The da Vinci Xi Robotic Four-Arm Approach for Robotic-Assisted Minimally Invasive Esophagectomy

Peter Philipp Grimminger1 Edin Hadzijusufovic1 Jelle Piet-Hein Ruurda2 Hauke Lang1 Richard van Hillegersberg2

1 Department of General, Visceral- and Transplant Surgery, University Medical Center of the Johannes Gutenberg University, Mainz, Germany
2 Department of Surgery, University Medical Center, Utrecht, The Netherlands


Abstract

Robotic surgery is gaining importance in complex thoracoscopic surgery, such as robotic-assisted minimally invasive esophagectomy (RAMIE). The RAMIE procedure was designed using the first generation of the robotic system. The latest da Vinci Xi system has substantially increased the dexterity, especially designed for multiquadrant surgery. The original three-arm RAMIE approach was modified including the robotic four-arm use for the thoracoscopic and laparoscopic part of the operation. This extended approach (four-arm RAMIE approach) provides more flexibility and raises the independence of the surgeon.

Keywords

- da Vinci Xi
- RAMIE4
- esophageal cancer
- MIE
- RAMIE

Introduction

Totally minimally invasive esophagectomies (MIEs) or robotic-assisted minimally invasive esophagectomies (RAMIEs) have been shown to be superior compared with open surgery.1,2 To date, no randomized comparison of RAMIE versus MIE is available. Such a trial would require many patients included and could only be evaluated by robotic high-volume centers. However, robotic surgeons, who perform MIE and RAMIE, already experience the RAMIE approach to be superior.3

Robotic surgery enhances several key aspects of minimally invasive surgery, such as enhanced vision, stable view, and highest precision due to articulated instrumentation and scaling of motion. However, an assistant with one or two extra trocar is commonly used to enhance the speed of suction, clipping, retraction, and similar. The robotic trocar position and use were derived from the former robotic systems (e.g., da Vinci Standard, S or Si, Intuitive Surgical, Sunnyvale, California, United States). The first-generation robotic systems had three relatively bulky arms with limited reach, resulting in collision of the arms and critical trocar positioning.4,5 Therefore, initially much effort was put into defining the ideal robotic trocar positions in the thorax to avoid collision and reach the entire thorax in a single docking of the robot chart.6 These trocar positions work well with the newer generation da Vinci Xi; however, this system allows for a further step. The da Vinci Xi is much more flexible; the robotic arms are more delicate and allow the usage of four robotic arms for thoracoscopic esophageal surgery (►Fig. 1). We developed a robotic four-arm approach optimized for esophageal cancer surgery.

The fourth arm allows several major improvements: control and mobilization of the lung or mediastinal tissue as well as the retraction of the esophagus by steady positioning or grasping through the additional robotic arm is one great benefit. Using the Clip Applier via the fourth arm is time saving, very ergonomic, and potentially helpful for immediate control of acute bleeding situations. Also repositioning of the camera is possible through the additional trocar and enables a change of the point of view during intrathoracic stapling or other procedures (►Fig. 2). The fourth robotic arm leads to a greater independence of the surgeon to control the exposition and operation, so that...
the complex RAMIE procedure can be performed without a highly skilled assistant.

In this article, we demonstrate how we perform the four-arm RAMIE approach (RAMIE4) several times a week and point out critical steps.

**Technique Description**

The abdominal part of the RAMIE procedure using four robotic arms abdominally has been described previously. Here, we focus on the technique of the thoracoscopic robotic RAMIE4.

The trocar placement is shown in Fig. 1A and B. The patient is in a left lateral to semiprone position and the right lung is not ventilated. The robotic instruments are the same as used in the abdomen for the abdominal part of the operation. Via the 8 mm robotic trocar in the intercostal space (ICS) 4, the Permanent Monopolar Cautery Hook or for some parts the Vessel Sealer is used. Via the 8 mm robotic trocar in the ICS 6, the da Vinci Xi 8mm 30° Endoscope is inserted. Via the 12 mm robotic trocar in the ICS 8, the Fenestrated Bipolar Forceps or Maryland Bipolar Forceps and later the EndoWrist Stapler 45 are used. Via the 8 mm robotic trocar in the ICS 10, the Tip-Up Fenestrated Grasper or (for a change of viewpoint) Endoscope is inserted for some parts of the operation. The dissection of the esophagus and sequence of dissection do not diverge from previously described techniques, however, some modifications are possible with the use of the fourth arm: The fourth arm is actively controlled by the surgeon and used for retraction and stable exposition and replaces critical maneuvers of the assistant. Moreover, the fourth arm is used to retract the lung or the esophagus for the dissection of the pericardial, left pleural, and aortic planes. It is also utilized to robotically apply clips, which is advantageous due to the ergonomics of EndoWrist Clip Applier. Also using the Vessel Sealer through the additional trocar can save time during dissection. In the upper mediastinum, the fourth robotic arm helps to precisely retract the trachea for paratracheal lymph node dissection. In the reconstruction with an intrathoracic esophagogastronomy, the fourth arm is used to either perform the purse string suture for the stapling method (Fig. 3A) or to generate a stable exposition for a robotic hand-sewn anastomosis (Fig. 3B). When using a circular stapling method, the circular stapler (28 mm as standard) is inserted into the gastric conduit via the minithoracotomy by expanding the 12 mm assistant trocar in the fifth ICS (Fig. 2). The completion of the gastric conduit preparation can be performed intrathoracically, using the da Vinci Xi 8 mm 30° Endoscope though the ICS 10 trocar and the EndoWrist Stapler 45 through the 12 mm trocar in ICS 8 (Fig. 2). The median duration of the past 12 fully robotic RAMIE4 cases was 140 minutes for the abdominal part and 214 minutes for the thoracic part. The procedure time for RAMIE4 is comparable to our MIE procedure time. The learning curve is difficult to define, as the surgeon performing RAMIE4 is experienced in open, hybrid, and minimally invasive esophagectomy. However, we believe that the learning curve for RAMIE4 is less than for MIE.
The presented robotic RAMIE4 technique reveals major advantages of the latest da Vinci Xi robot. The fourth arm replaces the second assistant trocar and enables intrathoracic stapling, endowristed clipping, more rapid dissection, change of viewpoint, and enables a fully stable control for the surgeon throughout the procedure, regardless whether a robotic hand-sewn or standardized circular stapling anastomotic reconstruction is performed. The learning curve seems to be less compared with MIE, especially for surgeons experienced in hybrid esophagectomy or MIE. The RAMIE4 procedure time is comparable to MIE.

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References