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HOW TO DO IT

Robot-assisted single-port surgery for mediastinal tumors

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Abstract
We successfully performed totally endoscopic single-port robotic surgery. A 50-year-old man with a mediastinal tumor underwent robot-assisted tumor resection. Only one port was placed on the right side of the chest, and a robotic endoscope and two robotic instruments were inserted through the port. The instruments were crossed while avoiding collision. Single-port robotic surgery for a mediastinal tumor using the cross-arm technique was safely achieved with good clinical results and excellent cosmetic results.

Keywords Robotics · Minimally invasive surgery · VATS · Mediastinal tumor · Incisions

Introduction

For the treatment of not only abdominal disease, but also thoracic disease, various minimally invasive surgical procedures have been developed to minimize the surgical incisions and improve the cosmetic results, including endoscopic and robotic surgery [1, 2]. We combined single-port endoscopic surgery and robot-assisted surgical technology with video-assisted thoracic surgery (VATS) using the da Vinci surgical system (Intuitive Surgical Inc., Sunnyvale, CA, USA). We herein report the outcomes of this case.

Patient and methods

Patient

A 50-year-old man was referred to our clinic for an enlarging neck tumor that had been followed for 8 years. A neck and chest CT scan revealed a right neck mass (65 mm in diameter) at the right lobe of the thyroid and a mediastinal mass (8 mm in diameter) in front of the ascending aorta (Fig. 1). Because the patient desired the resection of both tumors, conventional right hemithyroidectomy with concurrent robot-assisted endoscopic resection of the mediastinal tumor was selected.

Surgical procedure

The patient was placed in the supine position, and double-lumen endotracheal intubation was introduced. After conventional right hemithyroidectomy via a neck collar incision (60 mm in length), a port (25 mm in length) was made in the third intercostal space on the right anterior chest, and ipsilateral lung collapse was performed. The port was made on the intercostal space at the same height as the tumor to keep the insertion axis of the da Vinci system as perpendicular to the chest wall as possible. We attempted to perform CO_2 insufflation to maintain a sufficient distance from the tumor, but pneumothorax failed due to our inability to maintain an airtight environment.

The da Vinci system was then introduced via the left side of the patient. Robotic instruments and a camera were inserted through the port, and both robotic instruments were crossed while avoiding collision (Fig. 2a). The master–instrument association at the surgeon console was set to the reverse of the default settings so that the right master controlled the left instrument and the left master controlled the right instrument (cross-arm technique). A 30° up camera was used to prevent any horizontal collision of the arms outside of the thoracic cavity.

EndoWrist Maryland Bipolar Forceps (Intuitive Surgical Inc.) connected to a VIO 300D electrosurgical unit (ERBE, Marietta, GA, USA) were mainly used to dissect

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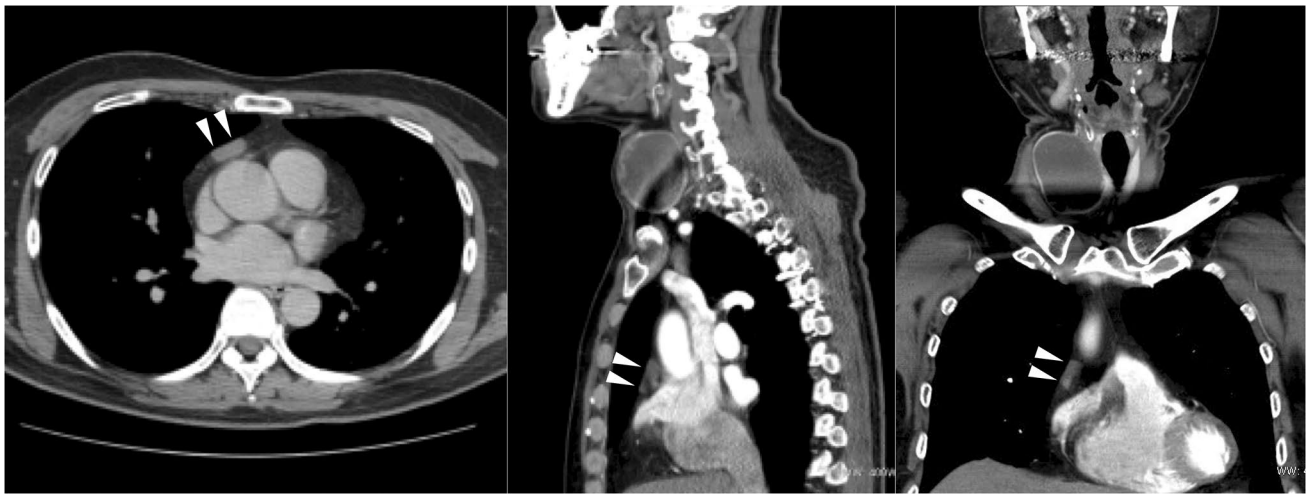

