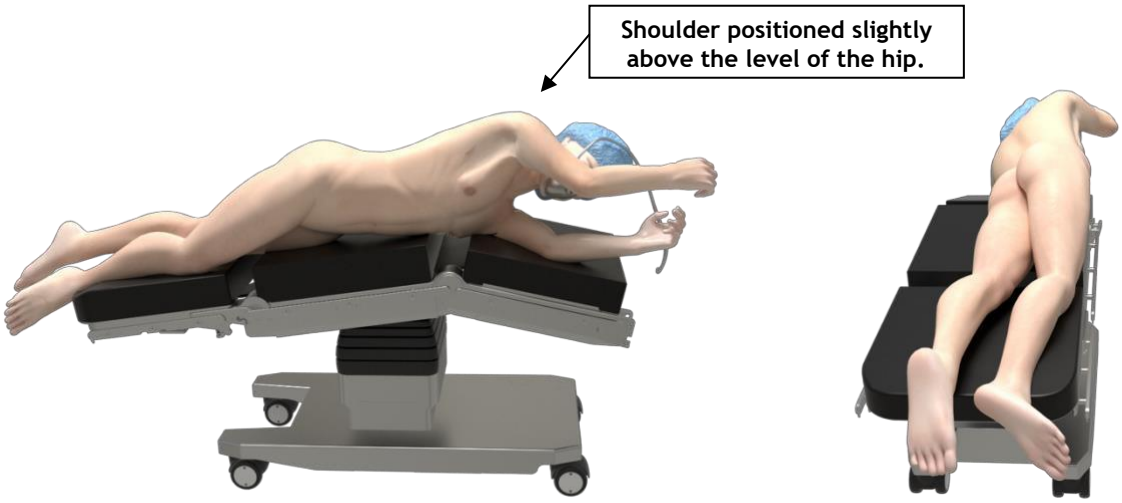


Figure 5: Patient positioning for thoracic phase

5. PORT PLACEMENT AND DOCKING

NOTE: Slight modifications to the port locations might be necessary due to patient's anatomy.

5a. Port Placement da Vinci Si

5.aa da Vinci Si Abdominal Phase [Figure 6]

1. Mark the midline, the subcostal margins and the mid-clavicular lines [MCL] on each patient side.
2. ***Si* Camera Port, 12 mm Ⓒ**: Place port midline slightly above or at the umbilicus. Distance to other ports should be at least 8 cm.
3. ***Si* Instrument Arm ① Port, 8 mm**: Place port on left mid-clavicular line at the same level with camera port. Distance to other instrument ports and endoscope port should be at least 8 cm.
4. ***Si* Instrument Arm ② Port, 8 mm:** Placed on right mid-clavicular line ~ 5 cm superior to camera port. Distance to other instrument ports and endoscope port should be at least 8 cm. This port may be repurposed as an *EndoWrist®* Stapler port in which case a 12 mm Stapler Cannula should be placed here.
5. ***Si* Instrument Arm ③ Port, 5 mm or 8 mm**: Place port on a straight line left as lateral as possible to arm ① port subcostally. Distance to *da Vinci* ① port should be at least 8 cm.
6. **Assistant Port, 12 mm Ⓐ:** Place a 12-mm port triangulated between the Camera Port and arm ② port at a distance of at least 7 cm. Keeping this port off the trajectory lines for those ports will facilitate the Patient-side assistant's access for retraction, etc.
7. **Liver Retraction Port, 5 mm (LR)**: Place 5 mm port subcostal lateral to arm ② port at a distance of at least 8 cm. Alternatively, a small skin incision can be made subxiphoid if a Nathanson Liver Retractor is used.

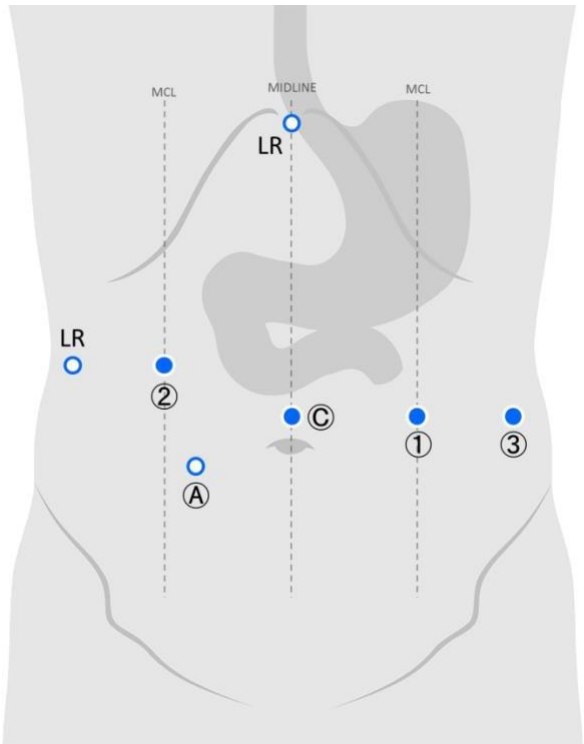


Figure 6: *da Vinci* Si Abdominal Phase port placement

5ab. da Vinci Si Thoracic Phase [Figure 7]

1. Single lung ventilation is introduced and moderate CO_2 insufflation of ~ 8 mmHg is applied creating the surgical workspace in the thorax. It is recommended to administer local anesthesia at the port sites prior to placement to reduce post-operative pain.
2. Mark the Anterior Axillary Line [AAL], Mid Axillary Line [MAL} and the Posterior Axillary Line [PAL].
3. ***Si* Camera Port, 12 mm Ⓒ**: Place port in the 6th ICS on the mid-axillary line [MAL]. To ensure an intra-pleural position one should dissect first manually down to the level of the endothoracic fascia. Distance to other ports should be at least 8 cm.
4. ***Si* Instrument Arm ① Port, 8 mm:** Placed under visual guidance in the 3rd ICS in the anterior axillary line [AAL] ~ 2 cm medial to the anterior edge of the scapula. When placing this port check for possible interferences with the patient's arm. Distance to the camera port should be at least 8 cm.
5. ***Si* Instrument Arm ② Port, 8 mm**: Placed in the 8th ICS on the posterior axillary line [PAL]. Distance to other instrument ports and endoscope port should be at least 8 cm. This port may be repurposed as an *EndoWrist®* Stapler port in which case a 12 mm Stapler Cannula should be placed here.
6. ***Si* Instrument Arm ③ Port, 5 mm or 8 mm**: Place port laterally in either the 8th or 9th ICS depending on patient habitus (more flexibility to reach the inferior pulmonary ligament is from the 9th ICS). Distance to *da Vinci* arm ② port should be at least 8 cm.
7. **Assistant Port/Mini-Thoracotomy, 12 mm Ⓐ:** A mini-thoracotomy (~ 3 cm) is placed lateral at the diaphragmatic fold on the AAL, triangulated between arm ② port and camera port. A size „small" Alexis Wound Retractor with laparoscopic cap (Applied Medical, Rancho Santa Margarita, CA, USA) is placed in the thoracotomy, and a 12 mm laparoscopic port inserted for assistant access. This will be the site for specimen removal and serves as an emergency port in case of substantial intra- thoracic bleeding.

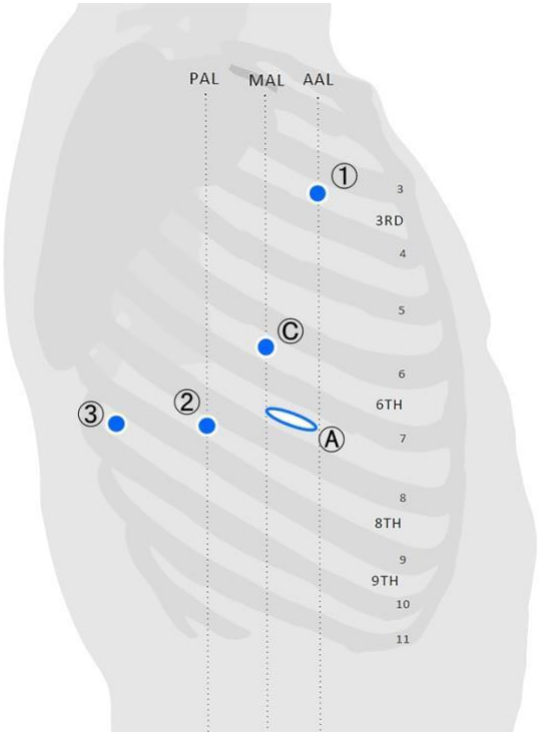


Figure 7: *da Vinci* Si Thoracic Phase port placement

5b. da Vinci Si Patient Cart Docking

Step 1: Adjust Camera Arm Set-Up Joint

- Position the camera arm set-up joint towards the patient's side with just one instrument arm (red arrow below) [Figure 8].

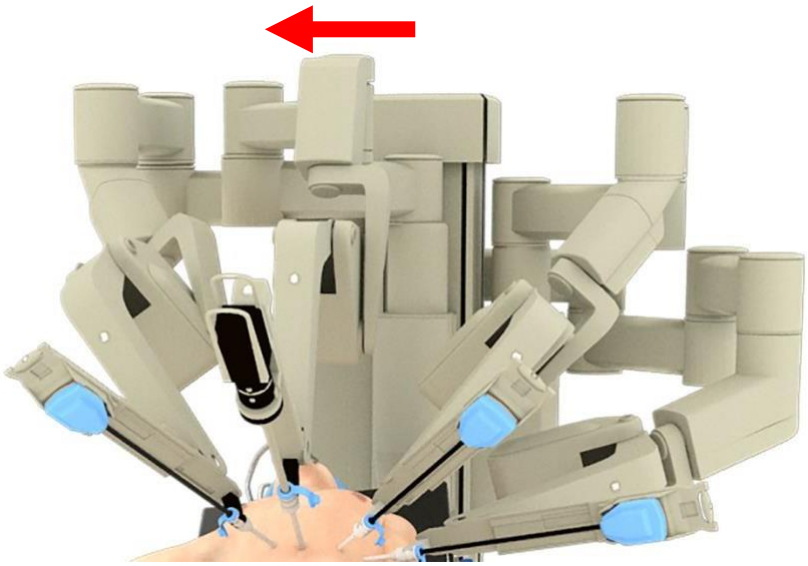
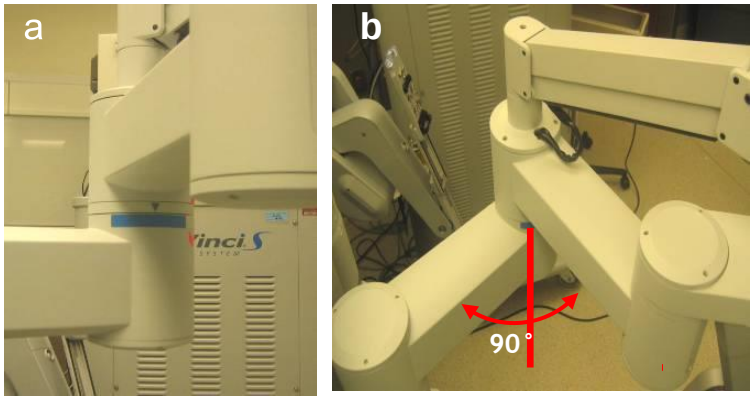


Figure 8: Positioning of camera set-up joint

Step 2: Determining "Sweet Spot"

- The "sweet spot" maximizes the range of motion for the instrument arms.
- Confirm "sweet spot" prior to docking.
- *da Vinci® Si*™ System - The blue arrow should align within the blue marker on the 2nd joint [Figure 9a] or assure a ~90°angle between the 1st and 3rd joint on the camera arm [Figure 9b].



Figures 9a-b: "Sweet Spot" on *da Vinci® Si*™

Step 3: Align Camera Arm

- Align the camera arm, camera arm set-up joint, column and target anatomy.
- A straight line should be achieved by ensuring that the setup joint of the camera arm is centered on the center column [Figure 10]

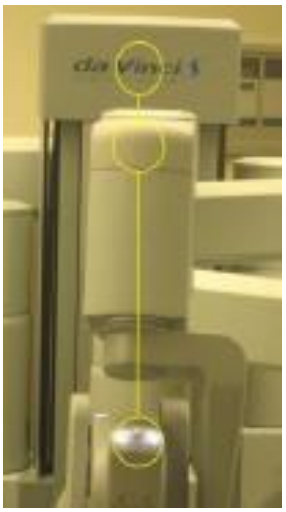


Figure 10: Align camera arm

Step 4: Roll in Patient Cart and Docking

- Lower OR table & position patient cart arms to clear patient.
- The arms of the patient cart should be positioned high enough to clear the height of the patient's chest.

NOTE: Make sure that the OR table is low enough so that the *da Vinci* patient cart can be driven in over the patient's shoulder during docking. If this cannot be achieved, the patient cart can be steered in around the shoulder and then straightened out for docking.

- Push aside overhead lights and equipment to maintain sterility of the Patient cart.

Abdominal Docking

- The Patient cart approaches the patient over the head [Figure 11].
- Move the Patient cart in towards the endoscope port along a straight line.

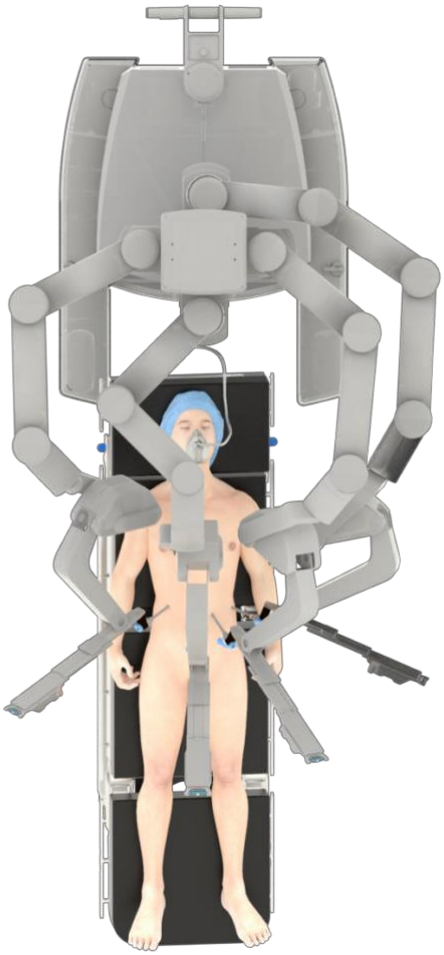


Figure 11: Correct roll up angle for da Vinci Si Patient Cart docking Abdominal Part

- Ensure endoscope port, target anatomy and Patient Cart center column are aligned. [Figure 11]
- Position camera cannula mount over the camera port and dock.
- Use port and arm clutch maneuvers to dock remaining instrument arms.
- Maximize spacing between arms.
- Keep instruments in the center of their range of motion.

CAUTION: Once system is docked, the OR table cannot be moved.

Thoracic Docking

- The Patient cart approaches the patient from the back side of the patient [Figure 12] and docked dorsocranially at about 30°.
- Move the Patient Cart straight in towards the camera port along this line.

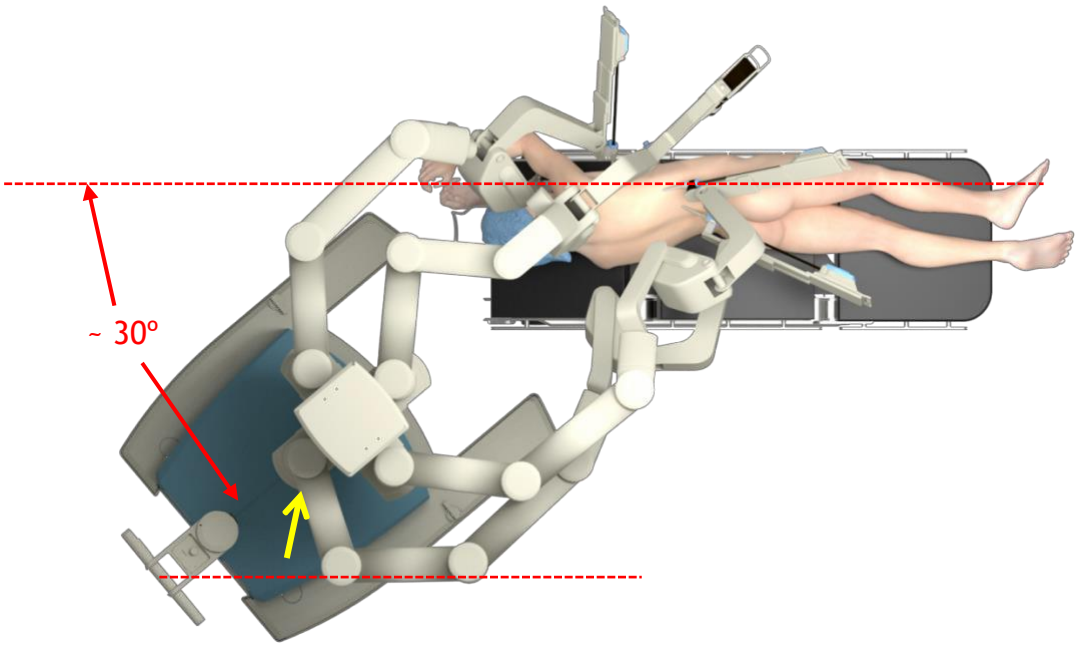


Figure 12: Correct roll up angle for Patient Cart docking Thoracic Part

TIP: It is recommended to "unlock" the 1st joint of instrument arm ③ (→) at the back of the column for greater flexibility in set up and management of interferences should they arise.

- Ensure camera port, target anatomy and Patient cart center column are aligned. [Figure 12]
- Position camera cannula mount over the camera port and dock.
- Use port and arm clutch maneuvers to dock remaining instrument arms.
- Maximize spacing between arms [Figure 13].
- Keep instruments in the center of their range of motion.

CAUTION: Once system is docked, the OR table cannot be moved.

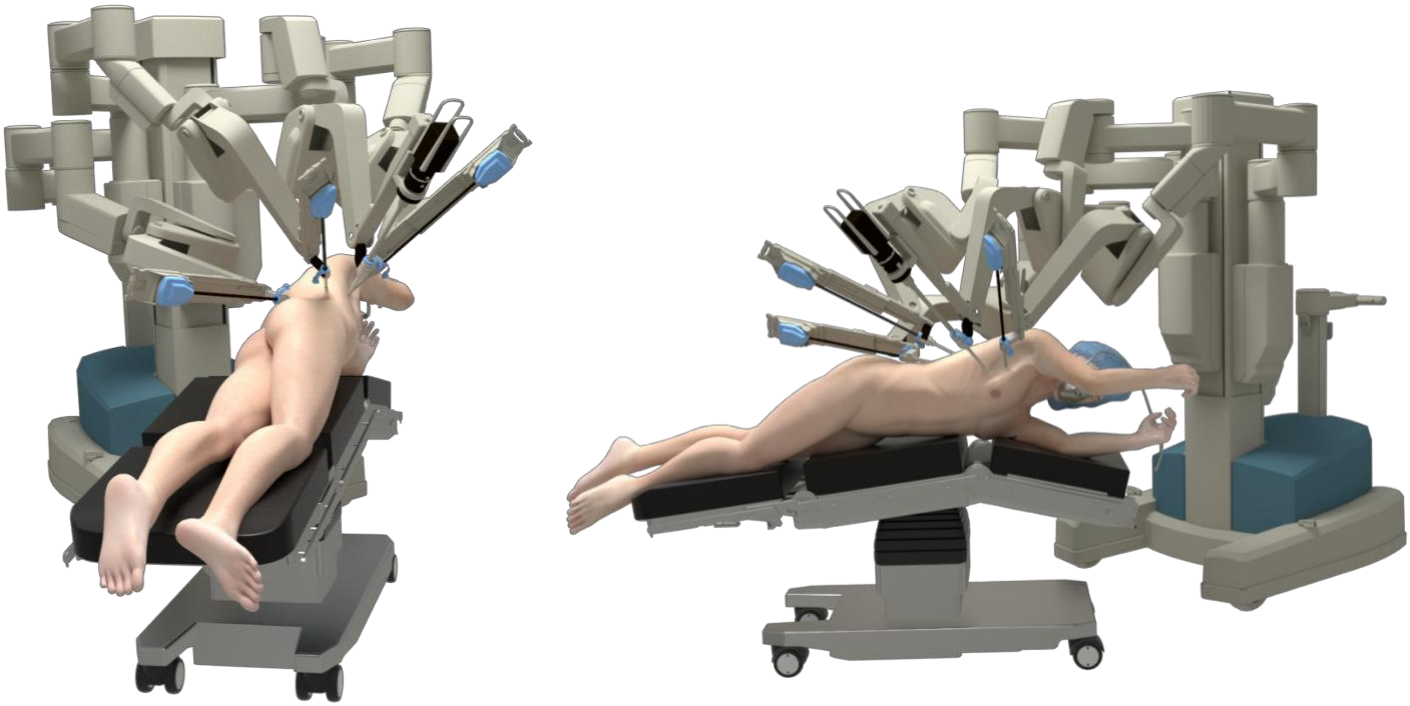


Figure 13: da Vinci Si Patient Cart docked Thoracic Part

5c. Port Placement da Vinci Xi

5ca da Vinci Xi Abdominal Phase [Figure 14]

1. Mark the midline, the subcostal margins and the mid-clavicular lines [MCL] on each patient side.
2. ***Xi* Instrument Arm ② Port, 8 mm (initial endoscope port)**: Place port midline slightly above or at the umbilicus.
3. ***Xi* Instrument Arm ① Port, 13 mm**: Place port on right mid-clavicular line [MCL] at least 8 cm away from arm ② port on a straight line. This port is used for the *EndoWrist®* Stapler. In case a laparoscopic stapler is used place arm ①* port as lateral as possible on the right 2-3 cm superior to arm ② port and at least 8 cm away from a laparoscopic 12 mm port used as assistant port (A)*.
4. ***Xi* Instrument Arm ③ Port, 8 mm:** Place port on the left MCL at least 8 cm away from arm ② port on a straight line.
5. ***Xi* Instrument Arm ④ Port, 8 mm**: Place port as far left lateral at least 8 cm away from arm ③ port on a straight line.
6. **Assistant Port, 12 mm (A):** Place a 12-mm port triangulated midway inferior between arm ③ and arm ④ port at a distance of ~ 7 cm to the ports. In case a laparoscopic stapler is used move assistant port (A)* to location of arm ① port.
7. **Liver Retraction Port, 5 mm (LR)**: Place 5 mm port subcostal superior to Assistant Port at a distance of at least 8 cm. Alternatively a small skin incision can be made subxiphoid if a Nathanson Liver Retractor is used.

