Accepted Manuscript online: 2024-08-29 Article published online: 2024-09-29

Single-Port da Vinci Robot–Assisted Cervical Esophagectomy: How to Do It

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Thorac Cardiovasc Surg 2024;72:654–658.

Abstract

Minimally invasive esophagectomies, including robot-assisted procedures, have demonstrated superiority over traditional open surgery. Despite the prevalence of transhiatal and transthoracic approaches, cervical access is less common in minimally invasive esophageal surgery. Advancements in robotic systems, such as the da Vinci Single Port (SP), enable controlled transcervical extrapleural mediastinoscopic access, potentially reducing pulmonary complications and extending surgical options to patients with comorbidities. The da Vinci SP robot-assisted cervical esophagectomy (SP-RACE) employs an SP and laparoscopic approach, demonstrating feasibility with comparable lymphadenectomy and recurrent nerve palsy rates to transthoracic methods. This technique, performed for the first time in Europe at the University Hospital Mainz, involves a transcervical SP phase that allows for effective mediastinal dissection and esophageal mobilization. Despite technical challenges due to limited space, robotic systems enhance controlled access and eliminate arm collision. The da Vinci SP platform's advantages include improved triangulation, fewer interferences, and better control of instruments in confined spaces. This novel approach shows promise for patients with high esophageal tumors and those unsuitable for transthoracic surgery, warranting further investigation into its clinical utility and reproducibility.

Keywords
- minimally invasive surgery
- robotics
- esophageal surgery

Introduction

Minimally invasive esophagectomies, including robot-assisted minimally invasive procedures, have demonstrated superiority over open surgery.[1] Robot-assisted esophageal surgeries commonly employ transhiatal or transthoracic approaches. While cervical access is typically performed via open surgery for cervical anastomosis or three-field lymphadenectomy indications, its use in minimally invasive esophageal surgery is less prevalent.[1] However, advancements in robotic systems, such as the new da Vinci Single Port (SP; Intuitive Surgical Inc., Sunnyvale, CA, United States), have enabled controlled transcervical extrapleural mediastinoscopic access. This approach

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received
June 9, 2024
accepted after revision
August 5, 2024
accepted manuscript online
August 29, 2024
article published online
September 29, 2024

DOI https://doi.org/10.1055/a-2405-2708.
ISSN 0171-6425.

Georg Thieme Verlag KG, Rüdigerstraße 14, 70469 Stuttgart, Germany

is anticipated to decrease the risk of pulmonary complications, including postoperative pneumonia, a common morbidity following transthoracic esophageal surgery, as it eliminates the need for single lung ventilation or thoracic access. Additionally, it could extend surgical options to patients previously considered unsuitable for surgical therapy due to comorbidities. The da Vinci SP robot-assisted cervical esophagectomy (SP-RACE) utilizes an SP in conjunction with a laparoscopic approach. This method, incorporating transcervical mediastinoscopy for mediastinal dissection, demonstrates feasibility with comparable lymphadenectomy and recurrent nerve palsy incidence rates when compared with transthoracic approaches.[2] However, transcervical esophagectomy poses technical challenges due to limited space and conventional minimally invasive instrument mobility constraints.[3] These technical hurdles may be addressed by employing robotic systems, potentially enhancing controlled robot-assisted transcervical extrapleural mediastinoscopic access.[3] Notably, the da Vinci SP platform exhibits advantages, particularly in upper, middle, and lower mediastinal dissection via the transcervical approach, owing to reduced robotic arm collision.[3,4] Combined with decreased operating time, an independent predictor of postoperative morbidity, this may lead to improved postoperative outcomes for esophagectomy patients. Thus far, this technique has been demonstrated in cadaveric studies.[3–6] Herein, we describe the novel transcervical robotic approach utilizing the da Vinci SP system.

Technique

The da Vinci SP-RACE procedure was performed for the first time in Europe, at the University Hospital Mainz, in the Department of General, Visceral and Transplantation Surgery in April 2024.

System and Instruments

The da Vinci SP system (Intuitive Surgical Inc.), along with its corresponding instrumentation, was employed.