Fig. 1 Chest CT revealed a mediastinal mass in front of the ascending aorta

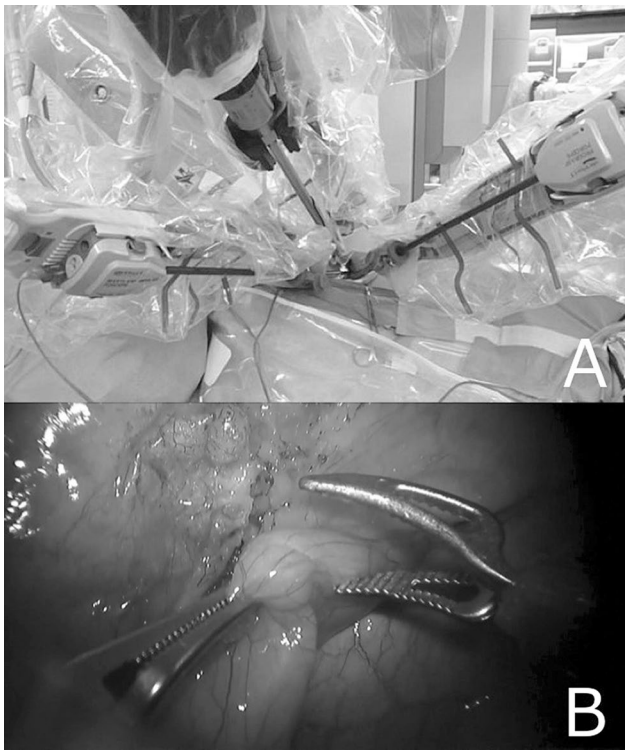

Fig. 2 Intraoperative view of robot-assisted single-port surgery for a mediastinal tumor. **a** da Vinci setup for single-port robotic surgery. **b** Intrathoracic view of single-port robotic surgery

the thymic tissue, as well as for cutting and coagulation (bipolar method) (Fig. 2b). The EndoWrist Prograsp Forceps (Intuitive Surgical Inc.) were used to grasp the thymic tissue. After the removal of the resected specimen using a bag, the port was closed in two layers without chest tube drainage.

Results

The operating time was 61 min for the thyroidectomy and 108 min for the robotic surgery. The patient's postoperative course was uneventful, and he did not require any analgesics, resulting in discharge on the third postoperative day (Fig. 3). A histopathological examination of the two specimens showed the neck tumor to be a 65 mm × 45 mm × 40 mm thyroid adenomatous nodule with a cystic lesion, and the mediastinal tumor was a thymic cyst measuring 8 mm in diameter.

Discussion

In the present case, the appropriate application of robotic technology allowed for robot-assisted VATS via a single port. Further enhanced minimally invasive surgery will be possible with the combination of the single-port concept and robot-assisted surgery. To our knowledge, this is the first report of robot-assisted single-port VATS. This technique will likely facilitate the development of a number of related procedures in the future.

Single-port VATS started with an initial report of thoracic sympathectomy in 2000 [3] and, more recently, has become an increasingly popular approach for treating thoracic surgical diseases [4]. Rocco et al. reported single-port VATS wedge resection of the lung in 2004 [5], and Gonzalez et al. performed the first single-port VATS lobectomy [6].