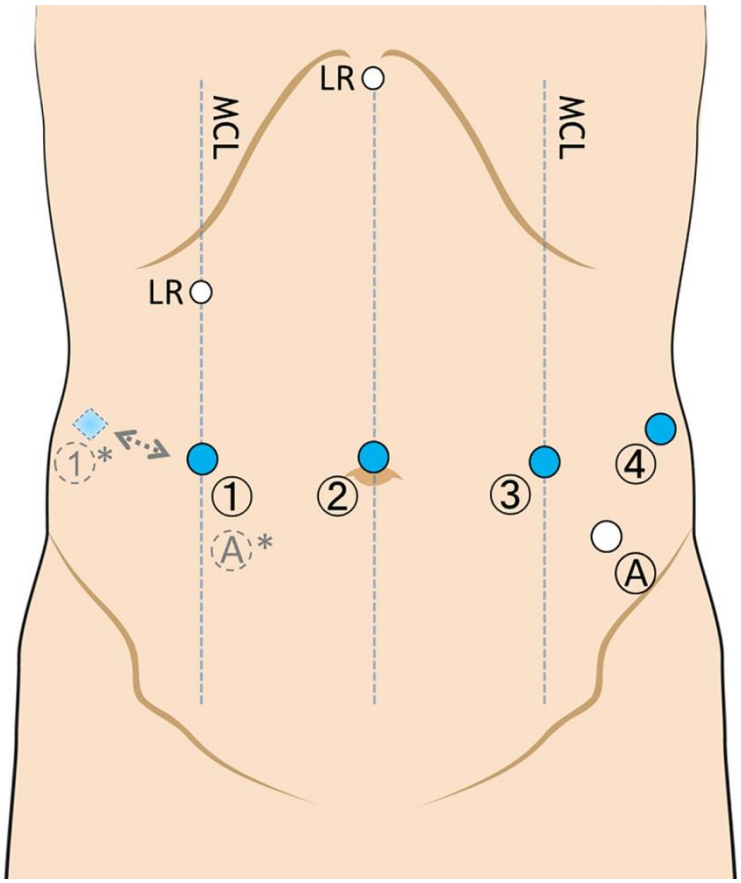


Figure 14: *da Vinci* Xi Abdominal Phase port placement

5cb. da Vinci Xi Thoracic Phase [Figure 15]

1. Single lung ventilation is introduced and moderate CO_2 insufflation of ~ 8 mmHg is applied creating the surgical workspace in the thorax.
2. Mark the Posterior Axillary Line [PAL] and the scapular line.
3. ***Xi* Instrument Arm ④ Port, 8 mm**: Place port in the 4th ICS, 1 cm medial to the scapula. To ensure an intra-pleural position one should dissect first manually down to the level of the endothoracic fascia.
4. ***Xi* Instrument Arm ③ Port, 8 mm:** Place port in the 6th ICS, slightly more medial than port ④ and closer to the PAL. This port is used initially for the endoscope. Maintain 6–10 cm spacing between ports.
5. ***Xi* Instrument Arm ② Port, 8 mm:** Place port in the 8th ICS at the same level than port ④. Maintain 6–10 cm spacing between ports.* This port (②) may be repurposed as an *EndoWrist®* Stapler port in which case a 12 mm Stapler Cannula should be placed here.
6. ***Xi* Instrument Arm ① Port, 13 mm:** Place port on the scapular line or slightly posterior to it in the 10th ICS. Maintain 6–10 cm spacing between ports. This port is used for the *EndoWrist®* Stapler.
7. All Xi Instrument Arm ports are arranged on a slightly curved line towards the approximate location of the azygos vein.
8. **Assistant Port, 12 mm:** there are two recommended options for the assistant port location depending on surgeon preference for the introduction of the circular stapler to construct the esophagogastrostomy:

   - **(A)[1]:** Place 12 mm port in the 9th ICS on PAL triangulated between ports ① and ②. This port might be enlarged to a mini-thoracotomy (~ 3 cm) with a size „small“ or “x-small” Alexis Wound Retractor (Applied Medical, Rancho Santa Margarita, CA, USA). This would be the site for specimen removal and entrance of circular stapler.

   or alternatively

   - **(A)[2]:** Place 12 mm port triangulated between ports ③ and ④ in the 5th ICS, slightly posterior to the PAL. This port might be enlarged to a mini-thoracotomy (~ 3 cm) with a size „small“ or “x-small” Alexis Wound Retractor (Applied Medical, Rancho Santa Margarita, CA, USA) placed here. This would be the site for specimen removal and entrance of circular stapler.

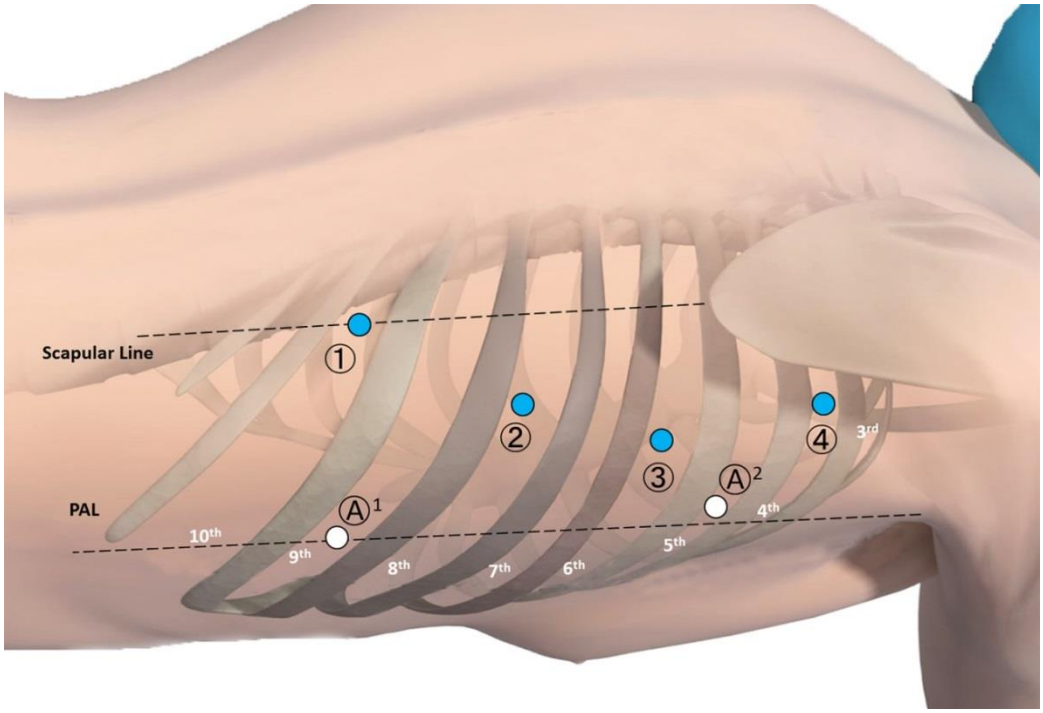


Figure 15: *da Vinci* Xi Thoracic Phase port placement

5d. da Vinci Xi Patient Cart Docking

Abdominal Docking [Figure 16]

- To deploy the da Vinci Xi for the abdominal docking select
  - **ANATOMY: UPPER ABDOMINAL**
  - **CART LOCATION: PATIENT RIGHT**
- The da Vinci Xi patient cart is rolled up from the right side of the patient. And the targetlaser aligned with the port for the endoscopic camera.
- Once docked perform targeting with the **TARGET: ESOPHAGEAL HIATUS.**

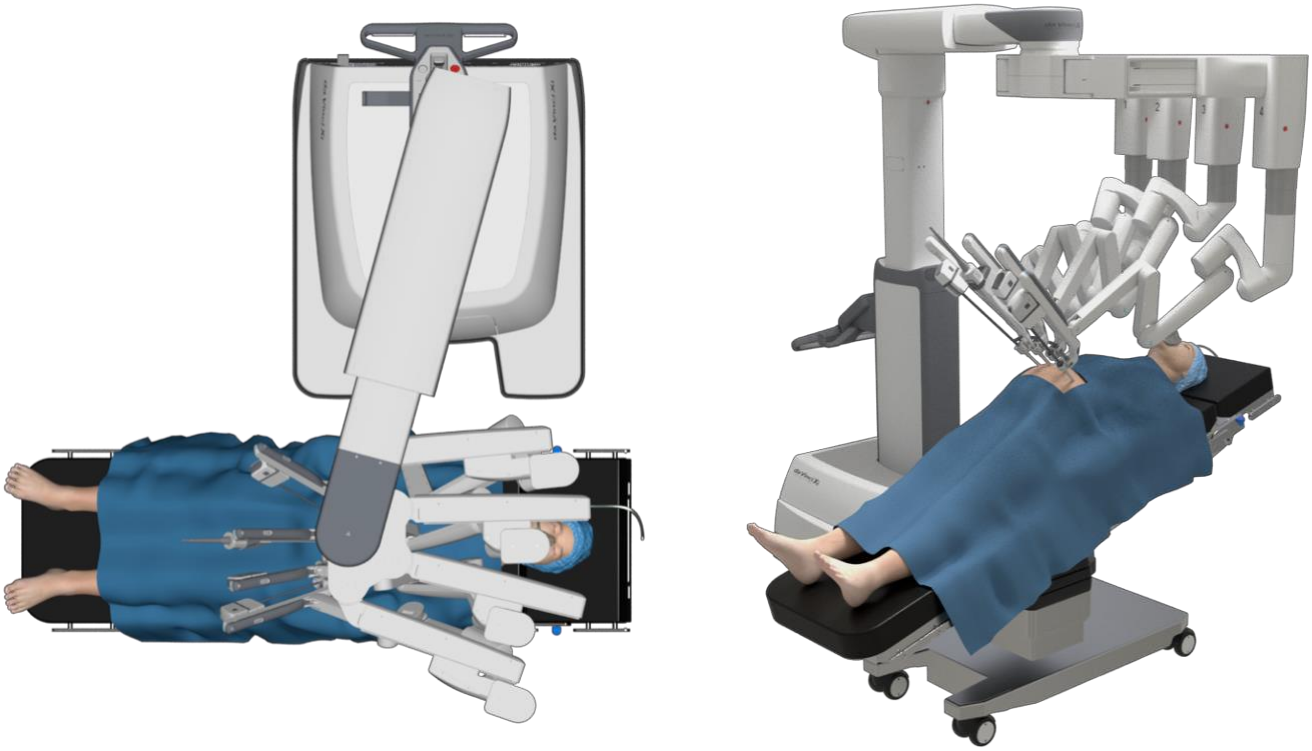


Figure 16: da Vinci Xi Patient Cart docked - Abdominal Part

Thoracic Docking [Figure 17]

- To deploy the da Vinci Xi for the thoracic docking select
  - **ANATOMY: CARDIAC**
  - **CART LOCATION: PATIENT RIGHT**

NOTE: "Anatomy Cardiac" is selected as it orients the boom of the *da Vinci* patient cart to a set up with the ports placed in line in the intercostal spaces similar to a cardiac procedure.

- The da Vinci Xi patient cart is rolled up from the right side ofthe patient. And the target laser aligned with the port for the endoscopic camera.
- Once docked perform targeting with the **TARGET: AZYGOS VEIN**

Figure 17: da Vinci Xi Patient Cart docked - Thoracic Part

5e. *da Vinci X* Considerations

5.ea da Vinci X Port Placement

- It is recommended to follow the port placement strategy for the da Vinci Xi (5.ca & 5.cb) when working with a da Vinci X system. This is because the range of motion and mechanical abilities of the X instrument arms match the capabilities of the da Vinci Xi closely in clinical use.

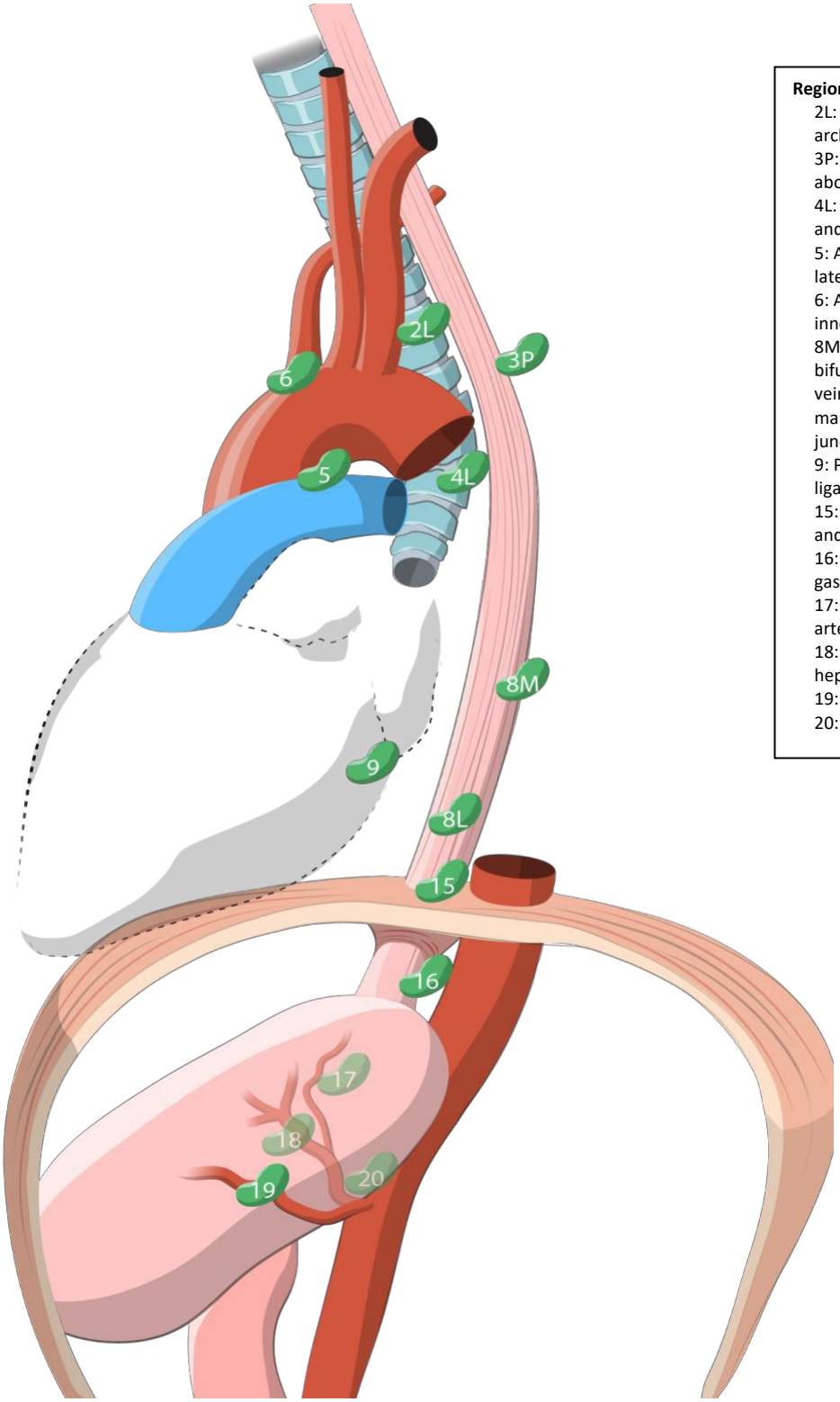
5.eb da Vinci X Patient Cart Docking

- It is recommended to follow the docking strategy for the da Vinci Si (5.b) when working with a da Vinci X system. This is because the mechanical design of the da Vinci X patient cart matches the capabilities of the da Vinci Si closely in clinical use.
- Use LASER to plan the docking approach [Figure 18]
    - Turn on the laser. Angle the da Vinci X cart so the laser line intersects the target anatomy and the initial endoscope port.
    - A good rule of thumb is for the laser line to intersect the endoscope port perpendicular to the line of ports.

Figure 18: da Vinci X Patient Cart Docking Approach (example) with LASER

6. PROCEDURE STEPS – IVOR LEWIS ESOPHAGECTOMY

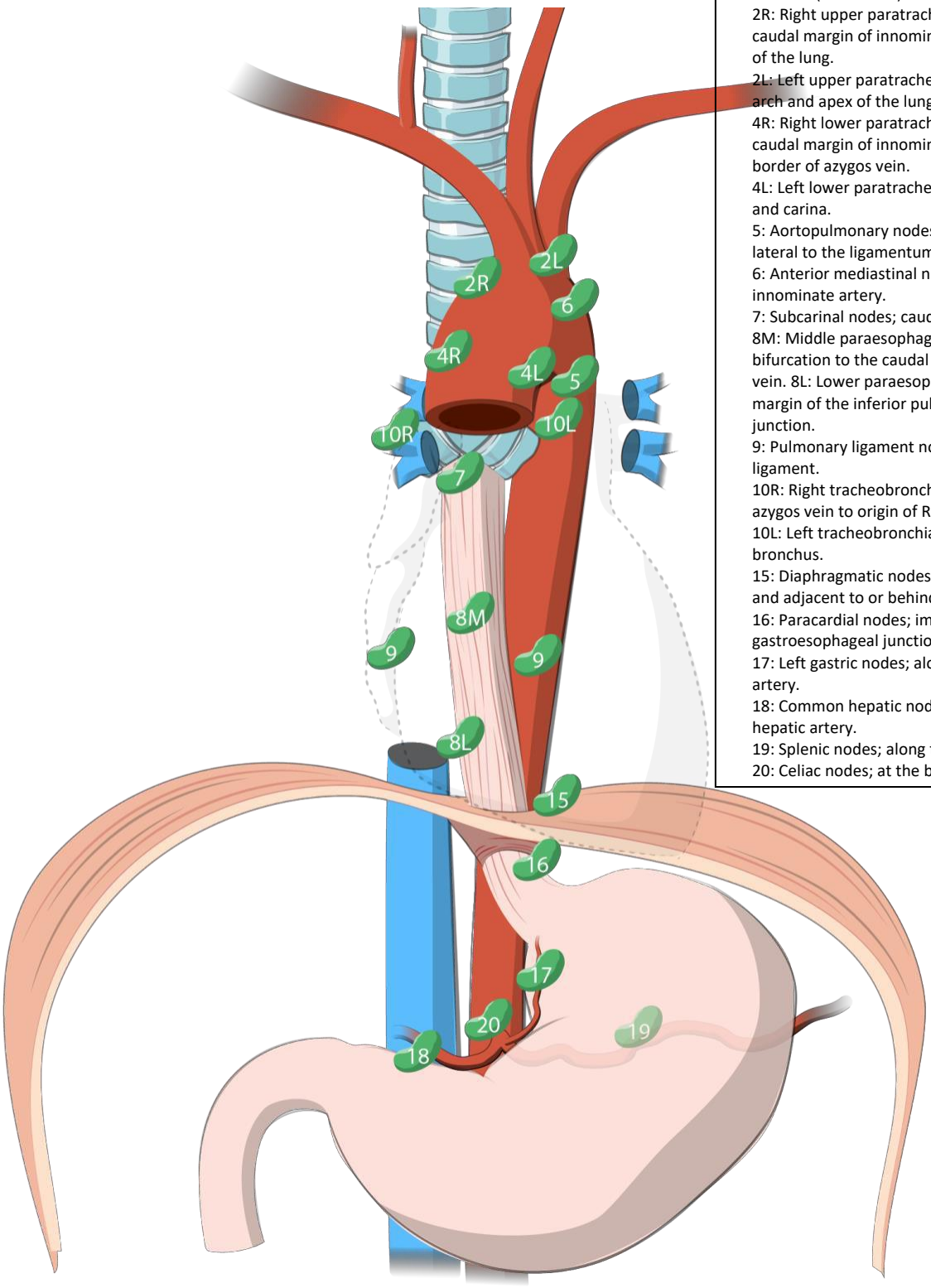
Figure 19 (a-c) provides an overview of the surgical anatomy and related lymph node stations.



Regional lymph node stations for staging esophageal cancer:

2L: Left upper paratracheal nodes; between the top of aortic arch and apex of the lung.
3P: Posterior mediastinal nodes; upper paraesophageal nodes, above tracheal bifurcation.
4L: Left lower paratracheal nodes; between top of aortic arch and carina.
5: Aortopulmonary nodes; subaortic and para-aortic nodes lateral to the ligamentum arteriosum.
6: Anterior mediastinal nodes; anterior to ascending aorta or innominate artery.
8M: Middle paraesophageal lymph nodes; from the tracheal bifurcation to the caudal margin of the inferior pulmonary vein. 8L: Lower paraesophageal lymph nodes; from the caudal margin of the inferior pulmonary vein to the esophagogastric junction.
9: Pulmonary ligament nodes; within the inferior pulmonary ligament.
15: Diaphragmatic nodes; lying on the dome of the diaphragm and adjacent to or behind its crura.
16: Paracardial nodes; immediately adjacent to the gastroesophageal junction.
17: Left gastric nodes; along the course of the left gastric artery.
18: Common hepatic nodes; along the course of the common hepatic artery.
19: Splenic nodes; along the course of the splenic artery.
20: Celiac nodes; at the base of the celiac artery.

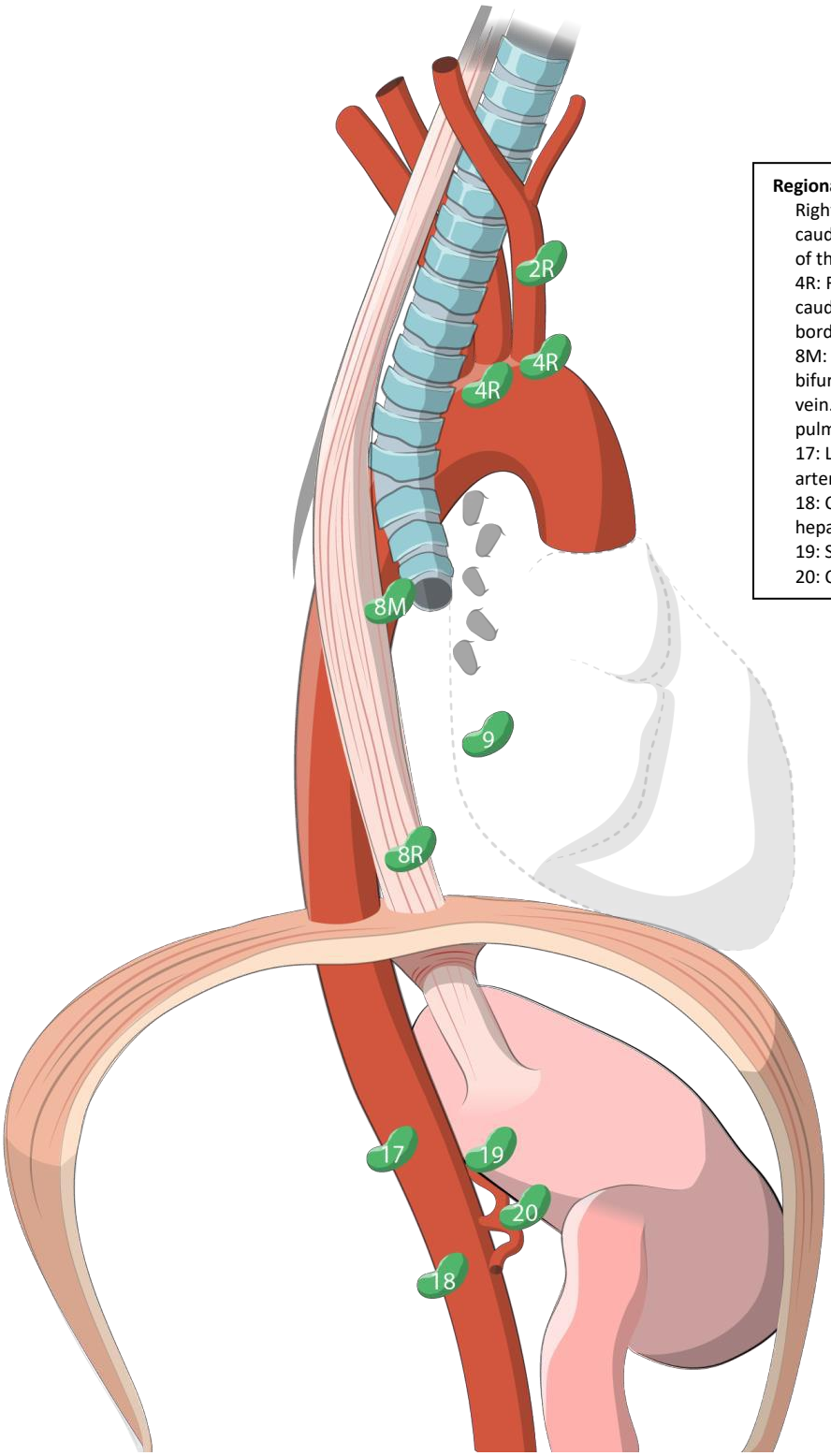
Figure 19a: Lymph Node Classification for Esophageal Cancer Staging – Side View Left



Regional lymph node stations for staging esophageal cancer:

1: Supraclavicular nodes; above suprasternal notch and clavicles (not shown).
2R: Right upper paratracheal nodes; between intersection of caudal margin of innominate artery with trachea and the apex of the lung.
2L: Left upper paratracheal nodes; between the top of aortic arch and apex of the lung.
4R: Right lower paratracheal nodes; between intersection of caudal margin of innominate artery with trachea and cephalic border of azygos vein.
4L: Left lower paratracheal nodes; between top of aortic arch and carina.
5: Aortopulmonary nodes; subaortic and para-aortic nodes lateral to the ligamentum arteriosum.
6: Anterior mediastinal nodes; anterior to ascending aorta or innominate artery.
7: Subcarinal nodes; caudal to the carina of the trachea.
8M: Middle paraesophageal lymph nodes; from the tracheal bifurcation to the caudal margin of the inferior pulmonary vein. 8L: Lower paraesophageal lymph nodes; from the caudal margin of the inferior pulmonary vein to the esophagogastric junction.
9: Pulmonary ligament nodes; within the inferior pulmonary ligament.
10R: Right tracheobronchial nodes; from cephalic border of azygos vein to origin of RUL bronchus.
10L: Left tracheobronchial nodes; between carina and LUL bronchus.
15: Diaphragmatic nodes; lying on the dome of the diaphragm and adjacent to or behind its crura.
16: Paracardial nodes; immediately adjacent to the gastroesophageal junction.
17: Left gastric nodes; along the course of the left gastric artery.
18: Common hepatic nodes; along the course of the common hepatic artery.
19: Splenic nodes; along the course of the splenic artery.
20: Celiac nodes; at the base of the celiac artery.