Surgical Procedure

- Abdominal phase: This part of the procedure has already been described previously.[5]
- Transcervical SP phase: A 3-cm skin cross-incision is made approximately two fingers above the left clavicle and anteromedial to the sternocleidomastoid muscle (►**Fig. 1A**). The platysma and the straight cervical muscles are transected. The left sternocleidomastoid muscle is displaced laterally, the caudal thyroid vessels are transected, and the lower pole of the thyroid gland is displaced medially. The left recurrent laryngeal nerve is visualized, and its function is confirmed using neuromonitoring. Afterward, the left common carotid artery is dissected from the surrounding tissue medially until the left portion of the esophagus is visualized. Following preparation of

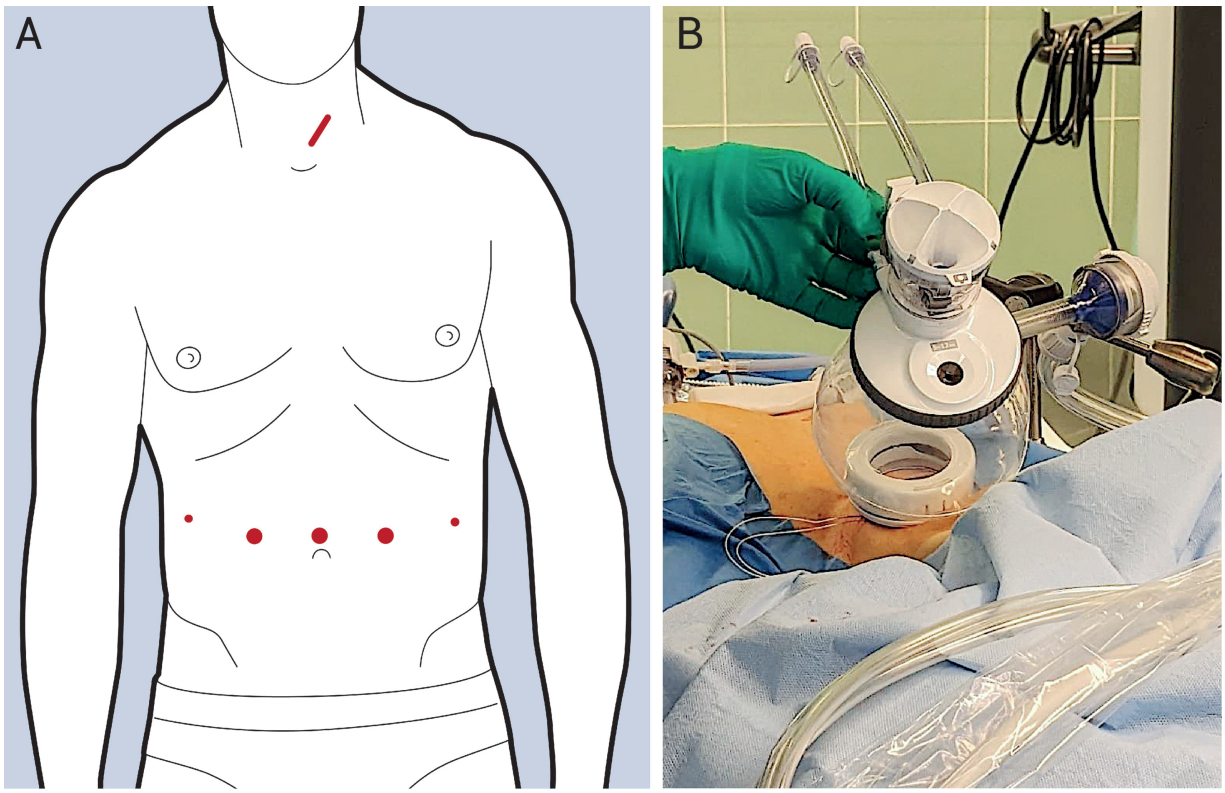

Fig. 1 (**A**) After incision above the left clavicle and anteromedially to the left sternocleidomastoid muscle, (**B**) a large incision (2.7 cm) single-port access port kit is inserted with a pressure of 8 mm Hg to induce capnomediastinum.