Ishikawa et al. reported on single-incision robotic surgery in an animal model with the cross-arm technique

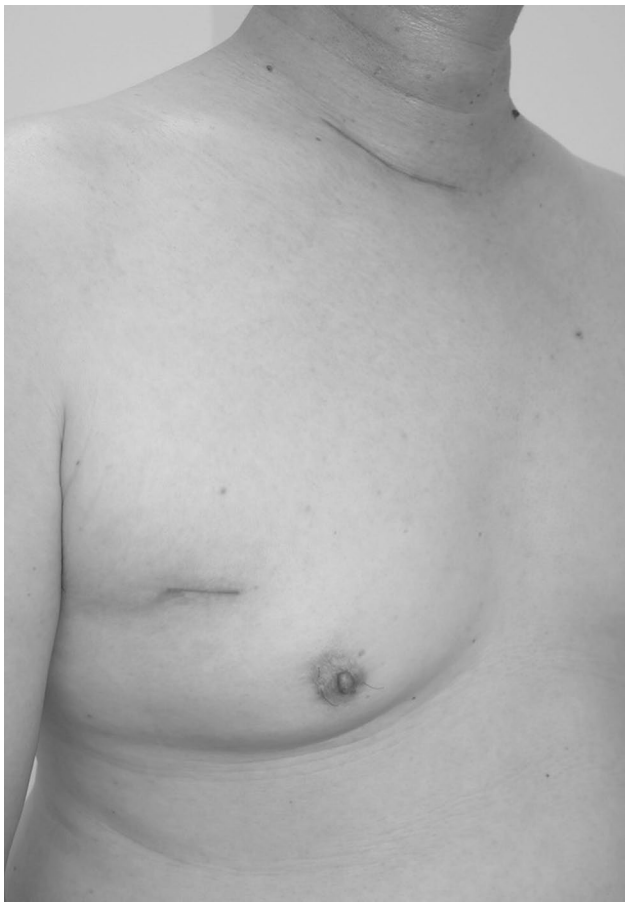

Fig. 3 Cosmetic outcome in a 50-year-old man 2 weeks after single-port robotic surgery and thyroidectomy

using the da Vinci system, and they concluded that this technique will contribute to the development of a number of procedures in the future [7]. Intuitive Surgical Inc. developed a single-site robotic platform, which will help address the limitations of endoscopic techniques. However, this platform is currently approved only for cholecystectomy. Furthermore, only a few dedicated instruments have so far been developed, and none have yet been equipped with wrist articulation, like the conventional da Vinci instruments.

The da Vinci system offers the computer-controlled manipulation of robotic instruments, which enables the surgeon to avoid forced reverse-hand manipulation simply by changing the settings of the master–instrument association at the surgeon console. Thanks to this cross-arm technique, the surgeon can manipulate the instruments intuitively by viewing what appears on the monitor without feeling a gap between the right and left arms, thereby avoiding collision between the outside arms of the robot. In the present case, the thoracic port was made on the same sagittal line of the tumor as far as possible from the tumor to avoid collision of the instruments in the thoracic cavity. Other advantages of the da Vinci system, such as three-dimensional visualization and accurate micromanipulation, may also prove useful for such surgeries in the future.

The limitations and indications of this robot-assisted single-port surgery should be discussed. While we are concerned about the distortion of the port by the wide horizontal movement of the instruments and camera during such surgeries as thymectomy, access to vertical and depth-directed movements may be beneficial in this procedure. Furthermore, the use of 5-mm instruments and an 8-mm camera can help keep the port small while still being suitable for this technique. In addition, 5-mm instruments have a larger wrist curve than 8-mm instruments, so each arm can achieve a greater insertion angle and better avoid collisions outside of the body. Regarding limitations associated with the operative field for tumor resection, safe and feasible resection is ensured with this procedure, regardless of the site or size of the tumor. This procedure will be superior to reduced port thoracoscopic surgery with respect to feasibility, maneuverability and dexterity.

Compliance with ethical standards

Conflict of interest Norihiko Ishikawa and the other co-authors have no conflicts of interest associated with this study.

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