Figure 19b: Lymph Node Classification for Esophageal Cancer Staging – Frontal View



Regional lymph node stations for staging esophageal cancer: 2R: Right upper paratracheal nodes; between intersection of caudal margin of innominate artery with trachea and the apex of the lung.
4R: Right lower paratracheal nodes; between intersection of caudal margin of innominate artery with trachea and cephalic border of azygos vein.
8M: Middle paraesophageal lymph nodes; from the tracheal bifurcation to the caudal margin of the inferior pulmonary vein. 8R/9: Pulmonary ligament nodes; within the inferior pulmonary ligament.
17: Left gastric nodes; along the course of the left gastric artery.
18: Common hepatic nodes; along the course of the common hepatic artery.
19: Splenic nodes; along the course of the splenic artery.
20: Celiac nodes; at the base of the celiac artery.

Figure 19c: Lymph Node Classification for Esophageal Cancer Staging – Side View Right

To avoid intraoperative complications:

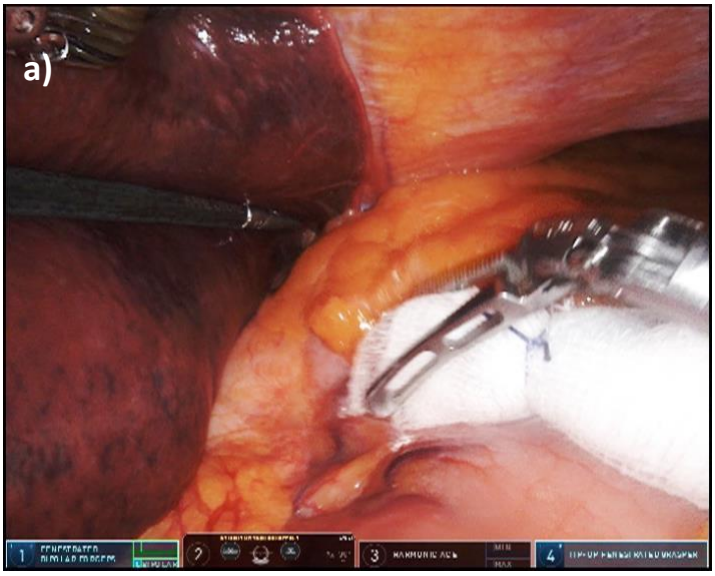
- Create adequate exposure
- Use proper traction and countertraction
- Develop the correct planes
- Standardize the assistant's role
- Utilize bariatric length (45 cm) laparoscopic instrumentation to avoid interferences for assistant
- Beware of the variations of vasculature and anatomy

6a. Abdominal Phase

6aa. Liver Retraction

Retracting the liver is essential for clear visualization. Utilizing a method for static retraction allows all da Vinci instrument arms to be free for dynamic use and localized static retraction where necessary. There are different options to retract the liver with a "static system":

1. the preferred method is the placement of a long bariatric grasper (45 cm length) through a 5 mm port in the right flank to lift up right hepatic lobe (use locking bariatric grasper to "lock" grips on right crus for static retraction of liver – grasper shaft builds a "bridge" for the hepatic lobe to be placed on top of) [Figure 20a]
2. placement of a Lapro-Flex® Triangular Retractor 5mm (Mediflex Surgical Products, Islandia, NY, USA) through a 5 mm port in the right flank held in place by a mechanical assist arm mounted to the operating table
3. placement of a Nathanson Liver Retractor (Cook Medical, Limerick, Ireland) through a small skin incision subxiphoid held by locking mechanical assist arm on OR table
4. placement of a "sling" around liver lobe percutaneously that lift's up on either the falciform or liver lobe edge for retraction [Figure 20b]



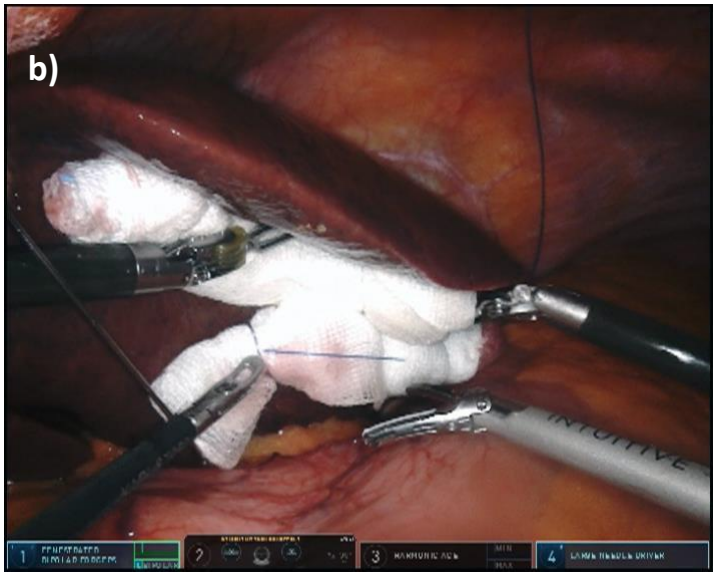


Figure 20: a) liver retraction with long bariatric length grasper, b) liver retraction with gauze sling around falciform and liver edge

6ab. Gastric and Distal Esophagus Mobilization

Da Vinci Instrumentation (Si/Xi/X):

- Endoscope 30° down
- Fenestrated Bipolar Forceps (left)
- Monopolar Curved Scissors (main right)
  - ➢ might be temporarily exchanged with Harmonic ACE, *EndoWrist®* Vessel Sealer, Large or Medium-Large Clip Applier
- Cadiere Forceps (secondary right)
  - ➢ Alternatively Tip-Up Fenestrated Grasper (Xi/X) or 5 mm Schertel Grasper (Si)

- The dissection begins by opening the gastrohepatic ligament close to the liver and up to the right crus of diaphragm after evaluation of an aberrant left gastric artery [Figure 21].

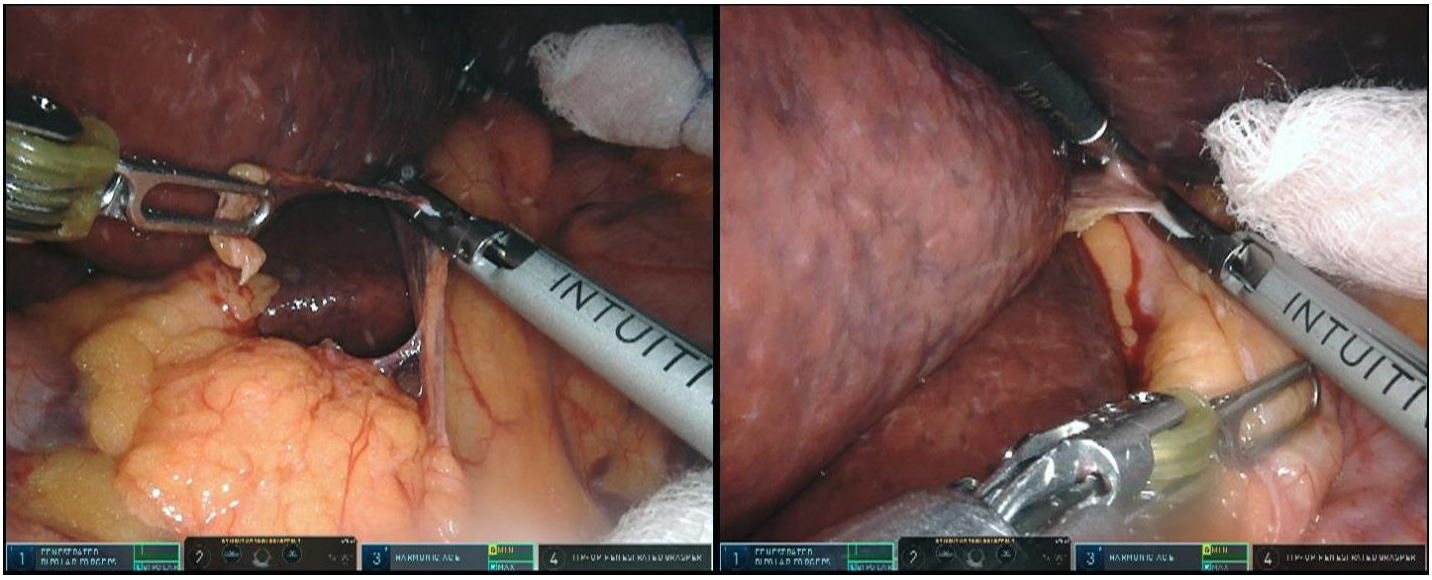


Figure 21: Dissection of gastrohepatic ligament

- Surgical tasks are performed while the right gastric artery, the hepatic artery, portal vein, and common bile duct are carefully protected.
- Now the common hepatic artery is prepared followed by a lymph node dissection of its upper margin up to the celiac axis [Figure 22].

Figure 22: Preparation of common hepatic artery (arrow)

- The right gastric artery is preserved and branches of the splenic and left gastric artery are prepared subsequently.
- The presence of an atypical left hepatic artery is verified (incidence ~5%)[6]. If present preserve it.
- The left gastric artery and the atrial coronary vein are ligated using a Large or Medium-Large Clip Applier in the main right arm [Figure 23].

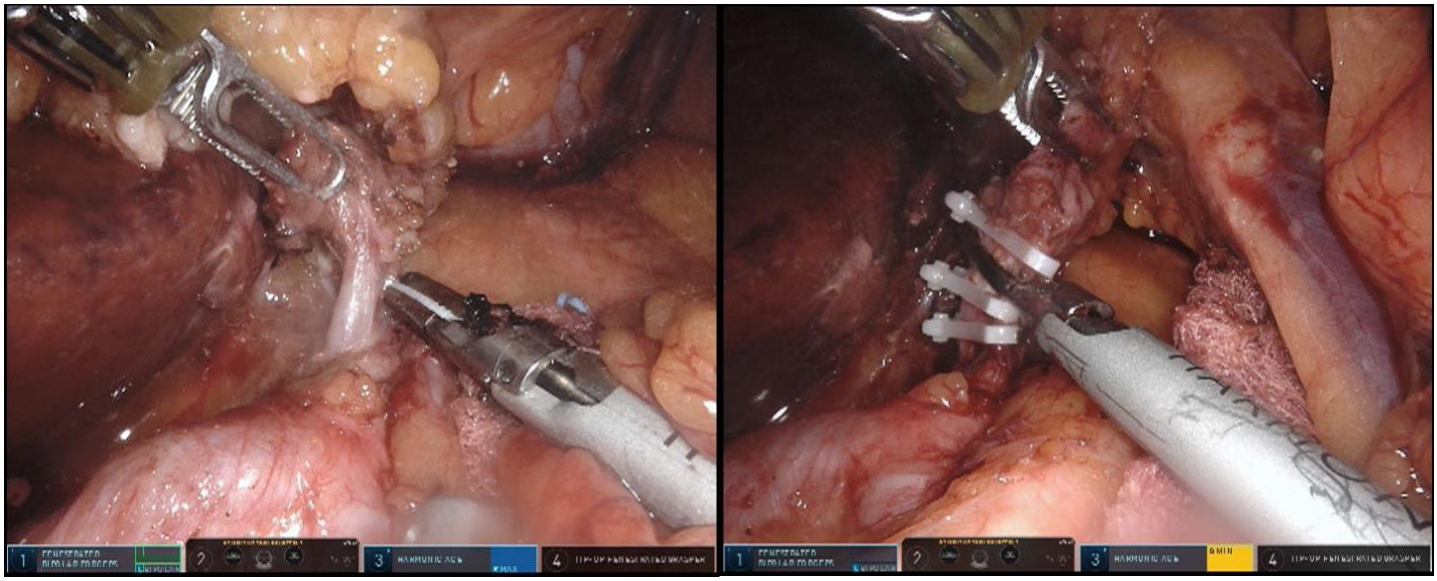


Figure 23: Dissection and transection of left gastric artery

- The gastric mobilization is following a medial to lateral approach. The gastric fundus is lifted up with the forceps in the secondary arm on the right to expose the esophageal hiatus, right and left crura, and the lesser sac. Care should be taken if a posterior gastric artery is encountered [Figure 24].

7 Hess NR et al.:Preservation of replaced left hepatic artery during robotic-assisted minimally invasive esophagectomy: A case series. DOI: 10.1002/rcs.1802

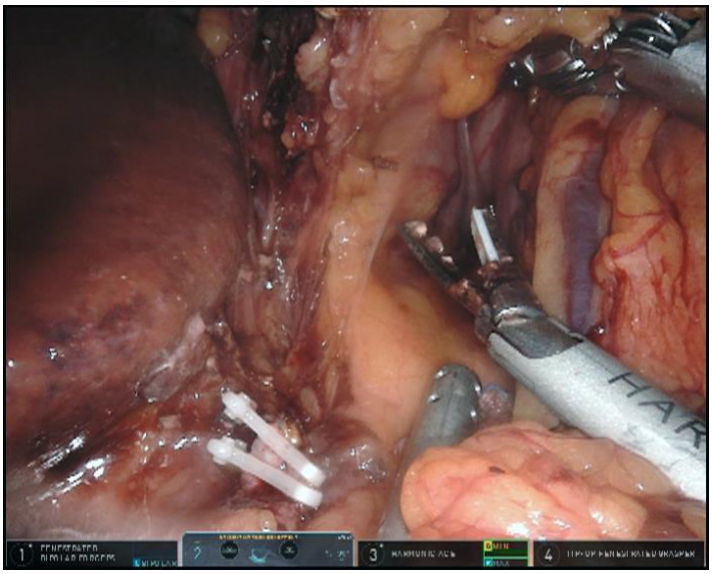


Figure 24: Lifting of the gastric fundus from medially to expose the esophageal hiatus

- The retro-gastric adhesions as well as the short gastric arteries can be dissected and ligated safely with the *EndoWrist* Vessel Sealer or Harmonic ACE [Figure 25].

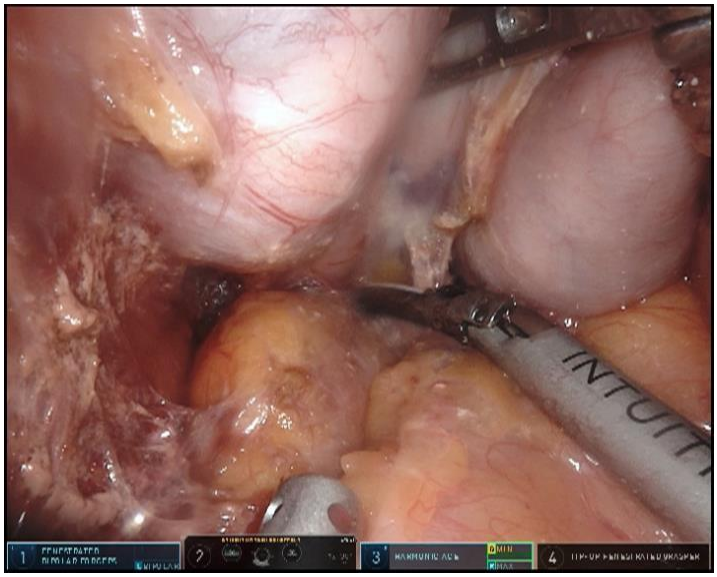


Figure 25: Dissection of the retro-gastric adhesions

- After ligating the right crus of diaphragm the hiatus is being dissected and widened. By doing so the esophagus can be released circumferentially, and mobilized high into the mediastinal cavity leads to a less challenging dissection of the greater gastric curvature and conservation of the right gastroepiploic arcade by fully dissecting the gastrocolic ligament. The fundus of the stomach is elevated with the Cadiere Grasper in the secondary right arm while the bedside assistant elevates the stomach by lifting the antrum [Figure 26].

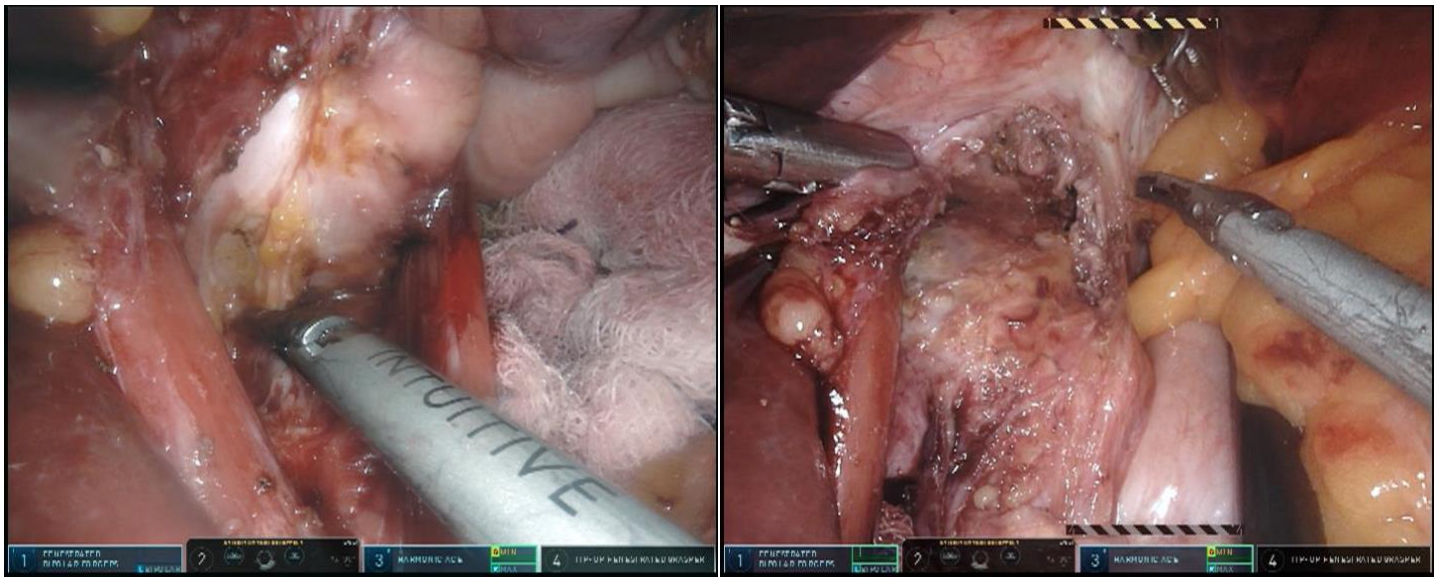


Figure 26: Circumferential release of the esophagus at the hiatus

NOTE: Prior to this step it should be communicated with the anesthesiologist that during the dissection at the esophageal hiatus the parietal pleura might be breached allowing insufflating carbon dioxide to rapidly expand the pleural space, causing a tension pneumothorax. Positive end-expiratory pressure application and/or insertion of an intercostal drain may be applied to manage pneumothorax secondary to the passage of gas into the interpleural space.

- The large curvature of the stomach is mobilized by dissecting the gastrocolic ligament going from caudal to cranial approximately 2–3 cm from the gastroepiploic artery preserving the right gastroepiploic vascular arcade. The *EndoWrist* Vessel Sealer or Harmonic ACE is used on the main right arm for the dissection [Figure 27].

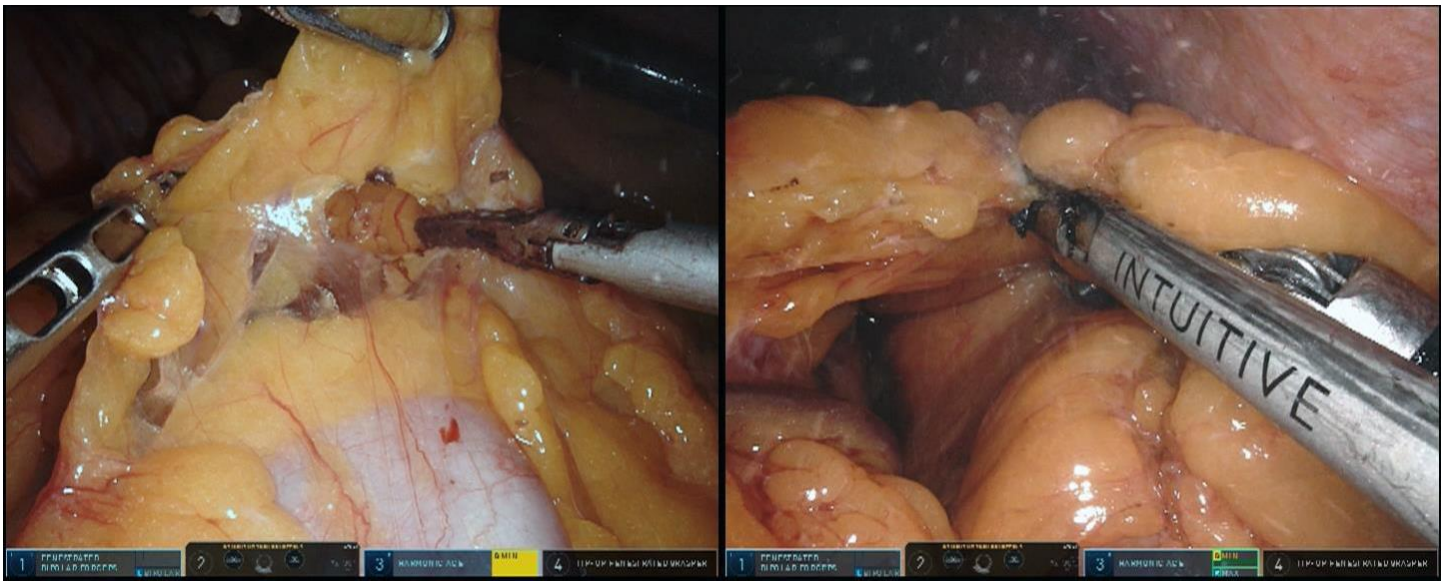


Figure 27: Dissection of the gastrocolic ligament in the caudal to cranial direction

- If consecutive protection of the esophagogastrostomy is preferred the omentum might be left attached to the greater curvature.

- The mobilization of the stomach is completed by freeing the pyloric antrum enabling tension-free consecutive displacement of the gastric conduit from the pylorus up to the right crus of the diaphragm [Figure 28].

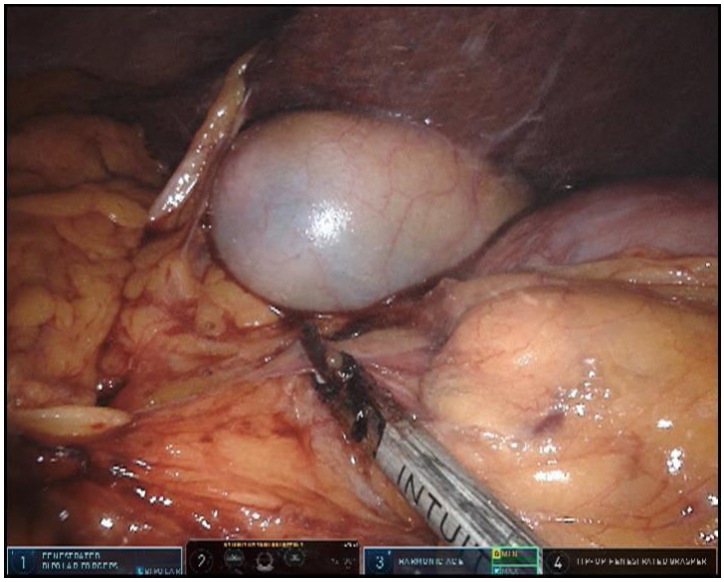


Figure 28: Release of the pyloric antrum

- If a Kocher maneuver is indicated or preferred incise the parietal peritoneum and mobilize the duodenum medially as faras possible. This allows for an additional 1–2 cm of length for the gastric conduit in case a cervical anastomosis in the neck is required later in the case.