the esophagus, a sling is positioned around the esophagus to aid in its retraction during upper mediastinal preparation. A large incision (2.7–7 cm) SP access port kit is inserted, and a pressure of 8 mm Hg is applied to induce capnomediastinum (►**Fig. 1B**). To effectively manage the limited operating field space, a high-flow insufflator is utilized, ensuring a stable operating field in a confined workspace. The da Vinci SP patient side cart is positioned cranially on the right side of the patient, and the robot is docked. The choice of instruments is at the surgeon's discretion. We used fenestrated bipolar forceps on position 1, a round tooth retractor on position 2, and Maryland bipolar forceps on position 3. A 30-degree camera is placed in an upward "cobra" position. The left side of the trachea is exposed and retracted to the right to identify the left recurrent laryngeal nerve, with neuromonitoring employed for guidance. This is followed by dissection of the upper mediastinal esophagus and surrounding lymph nodes along the left recurrent nerve. Using Maryland bipolar forceps, the esophagus is dissected from the tracheal pars membranacea, with the spinal vertebrae serving as dorsal and lateral landmarks for mediastinal dissection. Following these planes, the parietal pleura is delineated and followed as the boundary for further dissection. Subsequently, the aortic arch is identified in conjunction with the left recurrent nerve, confirmed using neuromonitoring. Circumferential dissection of the esophagus and paraesophageal lymph nodes follows, with the azygos vein and descending aorta serving as crucial landmarks (►**Fig. 2A**). At this point, indocyanine green (ICG) dye applied during the abdominal phase can be used to visualize and spare the thoracic duct (►**Fig. 2B**). By retracting the esophagus backward and upward simultaneously, the trachea can be tracked downward to the carina, where the right and left main bronchi and the carina are identified and dissected free of the esophagus. Care is taken not to injure these structures. Transcervical access notably facilitates carinal lymph node dissection. At the subcarinal level and distally, the pericardium, which lies ventrally, and the left and right parietal pleura serve as landmarks as the esophagus is dissected free toward the hiatus (►**Fig. 3**).

- Reconstruction: After the robot is de-docked, the specimen is resected. We planned to remove the specimen transmediastinally; therefore, during the abdominal phase, the gastric fundus was completely transected, and the conduit was fully formed. Stay sutures were placed to hold the small curvature and the tip of the conduit together, ensuring a less robust specimen for easy removal transmediastinally and transcervically using a laparoscopic grasping instrument. This was performed during an apneic phase induced by the anesthesiologist. Subsequently, an end-to-side stapled esophagogastrostomy was performed using an end-to-end anastomosis (EEA) 25-mm circular stapler (Covidien, United States). No drains were employed in the procedure, and skin sutures marked the end of the procedure.

The median total duration of the surgical procedure and the median console duration of the SP-RACE procedure were 05:18 and 02:31 hours, respectively, and they were comparable to the duration of the robot-assisted minimal invasive esophagectomy (RAMIE) procedure (data not shown).

Discussion

This pioneering procedure marks the inaugural SP-RACE in Europe. Total esophageal mobilization and dissection were achieved efficiently and within an acceptable time frame, accompanied by an adequate mediastinal lymphadenectomy. The da Vinci SP surgical system demonstrated excellent feasibility for paratracheal and subcarinal lymphadenectomy, as well as complete intrathoracic esophageal mobilization. However, the feasibility, reproducibility, and clinical utility of the described robotic-assisted transcervical SP-RACE esophagectomy warrant further investigation. Considering the surgical anatomy of the esophagus, noteworthy advantages of this method include controlled dissection of high esophageal tumors, superior left recurrent lymph node dissection, and reduced pulmonary complications attributed to complete extrapulmonary dissection. The da Vinci SP platform exhibits advantages, particularly in middle to lower mediastinal dissection via the transcervical approach. Additionally, the da Vinci SP system offers superior triangulation, leading to fewer interferences and improved control of the four combined instruments deployed through a small lumen trocar within a confined operating space, such as the posterior mediastinum. Furthermore, the smaller-diameter instruments of the SP (6 mm) contribute to enhanced maneuverability in the mediastinal space. At this moment, we see a potential limitation of the SP-RACE procedure in the case of T4b tumors, but the decision is always made on an individual basis. Potential indications for the utilization of the da Vinci SP surgical system encompass patients with upper esophageal cancer with mediastinal lymphadenopathy deemed unsuitable for a transthoracic operation, as well as patients necessitating esophagus-sparing complementary mediastinal lymphadenectomy following endoscopic resection of early esophageal cancer.

Authors' Contribution
E.H. and V.J.L. wrote the manuscript. E.H., V.J.L., E.V.G., L.B., H.L., and P.P.G. participated in conceptualization, methodology, supervision, and review of the final draft. All authors have read and agreed to the published version of the manuscript. E.H. and V.J.L. contributed equally to this manuscript.

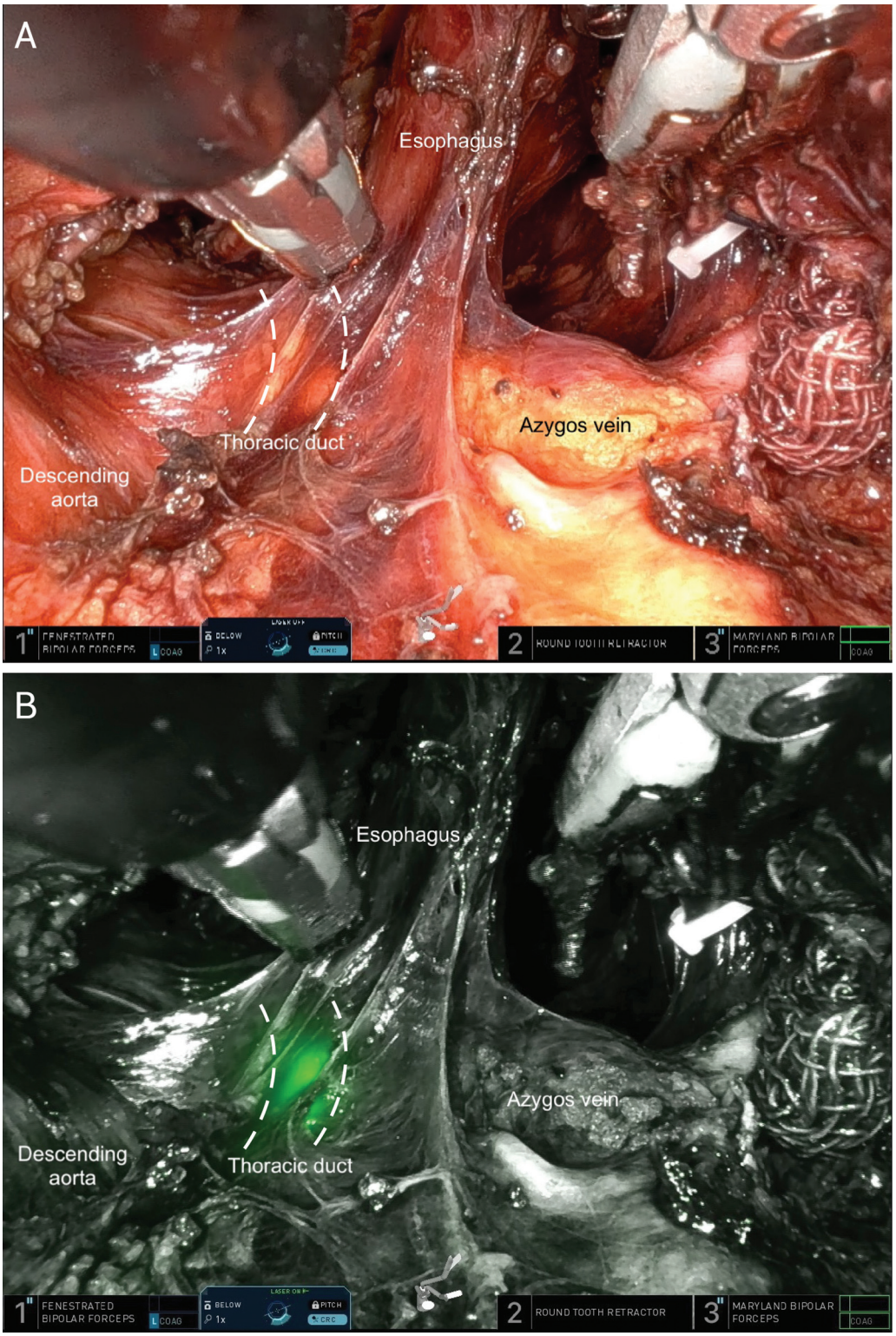

Fig. 2 (A) The azygos vein and descending aorta serving as crucial landmarks during the circumferential dissection of the esophagus and paraesophageal lymph nodes. (B) Indocyanine green (ICG) dye is used to visualize and spare the thoracic duct.