6ac. Stomach tube construction

Da Vinci Instrumentation (Si/Xi/X):

- Endoscope 30° down
- *EndoWrist®* Stapler 45 or *EndoWrist®* 60 (Sureform™) (left)
- Fenestrated Bipolar Forceps (main right)
  - ➢ might be temporarily exchanged with Large Needle Driver or Large *SutureCut* Needle Driver
- Cadiere Forceps or Tip-Up Fenestrated Grasper [Xi/X only] (secondary right)

- The assistant retracts the gastric fundus towards the left upper quadrant with a laparoscopic grasper.
- The EndoWrist Stapler 45 or EndoWrist Stapler 60 (Sureform™) is introduced on the left arm and starting at the pyloric antrum astomach tube on the site of the greater curvature (5 cm diameter) is formed. Alternatively this can be done with a laparoscopic linear stapler introduced through a 12 mm assistant port [Figure 29].

TIP: To approximate the diameter of the gastric tube either the Cadiere Forceps (grasping tip length 30 mm) or the Tip-Up Fenestrated Grasper (grasping tip length 60 mm) can be held up against the gastric conduit.

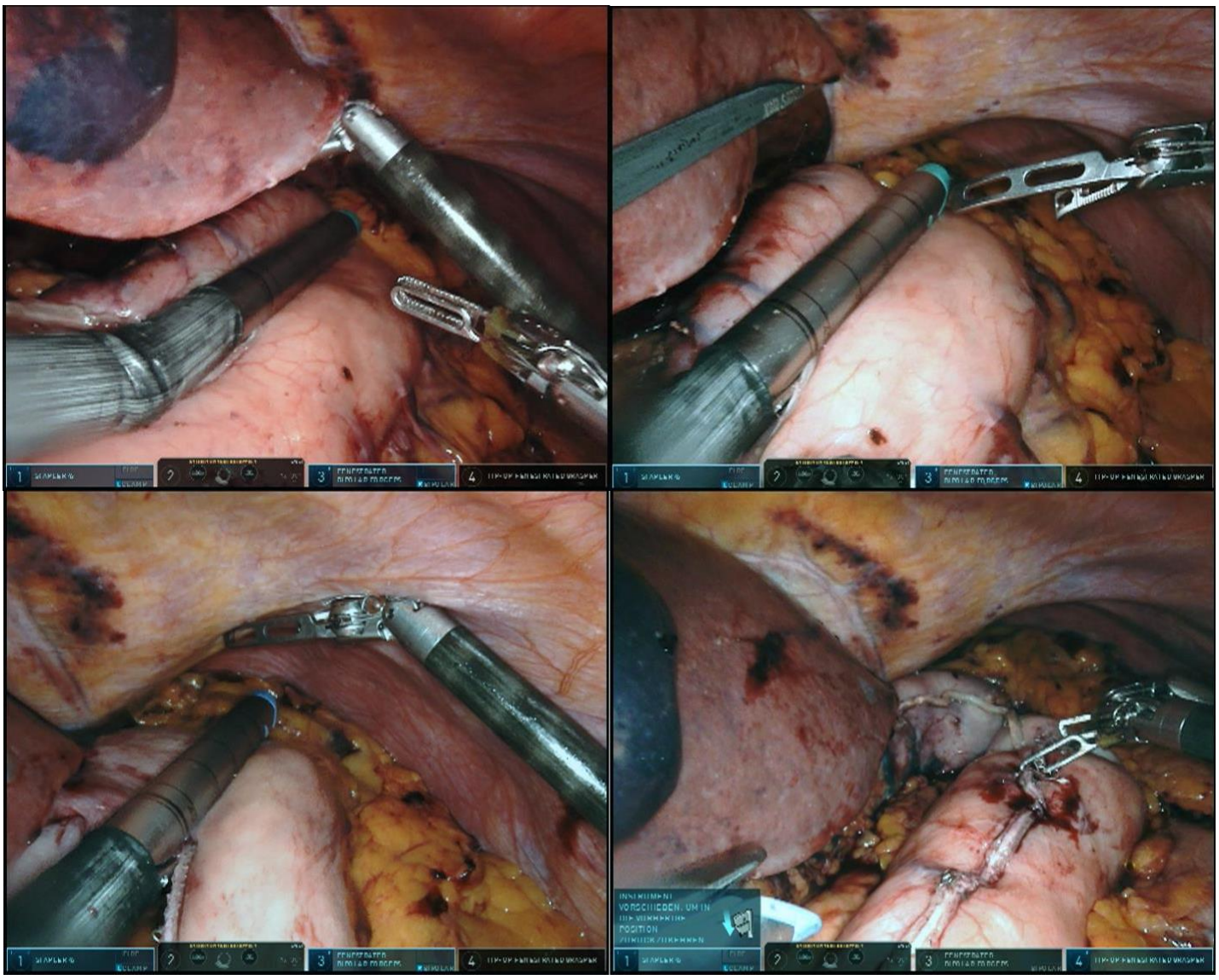


Figure 29: Creation of the stomach tube with the EndoWrist Stapler 45 or Sureform™ 60

- The stomach is carefully elongated with the EndoWrist instruments: Cadiere Forceps or Tip-Up Fenestrated Grasper on the secondary right hand lifts and stretches the fundus while the Fenestrated Bipolar Forceps (main right hand) puts gently tension on the developing gastric tube.
- For an esophagogastrostomy with the circular stapler the stomach tube is only partially created in the abdominal cavity. For this the stomach is stapled only 3 – 4 times to create the initial part of the tube with a remnant stomach left to introduce the circular stapler subsequently (see section ***6ca. Circular Stapler Anastomosis***) [Figure 30].

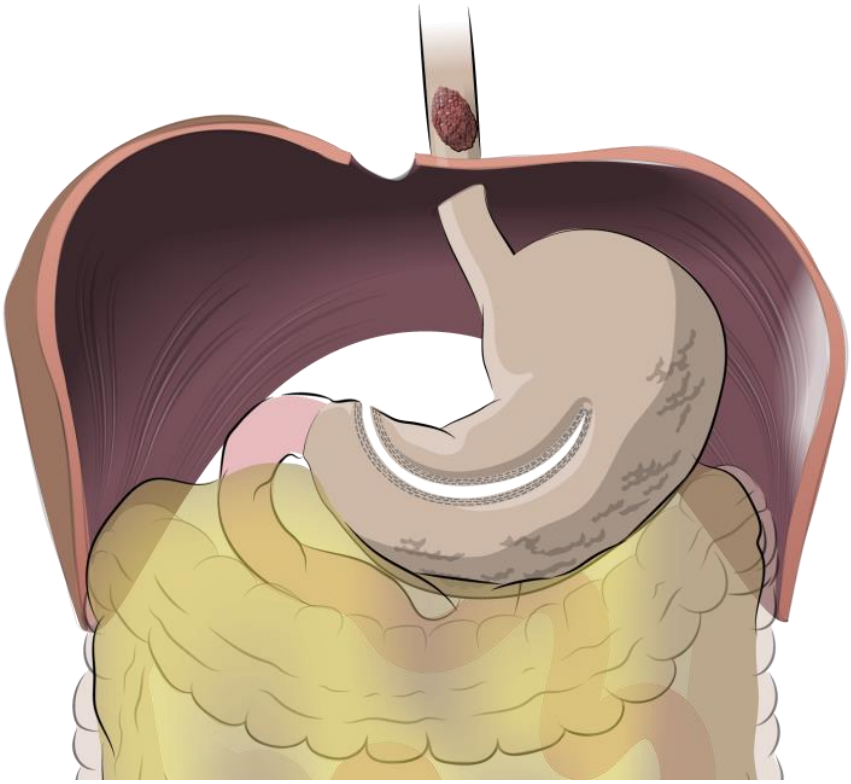


Figure 30: Creation of the stomach remnant and initial tube for esophagogastrostomy with a circular stapler

- For a hand-sewn or hybrid technique (Linear Stapler dorsal and Hand-Sewn ventral [side-to-side]) esophagogastrostomy the stomach tube is completed with the stapler in the abdomen.
- Sections where the stapler reloads overlap at gastric tube might be reinforced with a suture line.
- Transect the conduit and the specimen at the fundus with a final staple line. Stomach tube and specimen are re-approximated with a Vicryl suture (Large Needle Driver now in right hand). The distal end of an Easy-Flow drain is also fixated within the same suture line [Figure 31]. It will be pulled up into the chest with the conduit for consecutive drainage at the esophagogastrostomy and passed through the most lateral da Vinci port on the left patient side.

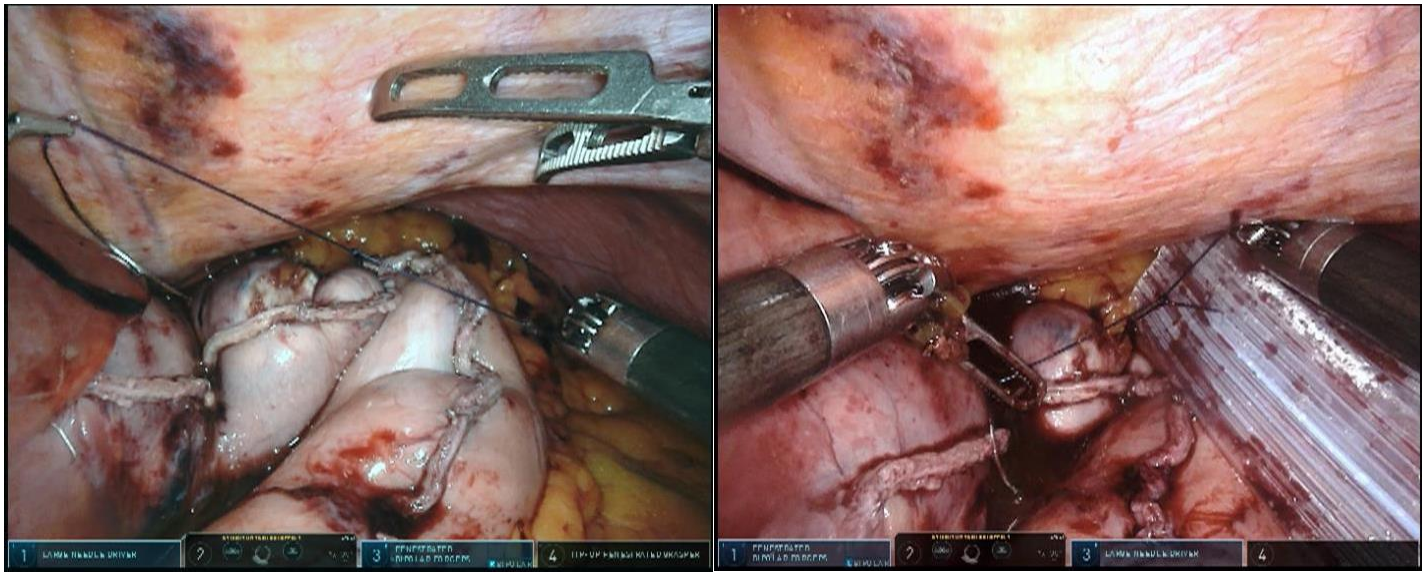


Figure 31: Re-approximation of conduit and specimen with fixation of an Easy Flow drain for consecutive drainage

- The end of the first stapling line at the lesser curvature is tagged with a Vicryl stay suture as a marker. This "marker" helps avoid damage to the conduit and enables estimation of the stomach tube length after gastric pull-up into the chest [Figure 32].

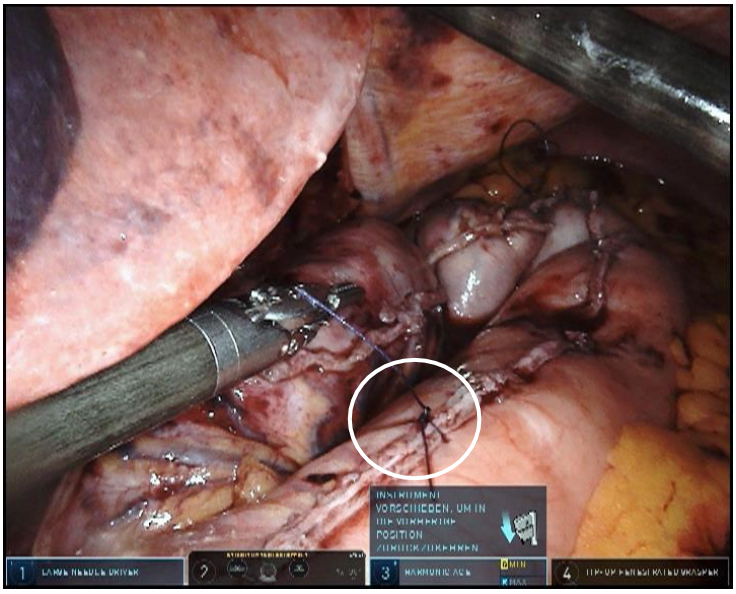


Figure 32: "Marker" stitch (circle) at first staple line

6ad. Pyloroplasty (if indicated)

Da Vinci Instrumentation (Si/Xi/X):

- Endoscope 30° down
- Cadiere Forceps (left)
- Large Needle Driver (main right)
  - temporarily exchanged with Monopolar Curved Scissors
- Fenestrated Bipolar Forceps, Cardiere Forceps or Tip-Up Fenestrated Grasper [Xi/X only] (secondary right)

- Retract pylorus to the left side to visualize the anatomy.
- Open pylorus longitudinally and extend incision into the distal pylorus and the proximal duodenum with the Monopolar Curved Scissors. Stay suture might be placed to aid in retraction [Figure 33a-b].
- Close the incision transversely with the Large Needle Driver and a single layer of 3–0 silk sutures [Figure 33c].

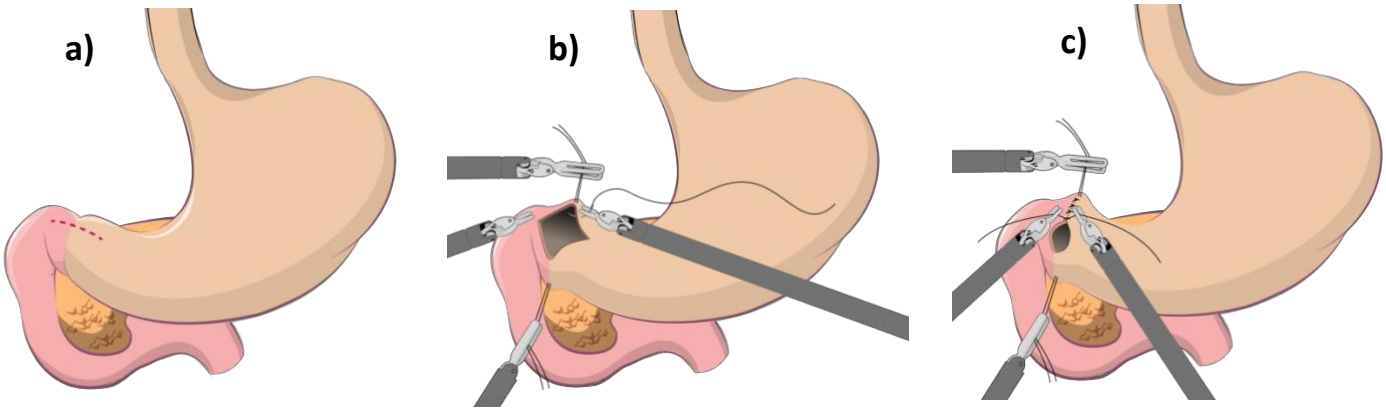


Figure 33: Pyloroplasty

6ae. Feeding Jejunostomy (if indicated)

Da Vinci Instrumentation (Si/Xi/X):

- Endoscope 30° down (initially)
- Fenestrated Bipolar Forceps (left)
- Large Needle Driver (main right)
- Cadiere Forceps (secondary right)

NOTE: For the utilized suture material please refer to the package insert for complete instructions, contraindications, warnings and precautions.

- The transverse colon is displaced and the first jejunal loop identified at the ligament of Treitz [Figure 34].

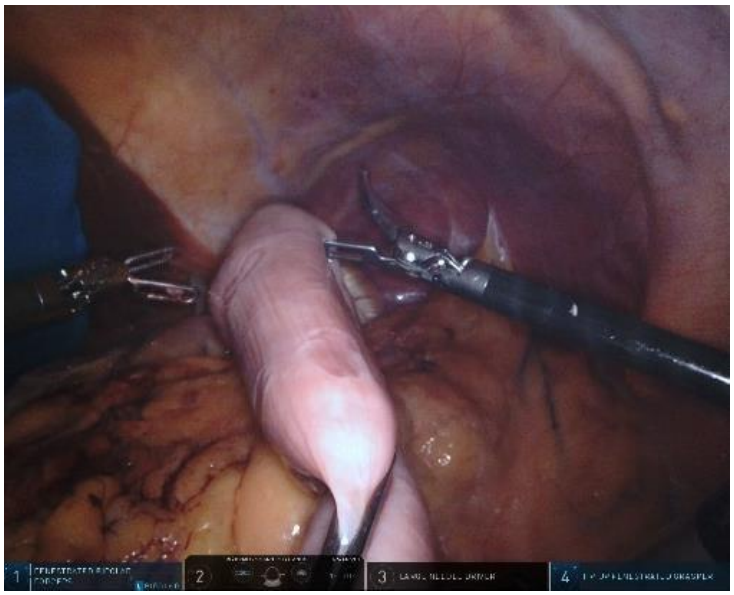


Figure 34: Identification of the first jejunal loop

- Endoscope is rotated to 30° up allowing visualization of the ventral abdominal wall. The location for the feeding catheter is a few centimeters caudal to the left subcostal margin on the mid-clavicular line. A wire guide introducer needle is introduced to guide construction of the feeding jejunostomy [Figure 35].

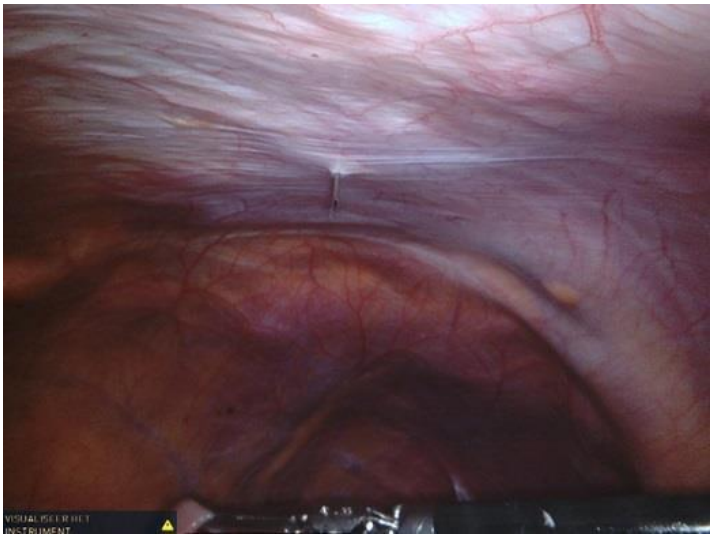


Figure 35: Placement of introducer needle to mark feeding catheter location

- The jejunum is presented to the needle insertion point to check for appropriate reach to the abdominal wall without great tension [Figure 36].

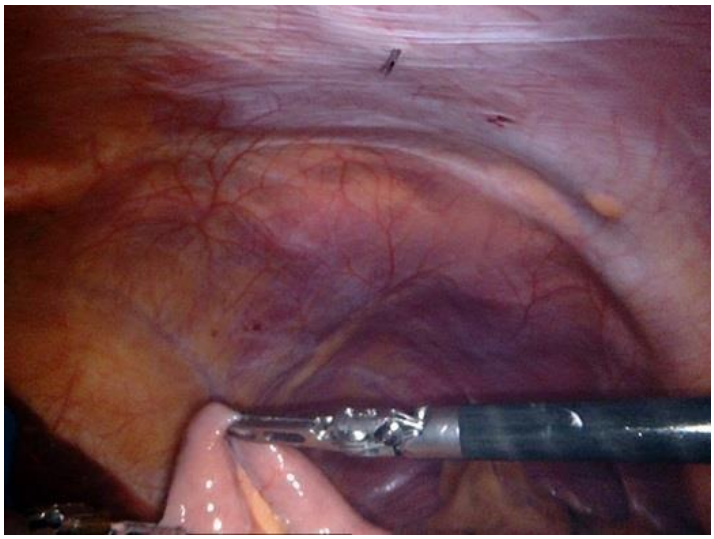


Figure 36: Checking for tension free reach of the jejunum

- The Endoscope is rotated back to 30° down. A purse-string suture is constructed with a V-LOC™ 180 (3-0, 23 cm, V-30 needle) suture to secure the jejunum to the abdominal wall for the feeding catheter. The first stitch is seromuscular on the jejunum, then placed through the parietal peritoneum and "looped" through the V-Loc eyelet for subsequent locking [Figure 37].

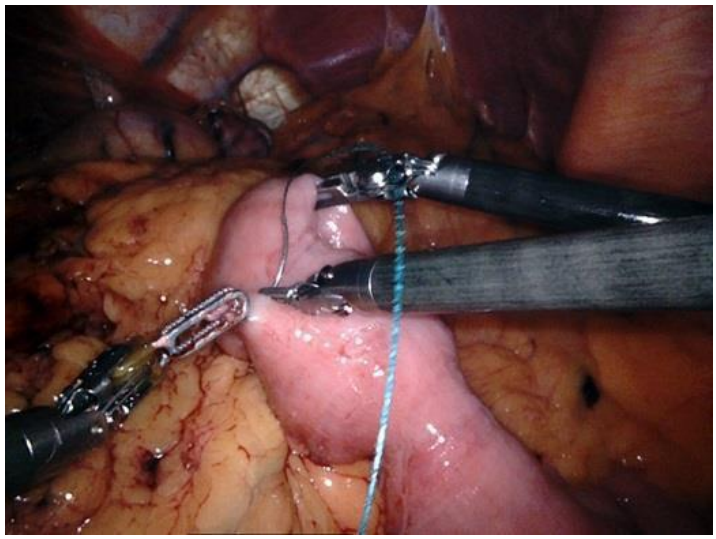


Figure 37: Start of the purse-string suture line

- For the remainder of the suturing tasks the endoscope is rotated to 30° up. Second stitch is into the parietal peritoneum about 1 cm cranial from the needle insertion point, starting at about the 10 o'clock location [Figure 38].

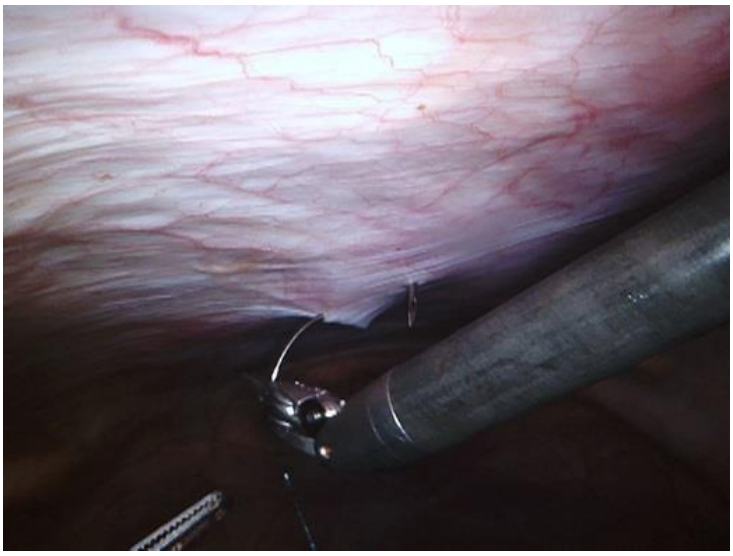


Figure 38: Second stitch of the purse-string suture line at the parietal peritoneum

- Subsequent needle throws are alternated between the jejunum and peritoneum constructing the purse-string line cranially. Stitches should be approximately 5 mm apart [Figure 39].