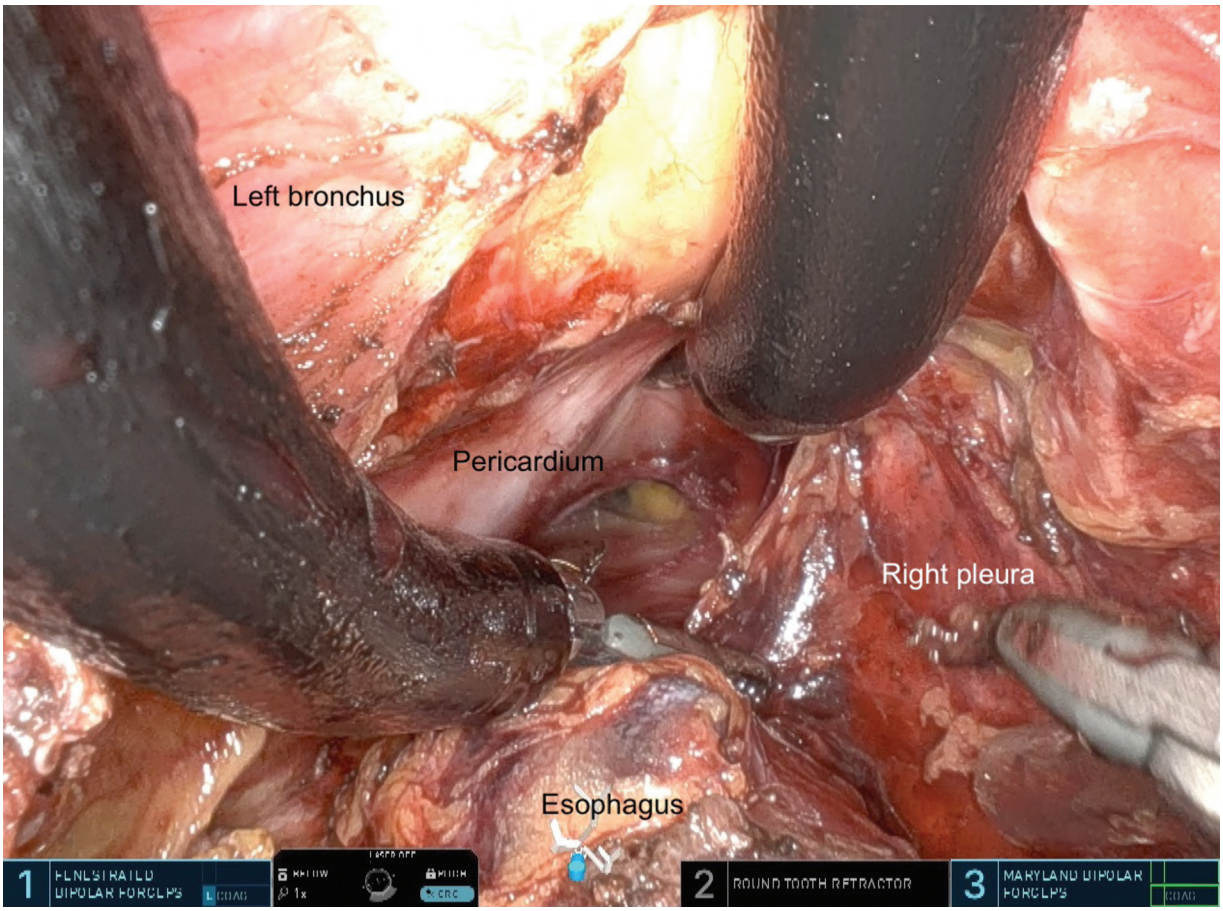

Fig. 3 At the subcarinal level and distally, the pericardium (ventral) and the left and right parietal pleura are landmarks for safe dissection of the esophagus toward the hiatus.

Conflict of Interest

P.P.G. serves as a proctor for Intuitive Surgical. All other authors declare no conflicts of interest.

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