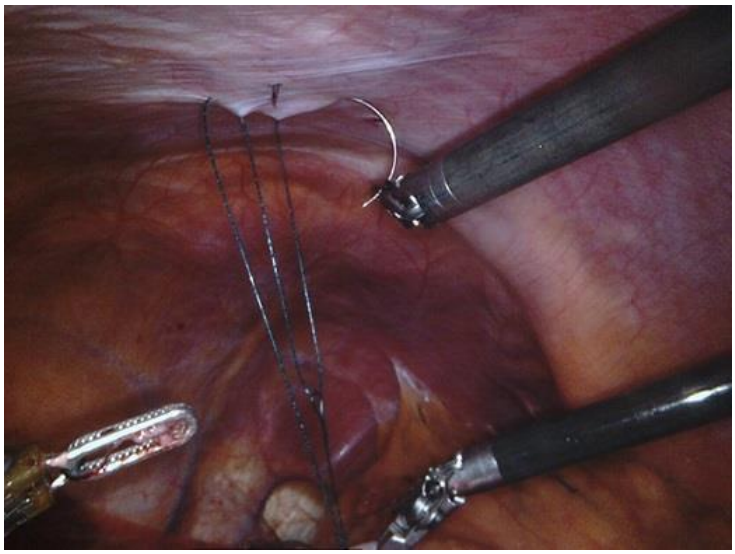


Figure 39: Subsequent needle throws to continue purse-string line

- Next the jejunum is approximated to the abdominal wall by pulling the loose sutures slightly snug for the completion on the caudal side [Figure 40].

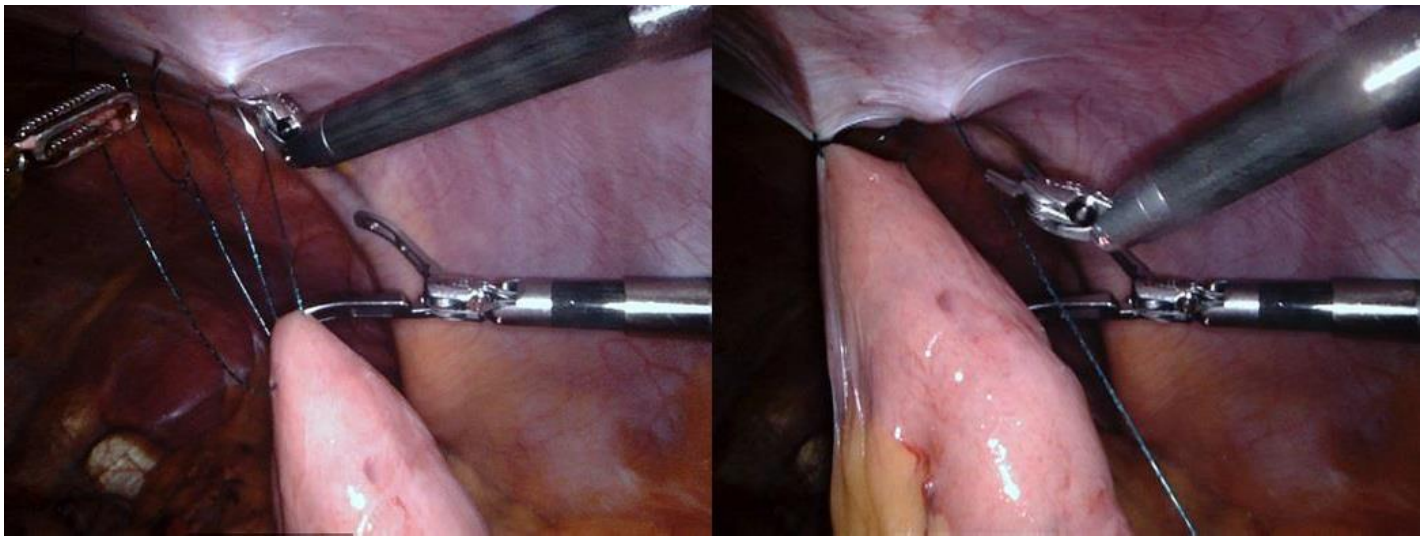


Figure 40: Approximation of the jejunum to the abdominal wall

- Now the remaining caudal stitches are placed circularly around the needle insertion point at a distance of ~ 1 cm in a clockwise direction [Figure 41].

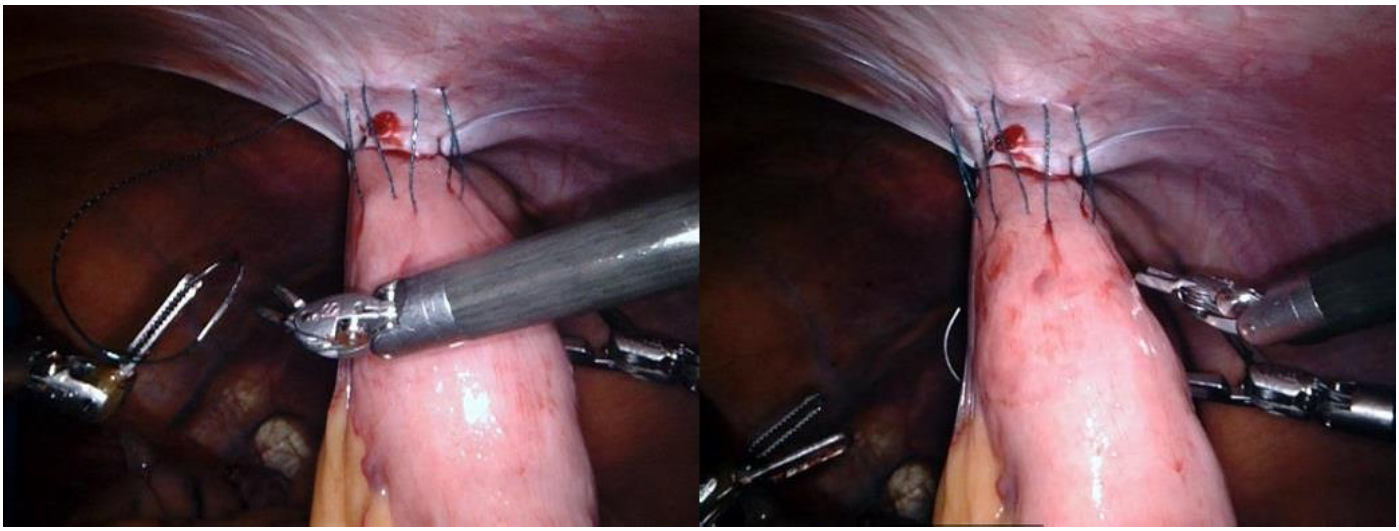


Figure 41: Continuation of constructing the purse-string suture line

- Following the wire guide needle is switched out for the catheter introducer needle. The jejunum is penetrated with the catheter introducer needle which is left in place until the jejunostomy catheter is placed [Figure 42].

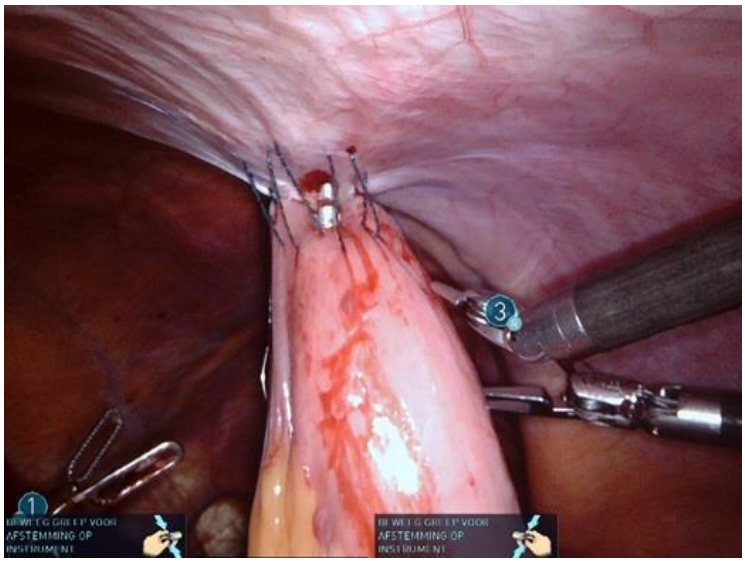


Figure 42: Placement of the feeding catheter introducer needle

- After catheter placement the limb distal from the jejunostomy is clamped off and saline injected through the catheter into the jejunum to asses for correct placement [Figure 43].

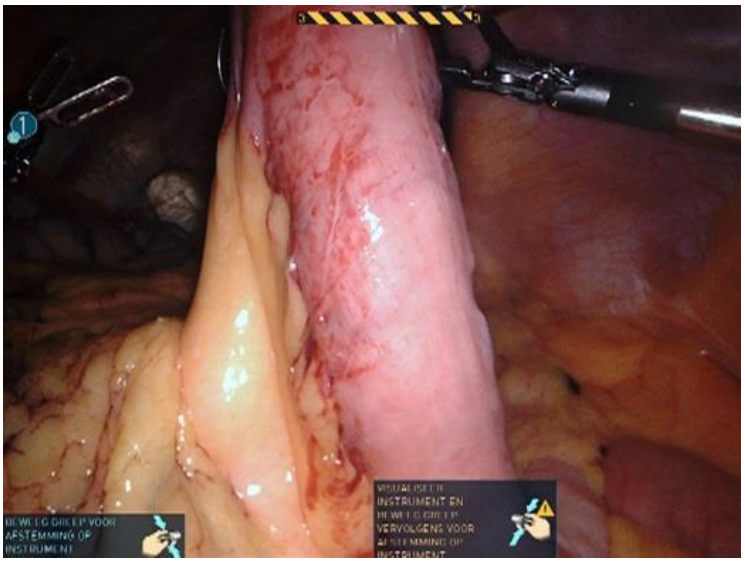


Figure 43: Saline injection to the distal limb to check for correct placement of feeding catheter

- After confirmation of proper catheter placement the jejunum is secured tightly to the abdominal wall by pulling the purse-string suture line snug with the self-locking V-Loc [Figure 44].

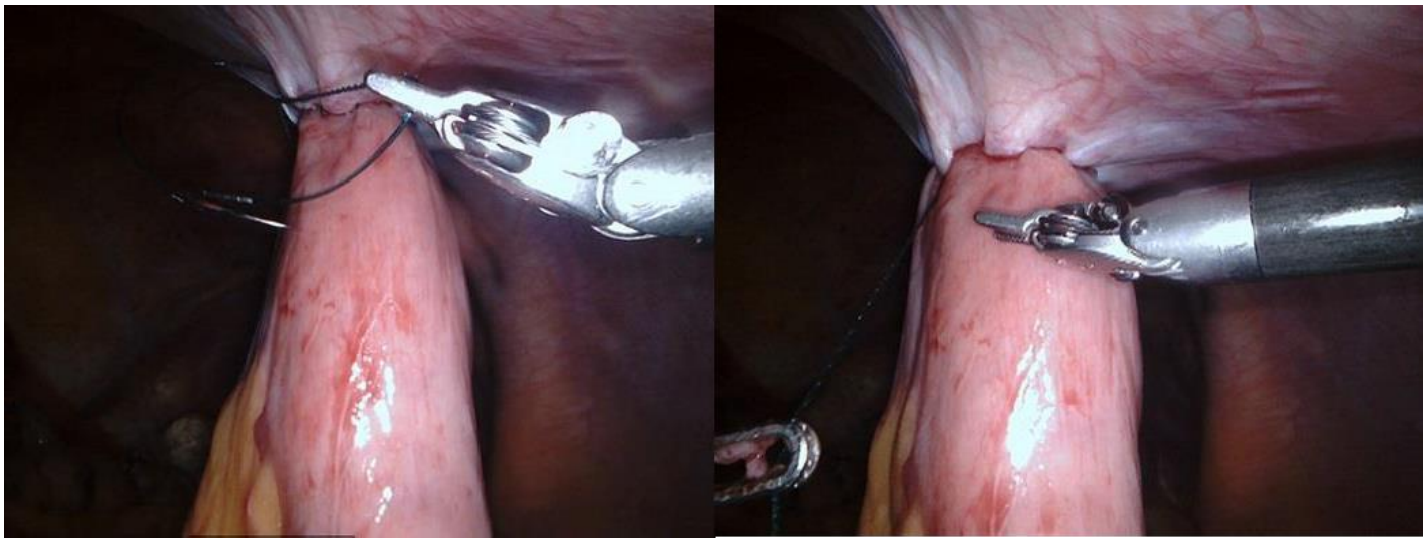


Figure 44: Completion of feeding jejunostomy by pulling the purse-string suture line snug with the self-locking V-Loc

- Close abdomen and turn patient to supine position for the thoracic part.

6b. Thoracic Phase

6ba. En-bloc esophageal mobilization

Da Vinci Instrumentation (Si/Xi/X):

- Endoscope 30° down
- Fenestrated Bipolar Forceps (left)
- Monopolar Curved Scissors (main right)
  - ➢ might be temporarily exchanged with Harmonic ACE, *EndoWrist®* Vessel Sealer, Large or Medium-Large Clip Applier
- Cadiere Forceps (secondary right)

- Incise the parietal pleura immediately below the azygos vein, which is exposed from the diaphragm to the azygos arch and toward the apex of the chest [Figure 45].

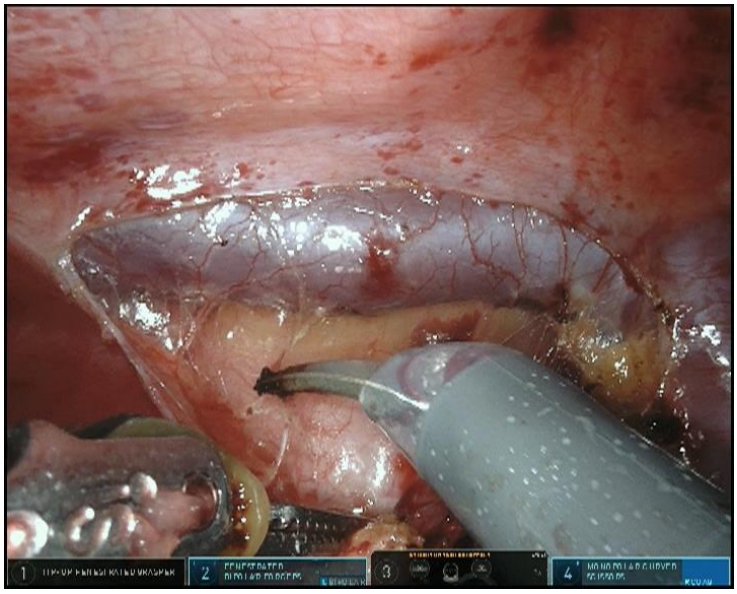


Figure 45: Dissection of the azygos vein

- Ligate azygos vein at its origin on the vena cava with two Hem-o-lok clips (Large or Medium-Large) and/or Vessel Sealer [Figure 46]

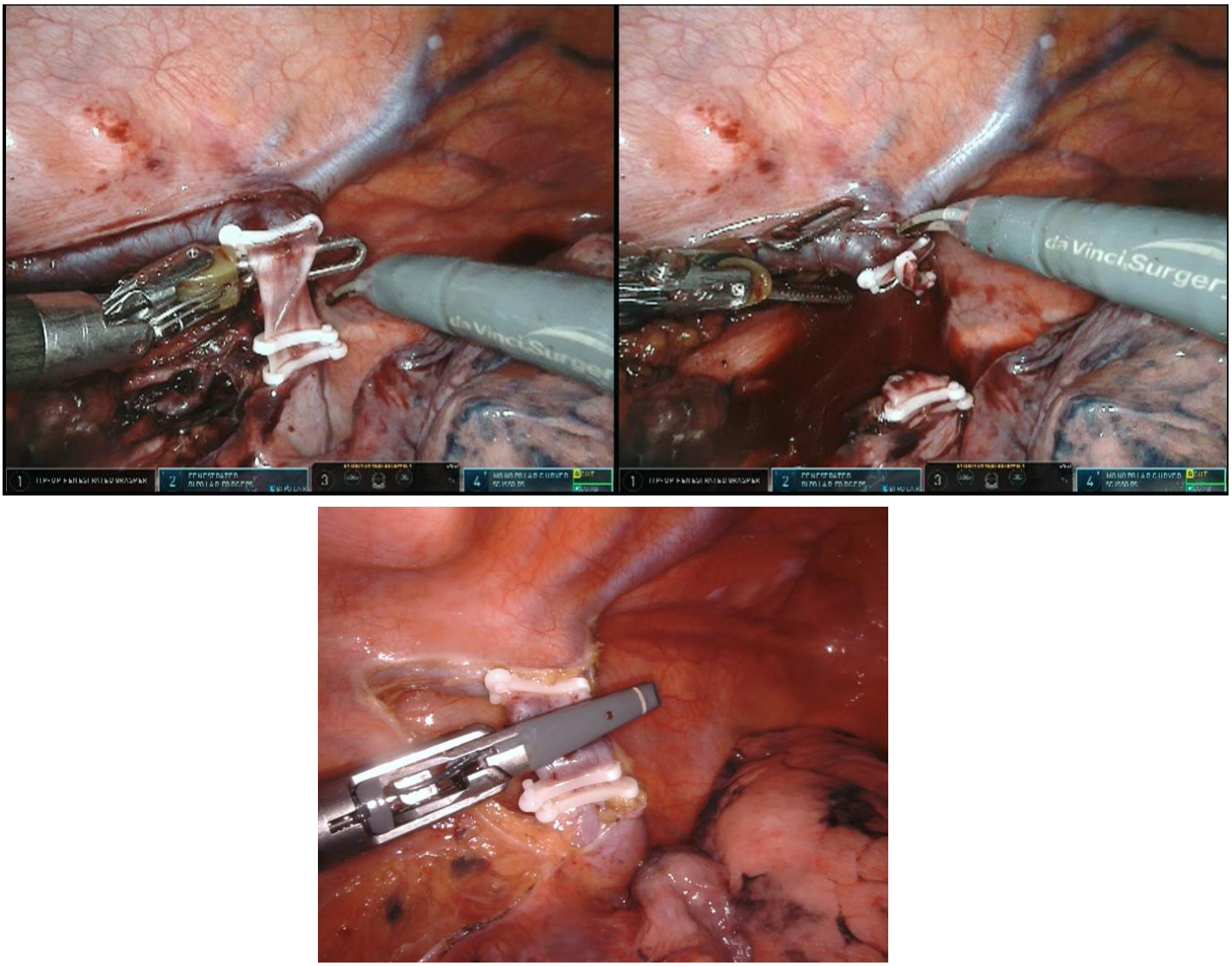


Figure 46: Ligation and transection of the azygos vein

- Take care to avoid injuring the thoracic duct during the posterior esophageal mobilization. If a thoracic duct injury is suspected then the duct should be ligated at the level of the hiatus with a Hem-o-Lok® clip [Figure 47].

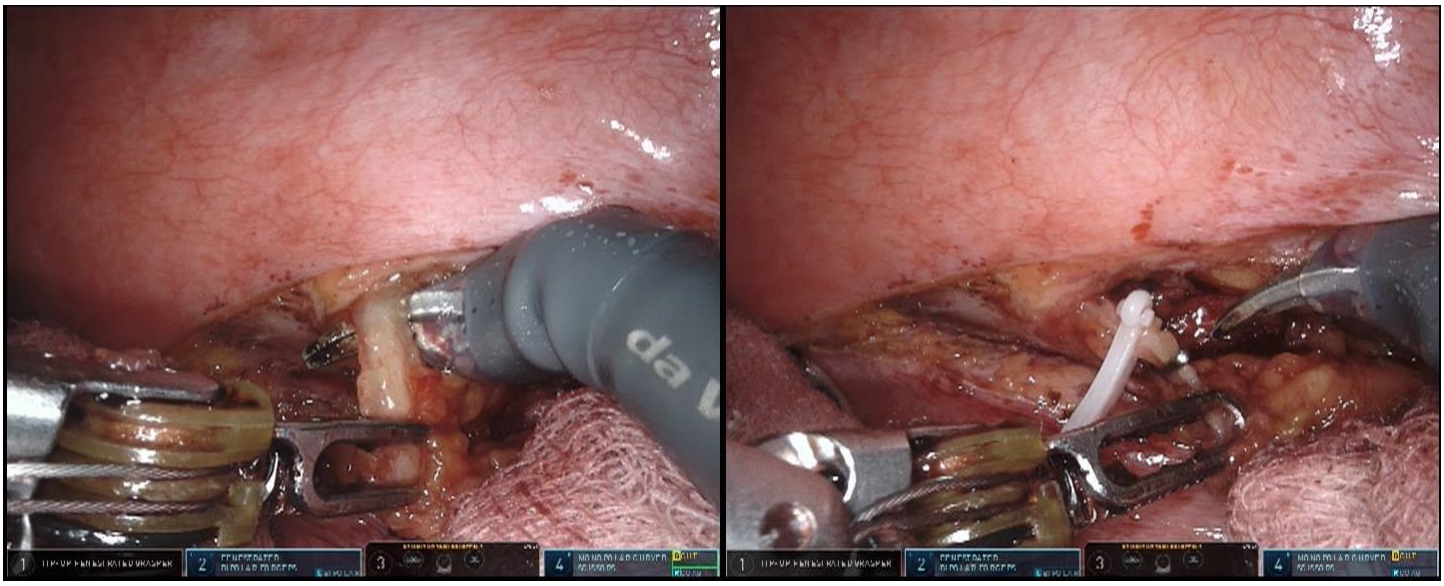


Figure 47: Ligation and transection of the thoracic duct

- Once esophagus is encircled retract esophagus anteriorly and cephalad with the 3rd da Vinci instrument arm
- Resect esophagus en-bloc with the peri-esophageal and infracarinal lymph tissue to the preparation level of the esophagus in the abdominal phase [Figure 48]:
    - Dissection removes all tissues superiorly along the pericardium from the level of the hiatus and inferior vena cava to the carina, lower trachea and right main bronchus, posteriorly along the length of the thoracic aorta, and laterally along the pleural surfaces.
    - Remove all subcarinal lymph nodes en bloc with the esophagus.
    - The dissection plane is defined by the adventitia of the aorta, mediastinal pleura with view of the ventilated left lung and the pericardium.
    - Mobilization of the esophagus in cranial direction is dependent on the tumor location and usually stops at the level of the azygos arch. Expose the esophagus to approximately 5 cm above the azygous vein.
    - upper mediastinal dissection is carried out above right and left upper laryngeal nerves on top of right subclavian artery to the level of cervical lymph nodes

NOTE: The extent of the esophageal mobilization cranially is depending on the location of the tumor, but usually stopped approximately at the arch of the azygos vein.

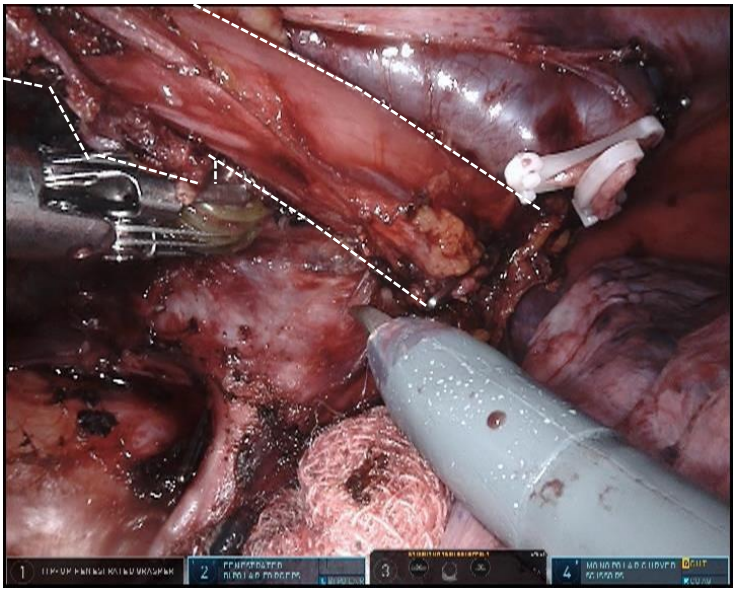


Figure 48: En-bloc resection of the esophagus (white outline) with peri-esophageal and infracarinal lymph tissue attached

- Next withdraw the stomach tube and transect the esophagus with the EndoWrist Stapler 30 or EndoWrist Stapler 45 or EndoWrist Stapler 60 (Sureform™) slightly above the level of the azygous vein [Figure 49]. ICG can be used to check transection line.

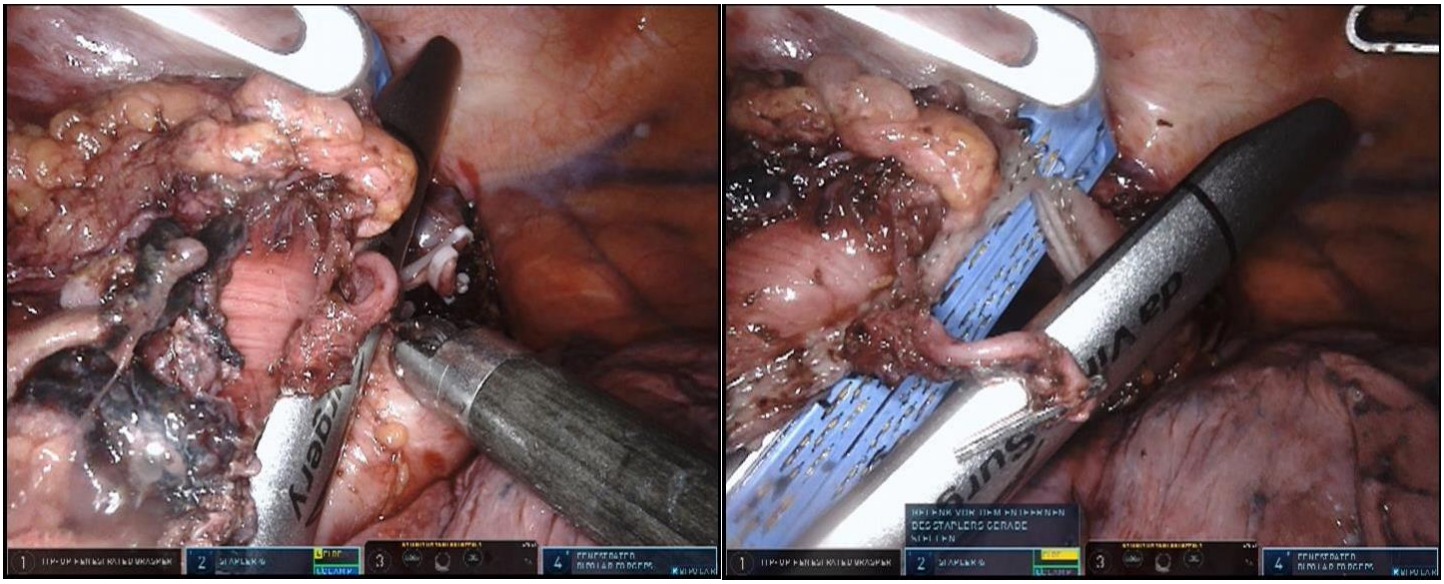


Figure 49: Transection of the esophagus at the level of the azygos vein

6bb. Stomach pull-up

Da Vinci Instrumentation (Si/Xi/X):

- Endoscope 30° down
- Fenestrated Bipolar Forceps (left)
- Cadiere Forceps or Tip-Up Fenestrated Grasper [Xi/X only] (main right)
  - ➢ might be temporarily exchanged with Monopolar Curved Scissors
- Cadiere Forceps (secondary right)

NOTE: This maneuver should be done with extreme caution due to the risk of damaging the fragile gastric tube. The patient side assistant should support the pull-up with laparoscopic graspers. Pay special attention not to twist it by keeping the lesser curvature toward the lateral chest wall.

For an esophagogastrostomy with the circular stapler the stomach tube is pulled up into the thoracic cavity as follows:

- Paying attention to keep the correct orientation of the mobilized conduit with the gastroepiploic arcade dorsally [Figure 50]

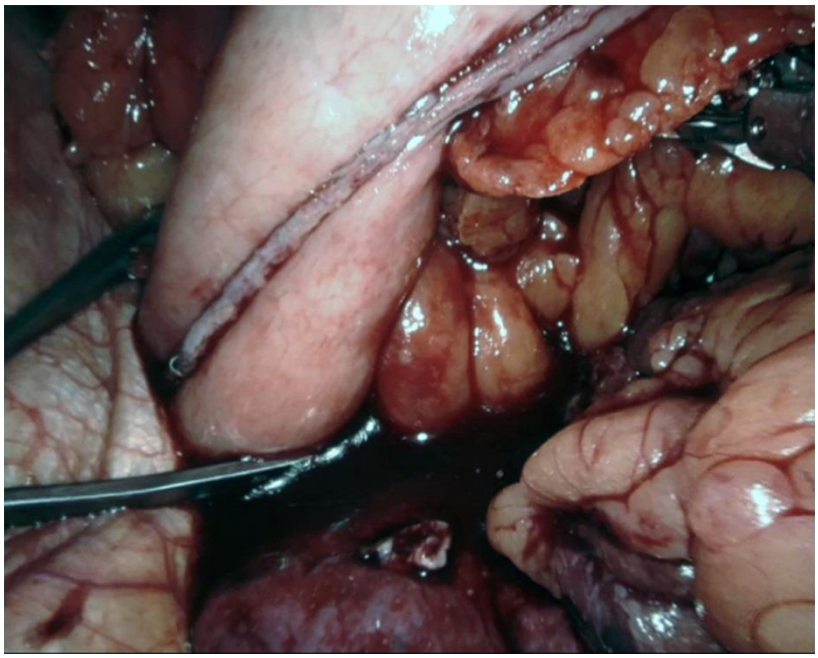


Figure 50: Stomach pull up with gastroepiploic arcade oriented dorsally

- Grasp the conduit carefully without compromising or traumatizing the right gastroepiploic arcade supplying the conduit
- Pull until the area of the unfinished gastric tube at the remnant stomach is comfortably located in the middle of the right thorax [Figure 51].

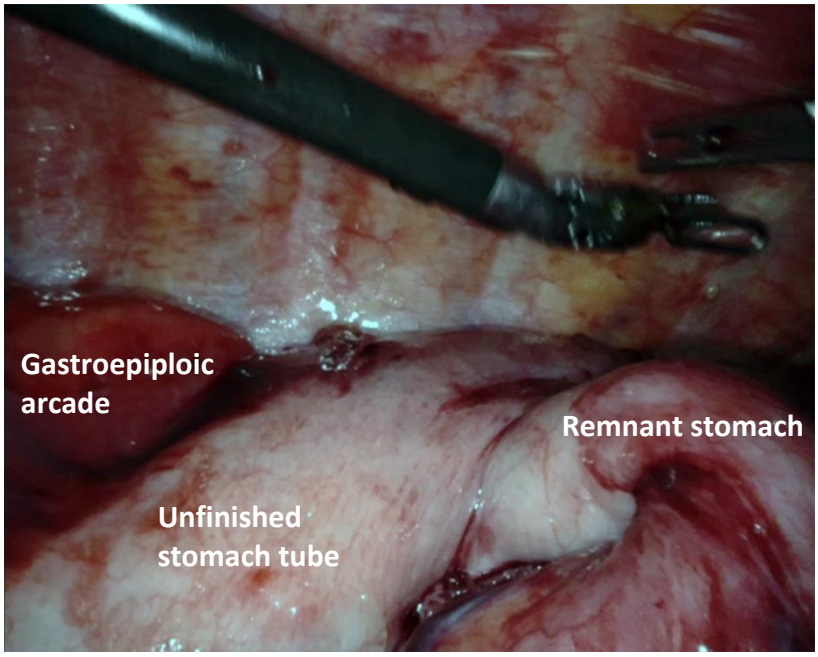


Figure 51: Stomach pulled up into the right thorax in correct orientation

For a hand-sewn or hybrid technique (Linear Stapler dorsal and Hand-Sewn ventral [side-to-side]) esophagogastrostomy the stomach tube is pulled up as follows:

- Pull the stomach tube into the thorax through the extended hiatus up to the Vicryl "marker" stitch at the end of the 1st staple line, which ensures that the maximum available length of the stomach tube is utilized [Figure 52].

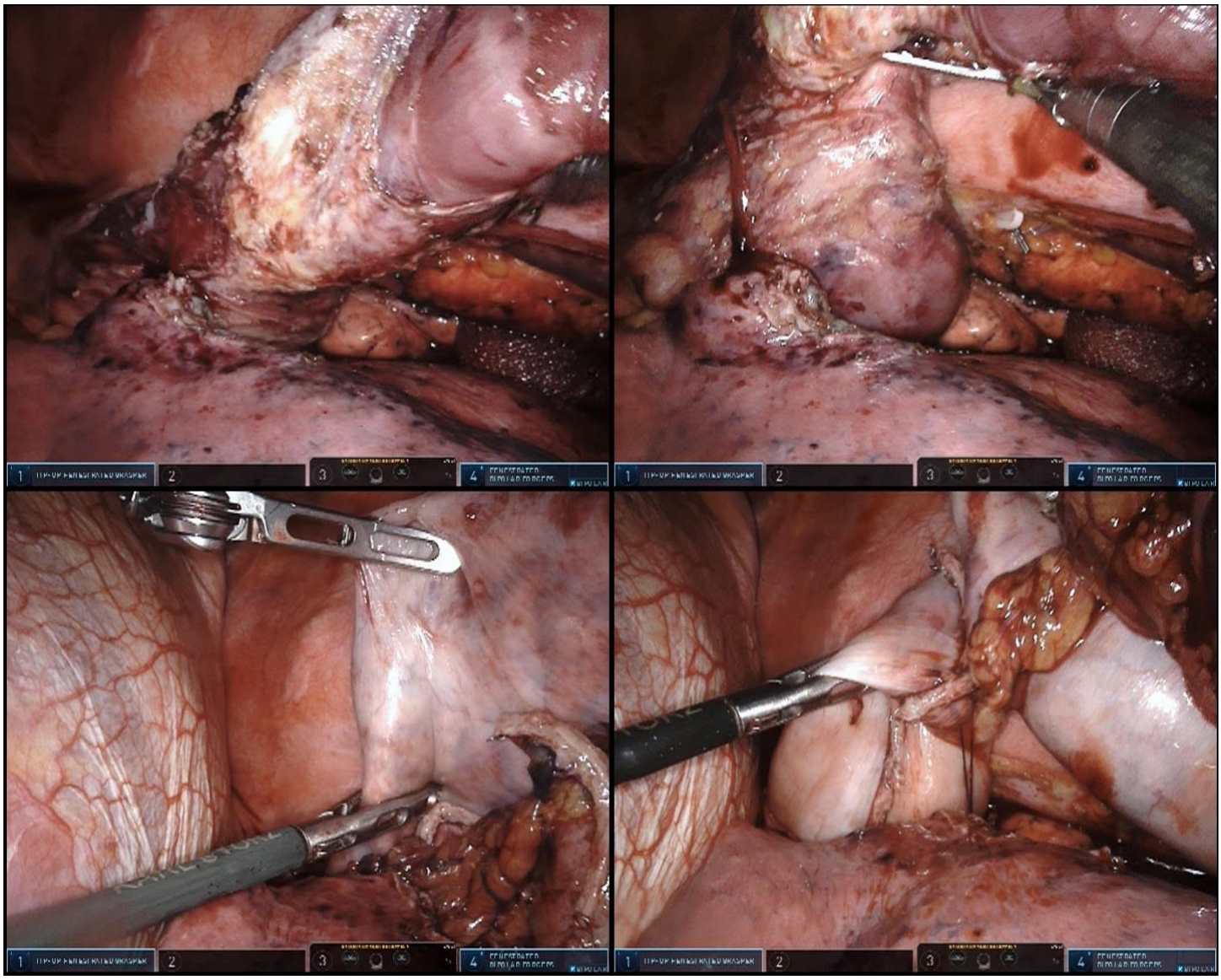


Figure 52: Pull up of the stomach into the thoracic cavity

- Cut the holding stitch between the stomach tube/drain and the specimen [Figure 53].

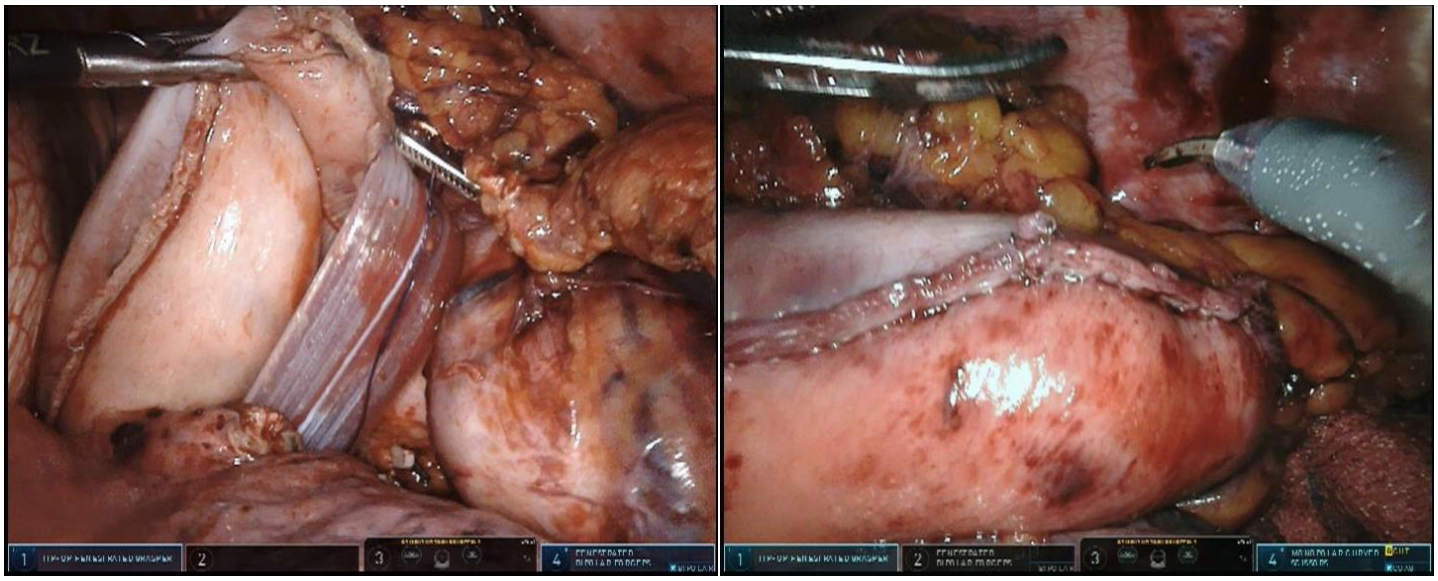


Figure 53: Release of the holding stitch at the drain (left) and conduit placed for reconstruction (right)

- Place specimen in tissue retrieval bag.
- Create a small thoracotomy at the assistant port side (Alexis®- wound retractor) and deliver specimen.
- Send for histopathologic frozen section.
- After specimen removal, reestablish carbon dioxide insufflation by closing the Alexis wound retractor with the appropriately sized cap.

6c. Reconstruction – Anastomosis

Different techniques can be utilized for the intra-thoracic esophagogastrostomy during the Ivor-Lewis procedure. We describe the following techniques to construct the anastomosis:

- Stapled anastomosis with circular stapler (side-to-end)
- Hand-Sewn with EndoWrist Instrumentation (two layer end-to-end)
- Hybrid Technique (Linear Stapler dorsal and Hand-Sewn ventral [side-to-side])

6ca. Circular stapled anastomosis

Da Vinci Instrumentation (Si/Xi/X):

- Endoscope 30°
- Large Needle Driver and ProGrasp™ Forceps (for circular stapler anvil grasping only) (right)
- Cadiere Forceps (secondary right)
- Cadiere Forceps or 5 mm Schertel Grasper/ EndoWrist Stapler 45 or 60 (Sureform™) [Si only] (main left)

NOTE: For the placement of the circular stapler anvil the endoscope is moved to the port location ② caudally to facilitate a better view into the esophageal lumen for manipulation. The surgeon now works with two right hands in ports ③ & ④.

- The circular stapler anvil (29 mm Curved Intraluminal EES Circular Stapler, Model CDH29A, long black handle, Ethicon EndoSurgery) is inserted transthoracic through the Alexis wound retractor into the esophageal stump with the ProGrasp™ Forceps. The bougie should be moved forward and then backward to guide the insertion [Figure 54A].
- Once placed the anvil is secured with a purse-string suture constructed of a Stratafix™ Spiral® PDS 3-0, SH needle, 15 cm length [Figure 54B].

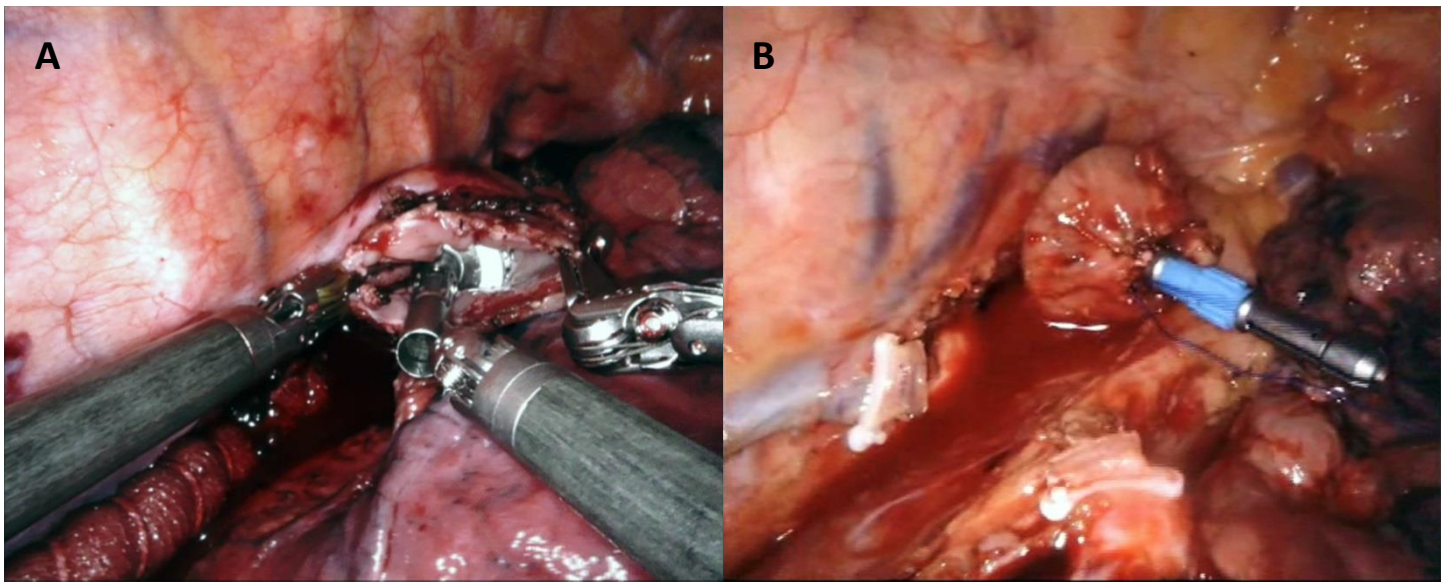


Figure 54: A) Placement of the circular stapler anvil in the esophageal stump. B) Secured anvil after purse-string suture.

- The intact minor gastric curvature of the transected specimen is brought out of the chest through the mini-thoracotomy.

NOTE: Now the endoscope is moved back to the port location ③ as in the initial setting to allow an optimal view onto the circular stapler thorn during its extension into the conduit wall. The left arm in port ① might be removed during this step to facilitate visualization and manipulation.

- To insert the circular stapler handle the stomach conduit is opened by incising the stapler line previously created at the antrum in the minor curvature [Figure 55].

NOTE: The incision is made in the distal third of the antrum to introduce the stapler handle as far away from the gastro-esophageal crossing and allow a large distance to the potential tumor.

- The best position for the anastomosis near the greater curvature of the conduit is chosen by the surgeon and the stapler thorn extended through the conduit wall.

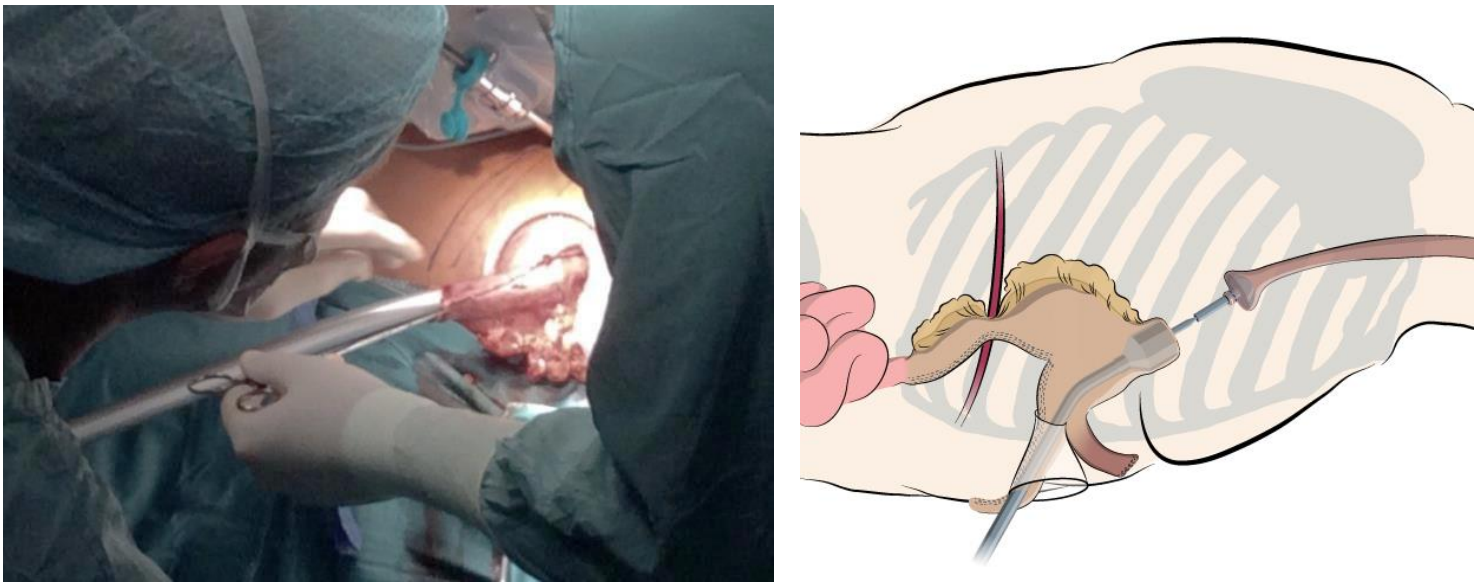


Figure 55: Insertion of the circular stapler handle and positioning in the conduit

- If desired, the perfusion of the gastric conduit can be checked again for confirmation with Indocyanine Green (ICG) utilizing the FireFly technology of the da Vinci system [Figure 56].

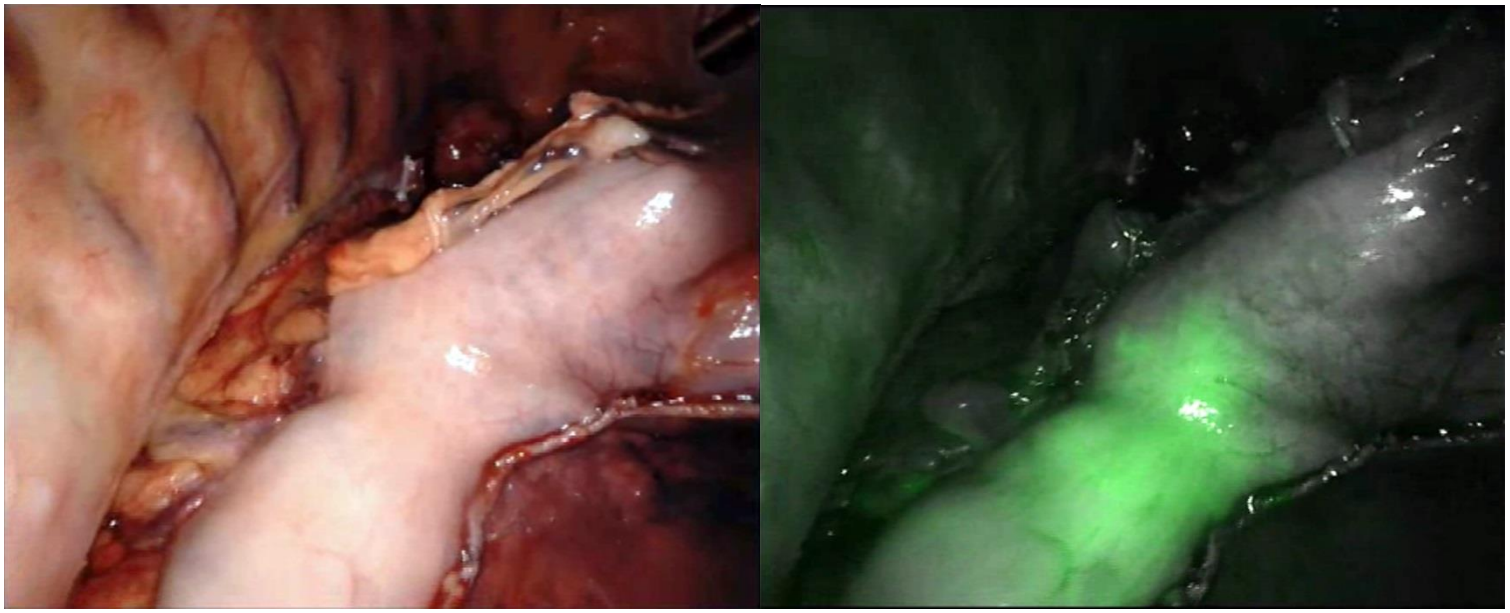


Figure 56: Confirmation of conduit perfusion for optimal placement of the stapler head and anastomosis with ICG

- The gastric conduit is then straightened by the assistant and stapled to the esophageal stump.
- Next a gastric tube is inserted past the anastomosis into the gastric conduit to prevent narrowing of the proximal conduit during the subsequent specimen transection.
- The remaining gastric part with the esophageal specimen attached is transected with the EndoWrist stapler in arm ① (aux left) [Figure 57] and removed through the mini-thoracotomy [Figure 58].

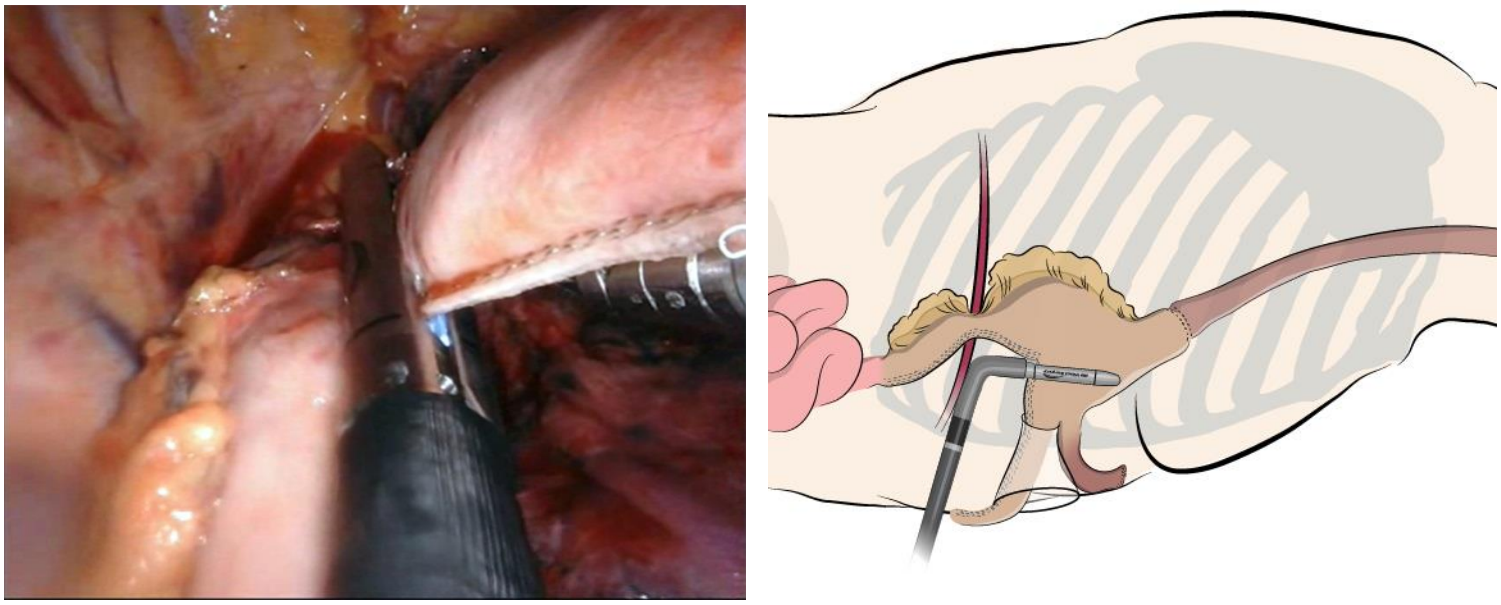


Figure 57: Transection of the esophageal specimen with the EndoWrist Stapler

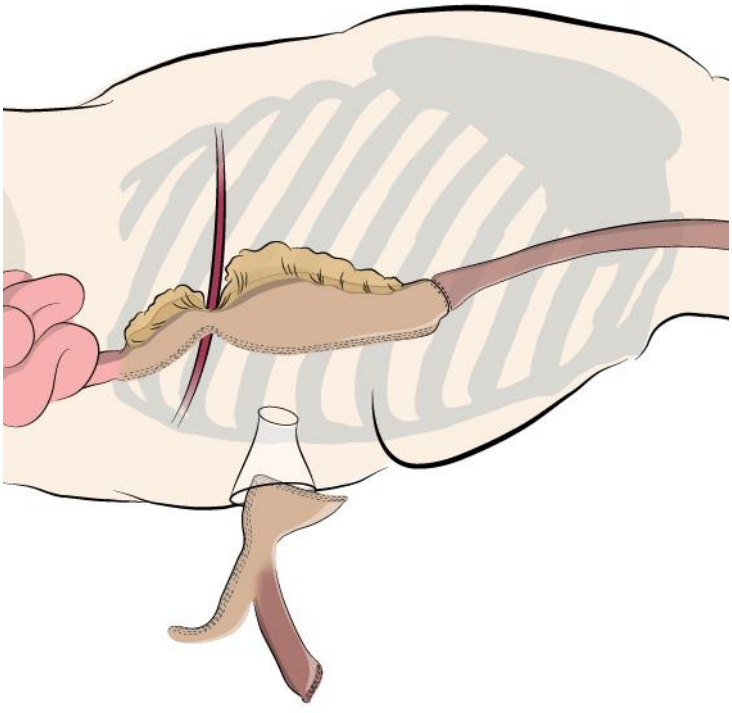


Figure 58: Removal of the resected specimen through the thoracotomy incision

- If desired the circular anastomosis can be secured with either single stitches or a running suture, and pulling in small piece of omentum for protection. This enables fixation of the gastric tube and

reinforcement of the anastomosis.

6cb. Hand-Sewn: Intrathoracic Esophagogastrostomy (two layer end-to-end)

Da Vinci Instrumentation (Si/Xi/X):

- Endoscope 30°
- Large Needle Driver (right)
- Cadiere Forceps (main left)
- Cadiere Forceps or 5 mm Schertel Grasper [Si only] (aux left)

NOTE: For the utilized suture material please refer to the package insert for complete instructions, contraindications, warnings and precautions.

- Check length and perfusion of the gastric conduit with Indocyanine Green (ICG) utilizing the FireFly technology of the da Vinci system [Figure 59].

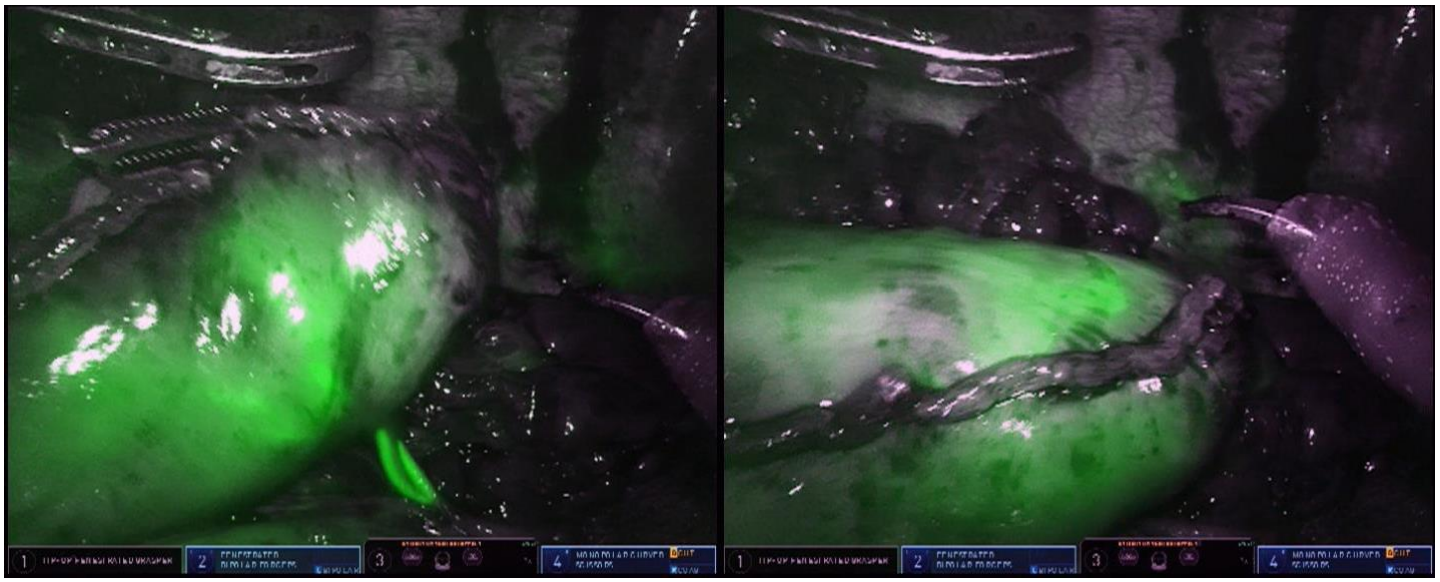


Figure 59: FireFly showing well perfused gastric conduit prior to anastomosis

- If a perfusion deficiency is identified adapt the location of the anastomosis and resect stomach further if necessary. Minimize arterial ischemia by maximizing the distance to the staple lines.

- Position conduit above the divided azygos vein and under the divided esophagus [Figure 60-1].

- The first layer of the posterior back wall is a running approximation suture from dorsal to ventral placing 4 to 6 stitches with a Stratafix Spiral® 4-0 (Ethicon Endosurgery, Sommerville NJ, USA). This fixates the gastric tube and minimizes tension during the reconstruction [Figure 60-2, Figure 61-1].

- The esophageal stump and gastric conduit are opened ventrally to the stapler lines with scissors. The staple lines are left in place and incorporated into the posterior suture line. The incision lengths are approximated to avoid mismatch on the completed anastomosis [Figure 60-3].

- Next the lumen of the esophagus is held up with a Cadiere Forceps by the da Vinci, while the assistant exposes the gastric tube in order to minimize the tension on the tissue [Figure 60-4, Figure 61-2]. The second layer of the back wall is created by a running Stratafix Spiral® 3-0 (SH) suture

placed transmural. The suture is started dorsally (9 o'clock position) and continued to ventrally (3 o'clock) via the 6 o'clock position with the needle inside-out on the esophagus and outside-in on the gastric conduit. The knot is placed extraluminally.

- After completion of the posterior back-wall suture line a feeding or nasogastric tube is advanced under direct vision in order to secure a sufficient lumen of the esophagogastrostomy. [Figure 60-5, Figure 61-3].

- The anterior front wall is closed with 2 Stratafix Spiral 3-0 sutures starting one each at the dorsal and ventral edge of the remaining opening. [Figure 60-6, Figure 61-4 to 61-6]. The first suture is started dorsally (9 o'clock) and run to the middle of the opening at 12 o'clock. The second suture is run from ventrally 3 o´clock finishing ventral at 12 o´clock, meeting the first suture line. The securing knot is placed extraluminally.

- A final check of the anastomotic perfusion can be performed with Indocyanine Green (ICG) utilizing the FireFly technology of the da Vinci system [Figure 62].

- The previously mobilized mediastinal pleura is closed with either single stitches or a running suture on top of anastomosis starting at azygos stump for about 4 cm distal, and pulling in small piece of omentum for protection. This enables fixation of the gastric tube and reinforcement of the anastomosis.

- Lastly the pulled-up easy-flow drainage tubes are fixated with Vicryl 4-0 to ensure optimum drainage control of the anastomosis and reliable indication of potential leakage.

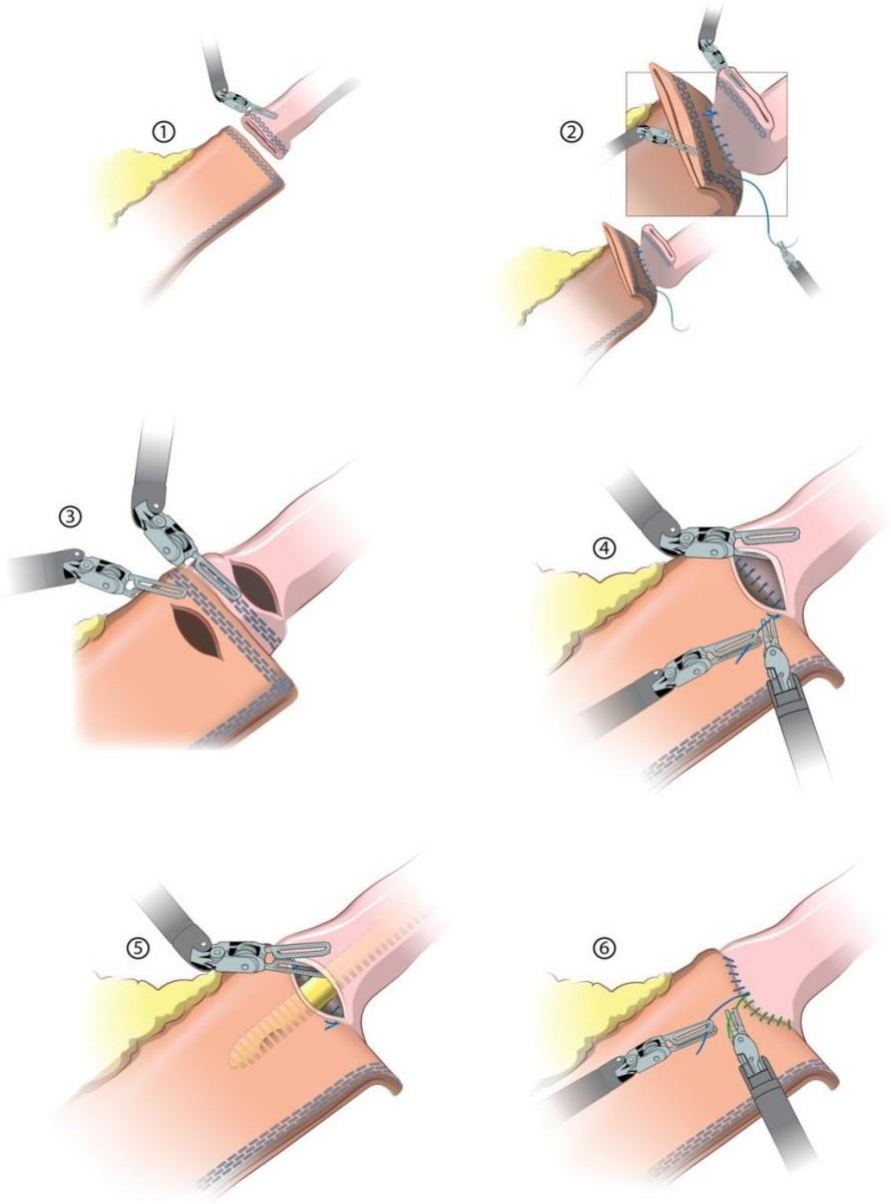


Figure 60 ①-⑥: Hand-sewn esophagogastrostomy technique

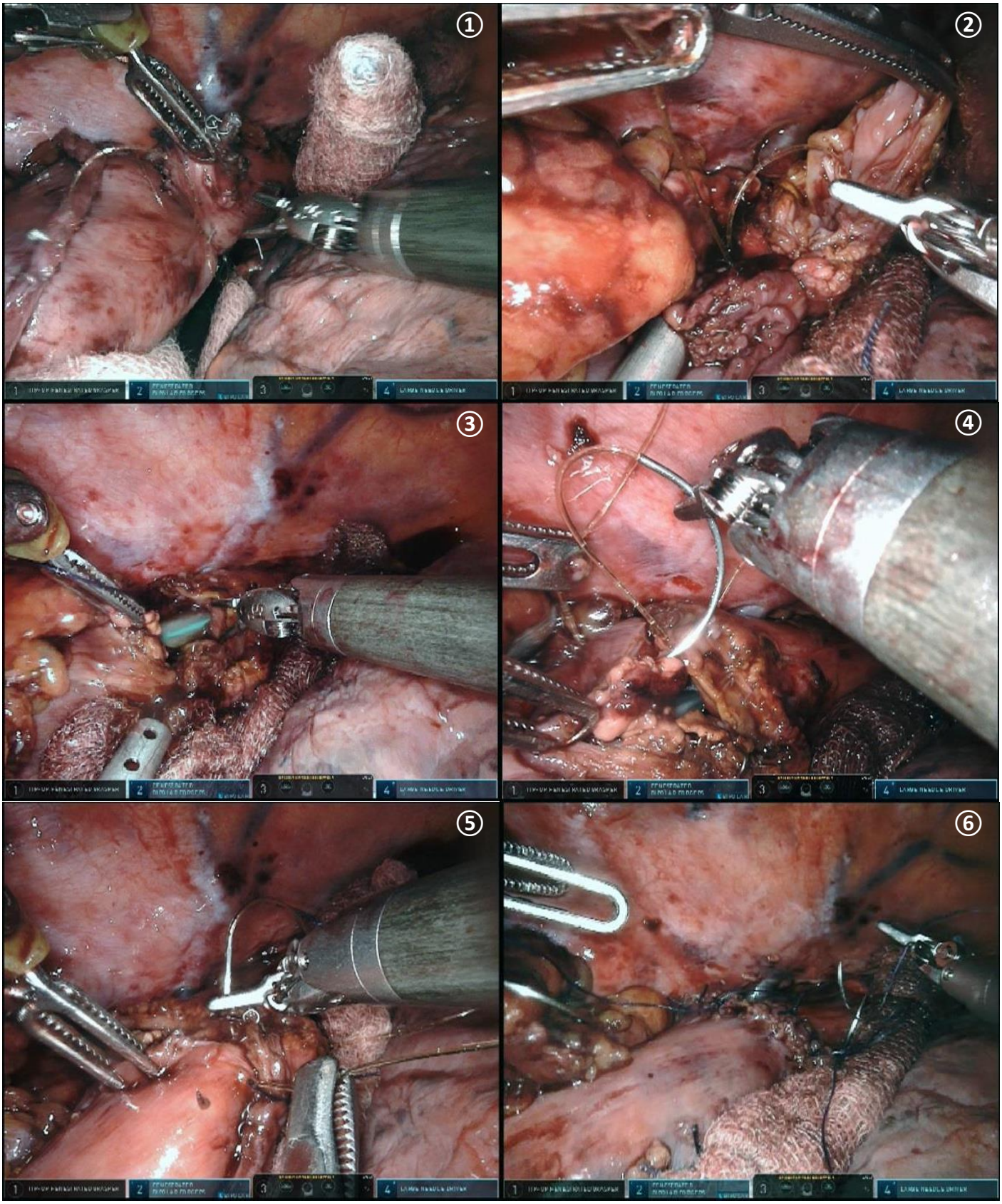


Figure 61 ①-⑥: Hand-sewn esophagogastrostomy technique

Figure 62: FireFly showing well perfused anastomosis

6cc. Hybrid Technique (Linear Stapler dorsal and Hand-Sewn ventral [side-to-side])

This anastomosis is done in a hybrid fashion whereas the dorsal part is connected with a linear stapler, and the ventral part hand-sewn with the EndoWrist instrumentation.

Da Vinci Instrumentation (Si/Xi/X):

- Endoscope 30°
- Permanent Cautery Hook or Monopolar Curved Scissors (right)
- Large Needle Driver (right, main left)
- Fenestrated Bipolar Forceps (optional on 3rd instrument arm - aux left)

NOTE: For the utilized suture material please refer to the package insert for complete instructions, contraindications, warnings and precautions.

- The esophageal stump is mobilized to ensure adequate length and mobility for the esophagogastrostomy, especially on the dorsal aspect. A 3-O PDS stay suture is placed in the middle of the suture line on the esophagus [Figure 63].

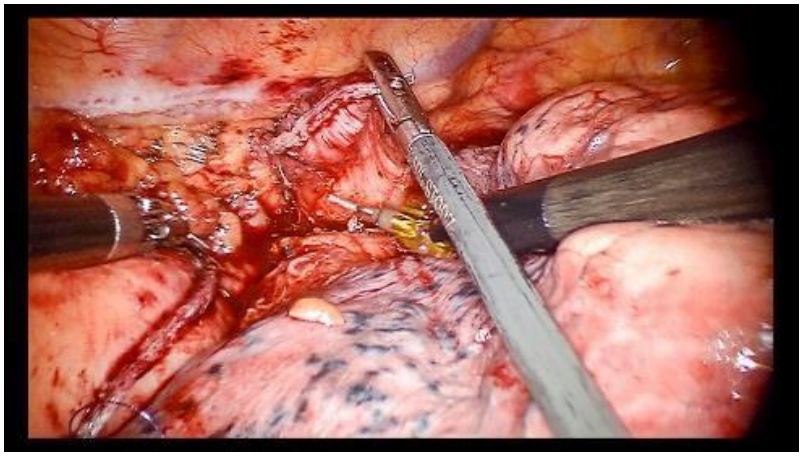


Figure 63: Complete mobilization of the dorsal aspect

- Check length and perfusion of the gastric conduit with Indocyanine Green (ICG) utilizing the FireFly technology of the da Vinci system [Figure 64].

Figure 64: FireFly showing well perfused gastric conduit prior to anastomosis

- The esophageal stump is opened on the right side with cold scissors or monopolar cautery hook proximal to the transecting stapler line [Figure 65].

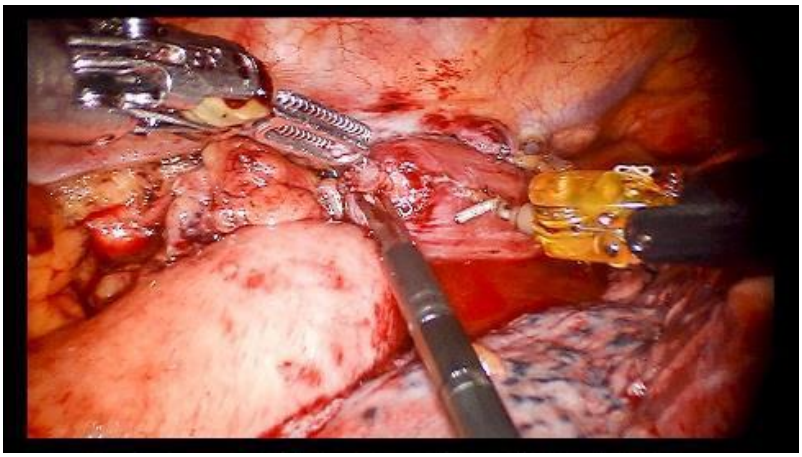


Figure 65: Opening of the esophageal stump

- Four retraction sutures are placed (dorsal, ventral, medial and lateral) around the opened esophageal lumen, making sure to fixate the mucosa to the rest of the esophageal wall [Figure 66]. These retraction sutures will serve for applying optimal retraction on the stump for anastomotic suturing as well as help guide the esophageal stump over the stapler anvil. Direct grasping of stump for these purposes could excessively traumatize the stump and/or deteriorate perfusion which in turn could be detrimental to the integrity of the anastomosis post-operatively.

Figure 66: Placement of retraction sutures

- Next, the gastric conduit is checked to be tension free and not twisted. The site for linear stapler insertion is measured to be at least 6 cm distal to the transecting staple line on the gastric conduit. The incision is made using monopolar cautery close to the gastroepiploic arcade [Figure 67].

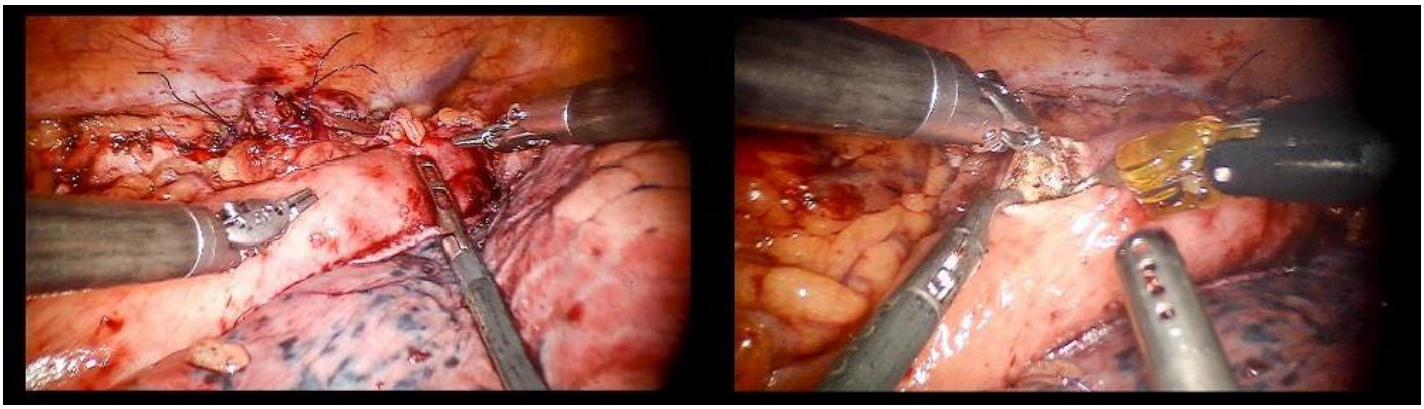


Figure 67: Incision in the gastric conduit 6 cm distal to the transecting staple line

- The EndoWrist stapler anvil and cartridge jaw (30 mm length) are inserted into the appropriate lumens while the console surgeon guides the tissue onto the stapler with the da Vinci instruments. Once sufficient tissue overlap is achieved (approximately 60 mm) the stapler is fired (blue reload) and the gastric conduit and esophageal stump are connected dorsally side-to-side [Figure 68].

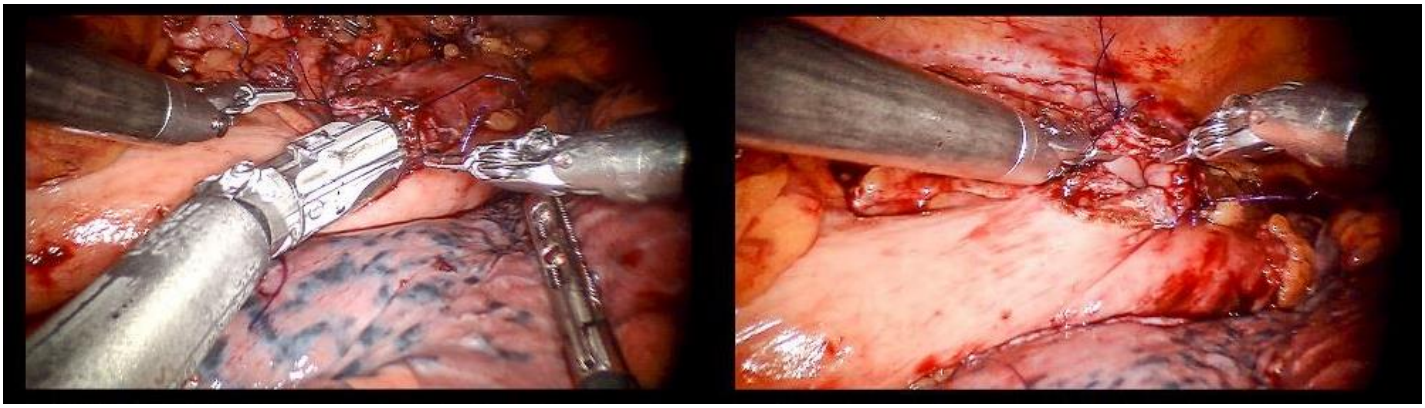


Figure 68: Linear stapling of the dorsal aspect of the esophagogastrostomy

- The ventral part of the anastomosis is completed in a hand-sewn technique utilizing two Large Needle Drivers.
- First a stay suture is placed at the anterior confluence of the remaining opening [Figure 69].

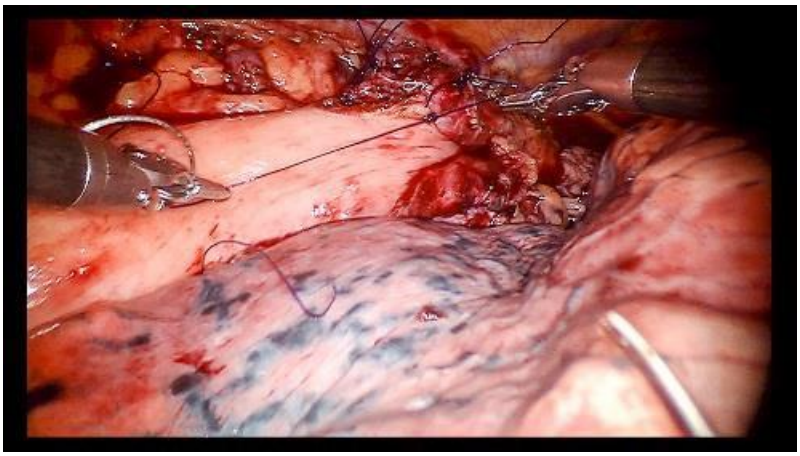


Figure 69: Placement of first stay suture at anterior edge

- A second stay suture is placed at the posterior edge for manipulation of the tissue during anastomosis construction [Figure 70].

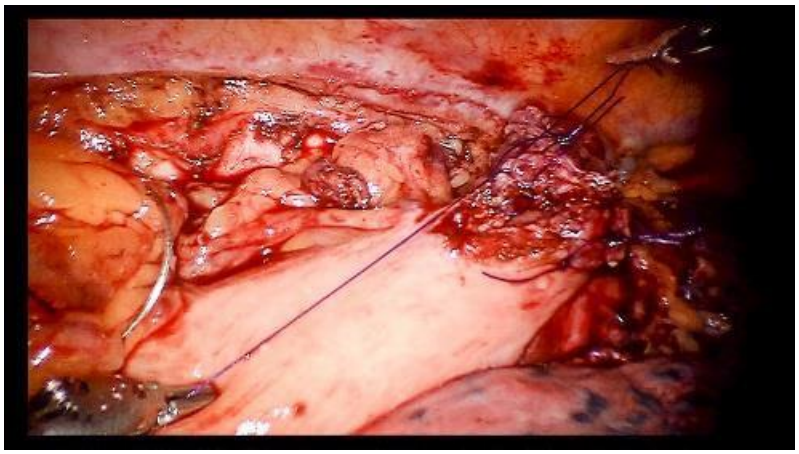


Figure 70: Placement of second stay suture at posterior edge

- A stomach tube (size 34 Fr) is advanced distally to the anastomotic opening in order to secure a sufficient lumen of the esophagogastrostomy [Figure 71].

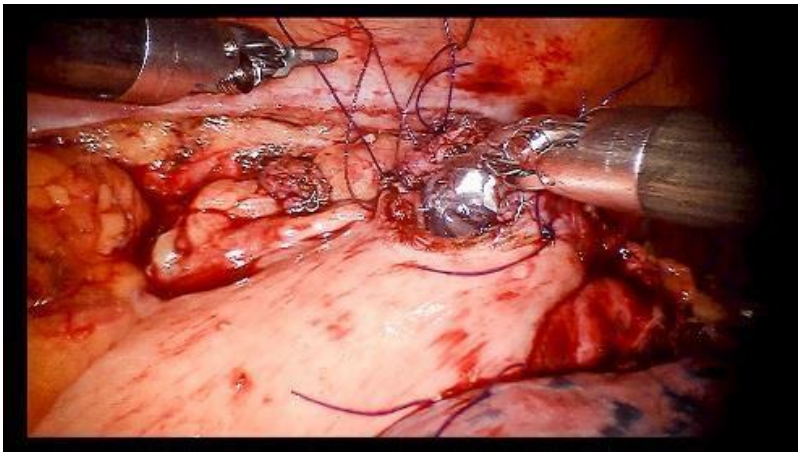


Figure 71: Advancement of stomach tube distally

- Following, the opening is closed by applying two Stratafix™ (4-0, RB-1 needle, 15 cm length) sutures that run from each edge to the middle of the opening.
- First Stratafix suture is started at the posterior edge running to the midline [Figure 72].

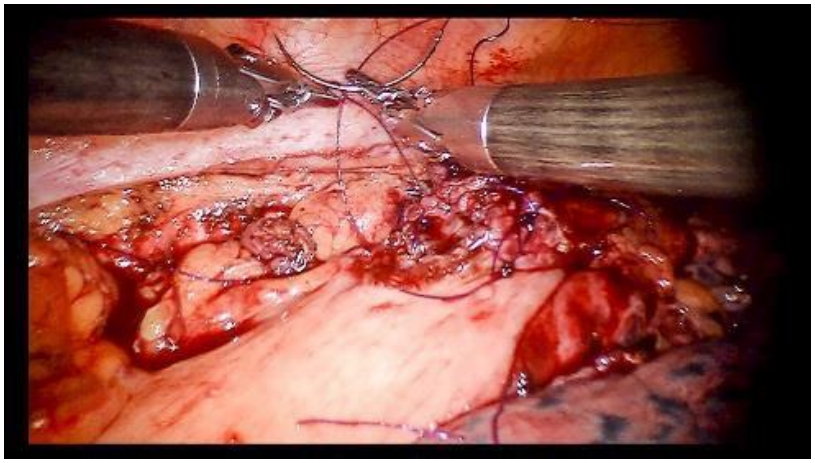


Figure 72: Start of the first suture at the posterior edge running to the midline

- The second running Stratafix suture is started at the anterior edge and run towards the midline meeting the first Stratafix and tied [Figure 73].

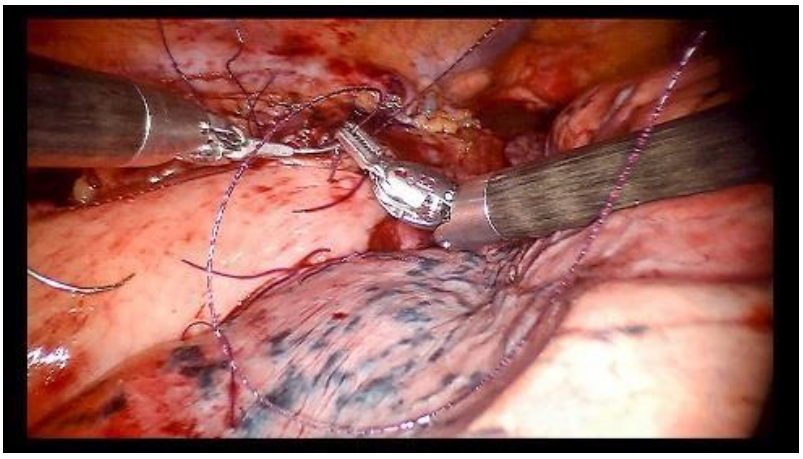


Figure 73: Start of second suture at the anterior edge running to midline

- The 34 Fr stomach tube is exchanged to a smaller size tube and a second layer suture line (Stratafix 4-0) placed on top [Figure 74].

Figure 74: Second layer suture line on top of the anastomosis

- The anastomosis is inspected for adequate blood perfusion with Indocyanine Green using the Firefly feature. Particular attention is given to sufficient perfusion of the gastric conduit part of the anastomosis [Figure 75].

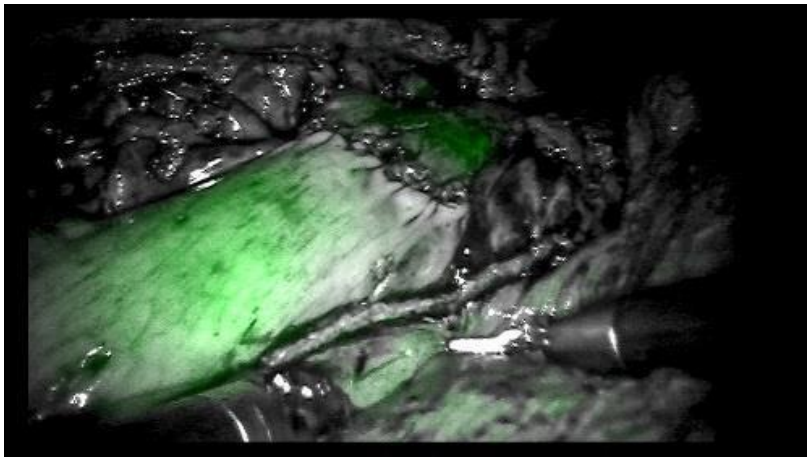


Figure 75: Firefly showing well perfused anastomosis

- Patency of the anastomosis is checked to avoid post-operative leakage. The area around the anastomosis is filled with an amount of sterile Saline solution sufficient to submerge the anastomosis. Distal to the anastomosis the gastric conduit is “clamped” off and air is pushed into the esophagogastric lumen through the stomach tube and checked for air bubbles [Figure 76].

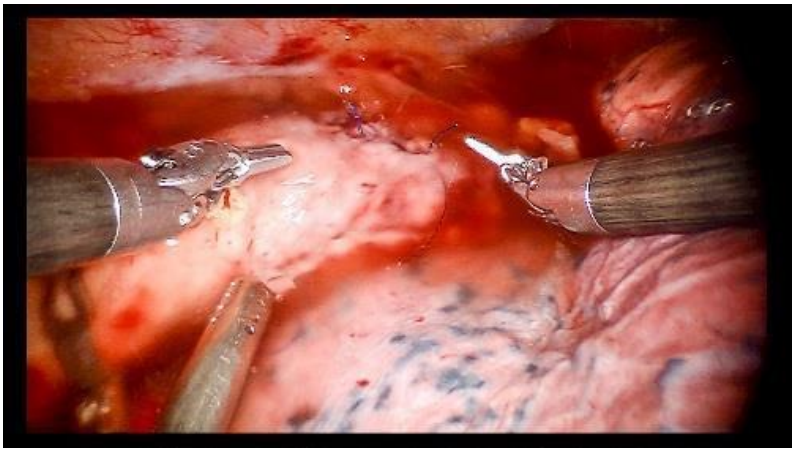


Figure 76: Airleak test on the anastomosis

- Finally the anastomosis is protected by suturing a piece of omentum remaining from the gastric conduit over the esophagogastrostomy with a PDS suture [Figure 77].

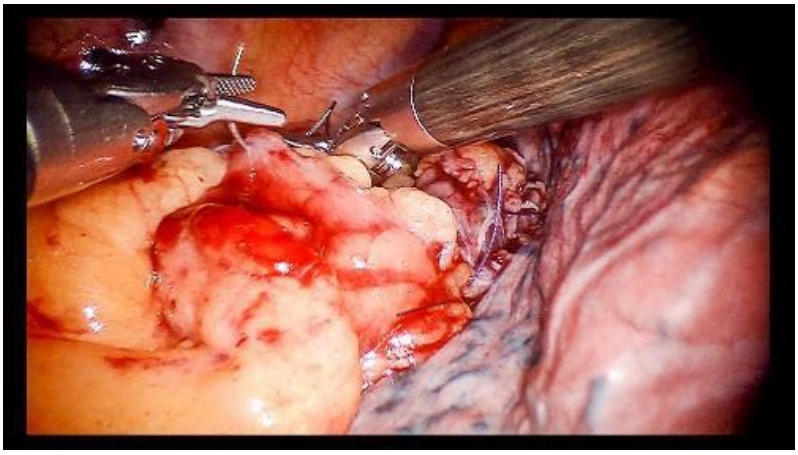


Figure 77: Protecting the anastomosis with a piece of omentum secured by suture

6d. Procedure Completion

- Close ports after previous injection of a local anesthetic for pain reduction.
- Place a 28 French chest tube in the chest under direct vision one by the diaphragm and one near, but not directly at the anastamosis
- Reinsufflate lungs
- Close chest in standard fashion.

7. POSTOPERATIVE CARE

- Postoperative pain management
    - Dispense pain medication per usual postoperative regimen
    - Respiratory suppression is avoided and patient placed on aspiration precautions (no oral intake until fully awake and able to sit upright)

- Inpatient hospital follow-up and discharge should be based on surgeon's experience and preference.
    - Patients are extubated in the OR and transferred to the recovery room and to the appropriate hospital inpatient setting (bed with monitoring until discharge).
    - Patients should be monitored with oximetry around the clock
    - Chest drain removal once output is less than 450 mL/day
    - The patient is discharged from the hospital if stable, most commonly on day one or two.

- Outpatient hospital follow-up
    - Follow up visit three weeks postoperatively
    - In cases of malignancy, following pathology review, counsel the patient concerning the need for additional therapy or adjuvant chemotherapy as indicated. Adjuvant therapy, even radiotherapy which is rarely indicated, can be started as soon as 3 -6 weeks post-op, depending on patient's performance status.

APPENDIX A - TECHNICAL PEARLS/TIPS & TRICKS

- As a general guideline to avoid intraoperative complications:
    - Create adequate exposure
    - Use proper traction and counter-traction
    - Develop the correct planes
    - Standardize the assistant's role
    - Beware of the variations of vasculature and anatomy

- Collisions and reduced workspace for the assistant:
    - Ensure that ports are placed and distanced appropriately as described in section **5. PORT PLACEMENT AND DOCKING**
    - Initially select patients taller than 5 feet with an BMI less that 35
    - Utilize the 0°endoscope instead of the 30°endoscope down to provide more working space for the Patient-side assistant to perform his tasks (suction-irrigation, bagging specimen, etc) if necessary.

- Stapling:
    - Pull the endoscope all the way back into the camera cannula for a more panoramic view
    - If necessary pull the EndoWrist® Stapler Cannula slightly out of the body to gain additional insertion length for the stapler devices.

- Dealing with adhesions:
    - Start procedure with the assistant port incision and free adhesions utilizing laparoscopic technique until enough space is created to dock the *da Vinci* arms.

APPENDIX B - CANNULA REMOTE CENTER SETUP

- To correctly place the remote center, the **thick** black line on the *da Vinci* cannula (which indicates the remote center) should be inserted within the boundaries of the patient's body wall. Correct placement will allow the robotic instrumentation to pivot through the incision with the least friction and highest precision, which will minimize tissue trauma [Figure B1a].
- Correct placement of the cannula should be verified by looking at the cannula tip with the endoscopic camera (cannulas should always be placed under endoscopic camera view). Only the first thin line at the distal cannula tip should be visible. This indicates that the remote center is placed correctly within the boundaries of the patient's body wall [Figure B1b].
- If the thick black line on the cannula is seen in the endoscopic view, this means that the remote center is set incorrectly (inserted too deeply). Setting the remote center incorrectly will increase friction, reduce precision and increase tissue trauma at the port site [Figure B1c].

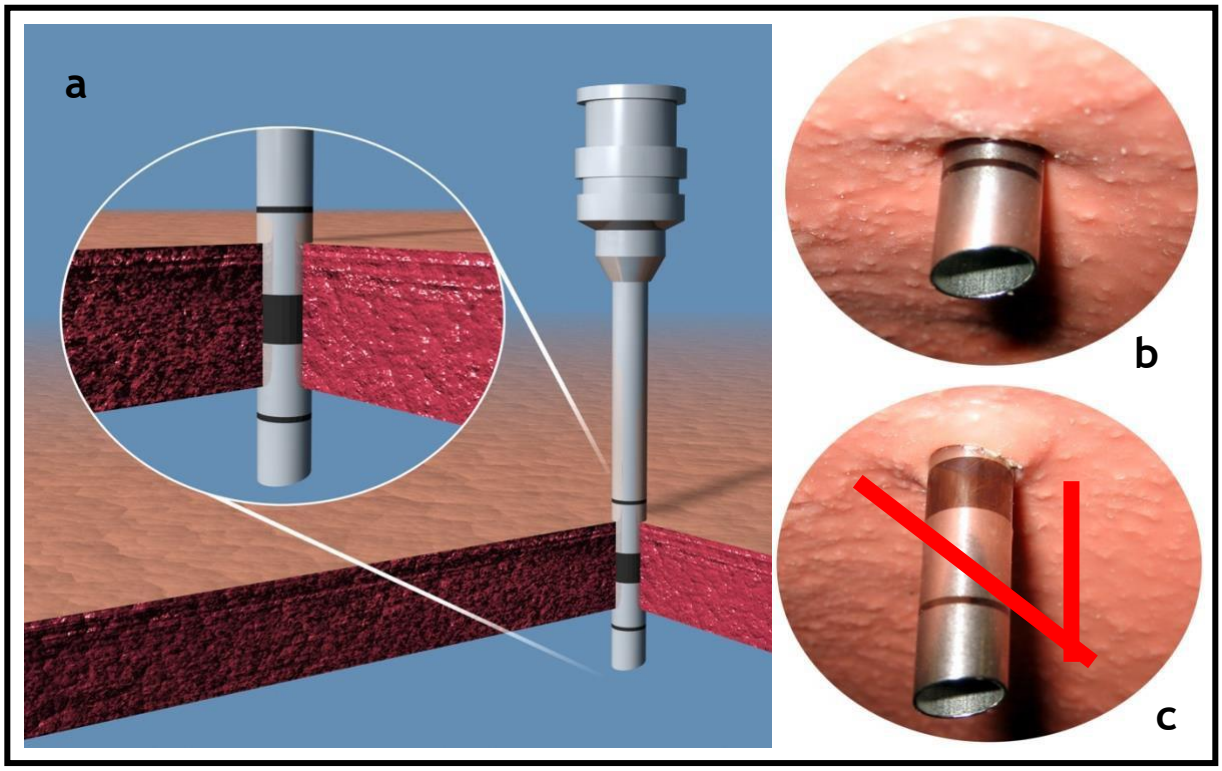


Figure B1: Proper placement of the instrument's cannula remote center

Thoracic

Specifically for thoracic procedures it is important that the remote center is set up correctly within the boundaries of the body wall on the level of the ribs [Figure B2). If the remote center is not set correctly, the movement caused in the port surrounding tissue and ribs can negatively impact the systems precision and cause trauma to the tissue and ribs.

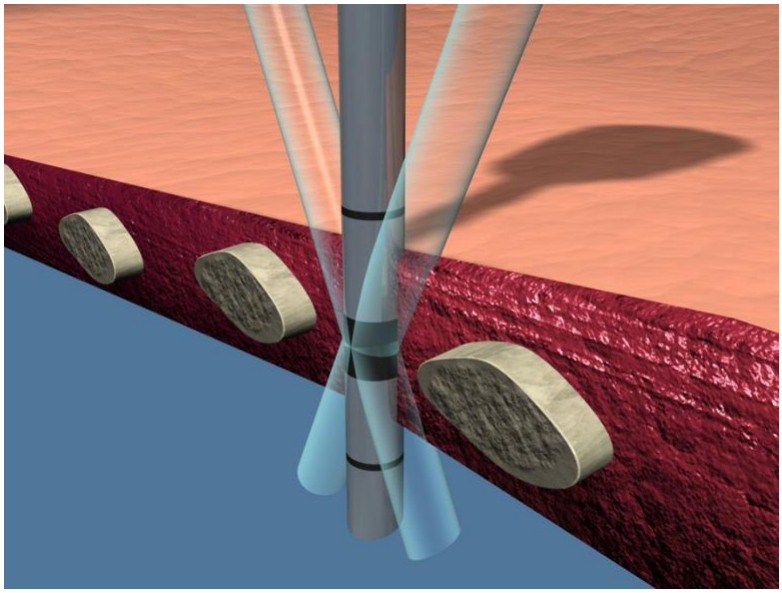


Figure B2: Correct remote center setup in thoracic procedures