EARLY EXPERENCE WITH UNIPORTAL ROBOTIC THORACIC SURGERY LOBECTOMY

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Introduction

Invasiveness is considered one of the cornerstones in every field of surgery due to less morbidity and faster postoperative recovery compared to open surgery. Video-assisted thoracoscopic (VATS) approaches are now routinely used worldwide to perform pulmonary resections, not just limited to standard procedures or early-stage lung cancer, but also in case of advanced stages requiring complex reconstructions (1, 2, 3, 4). In particular, from 2004 uniportal VATS (U-VATS) has progressively gained relevance in the thoracic surgery units, including our center, due to its invasiveness compared to multiportal approaches, without differences on feasibility and oncological outcomes (5, 6). Recently, robotic-assisted thoracic surgery (RATS) is increasingly becoming the preferred technique in many centers around the world. The main advantages are the 3D vision on operative field, the intuitive management and the easy maneuverability allowing safer and more accurate surgical acts due to the wristed arms and the use of bipolar energy and grasping in both hands (7, 8). However, RATS is routinely performed using 3 or 4 ports with at least one service incision (9), in contrast to the real concept of less invasiveness. The possibility to blend the uniportal approach with robotic technology would be an enormous improvement in terms of feasibility, safety, oncological outcomes and enhanced postoperative recovery. An update of the literature during the revision process of our paper showed a very recent description of the technique (10, 11) and a previous case report (12). Thus, considering our personal experience on U-VATS and standard robotic technique, we recently started our U-RATS program. Hereby we present our early series of U-RATS pulmonary resections for early-stage lung cancer focusing on feasibility, safety, surgical technique and early postoperative outcome.

Patients and Methods

Based on our experience with U-VATS and 4 ports robotic surgery, in January 2022 at IRCCS "G. *Pascale Foundation"* National Cancer Institute of Naples we started the U-RATS program. Twenty four consecutive patients (9 males and 15 females, mean age 64 $\pm$ 11 years) with lung cancer underwent anatomical pulmonary resections. All patients signed a standard informed consent because this approach has not an experimental purpose. Patient characteristics are reported in Table 1. Standard preoperative workup was performed including routine blood examinations, pulmonary function tests, arterial blood gas analysis, cardiological assessment, total body computed tomography (CT) and total body positron emission tomography (PET). In the majority of patients, whenever possible, a preoperative diagnosis of lung cancer was achieved by CT fine needle biopsy or fiberoptic bronchoscopy; in other cases, the diagnosis was intraoperatively confirmed after a wedge resection. Our standard pain control for minimally invasive surgery includes intraoperative nerve blocking of 3 to 4 intercostal spaces with 100 mg of local anesthesia (Ropivacain) performed at the beginning of surgery, followed by intravenous post-operative Ketorolac 90 mg/24 hours for two days, plus 1 gr of Paracetamol, if needed in selected cases. No opioid are routinely used. All surgical procedures have been performed at console by the same surgeon. In this report, we focus on surgical technical steps, feasibility and early postoperative outcome, including pain evaluation using the Numeric Pain Rating Scale (NRS), complications and functional recovery, evaluated at the outpatient visit by specific questions about life activities.

Surgical technique

All procedures were performed under general anesthesia with single-lung ventilation, using the *da Vinci Xi* robotic surgical system. The patient is placed in lateral decubitus as for a posterolateral incision and flexed to better expose the intercostal space. A 4 cm skin incision is made at the V or VI

intercostal space in the middle axillary line. The correct location of the incision is of paramount importance and it can vary based on the target of surgery and the chest shape. The incision must be as closer as possible to the vascular structures that must be resected. This allows to the robotic arms to be perpendicular to the target, limiting their conflict and optimizing the available space (Fig.1A). A soft wall protector is used to avoid an excessive trauma to the chest wall.
Three robotic arms are always used, and the trocars are directly anchored to the arms without any pressure valve. A 30-degree 10 mm camera is placed in the posterior edge of the incision as in U-VATS surgery and the other two arms are placed in the remaining space anteriorly. The operative robotic arms work crossing each other inside the chest, thus the right robotic arm will be the left surgeon's hand and the left robotic arm will be the right surgeon's hand, as shown in figure 2. With this setting, to avoid mirroring effect it is necessary to apply a reverse mode to the console touchpad, allowing the right hand to control the left robotic arm and vice versa. Gauze peanuts are freely inserted in the chest to be used to mobilize the lung, reducing parenchymal trauma and optimizing movements. A robotic Maryland Bipolar Forceps dissector is controlled by the right surgeon's hand and a Monopolar Fenestrated Forceps by the left surgeon hand. As usually, the assistant surgeon stands anterior to the patient handling the suction catheter, in the space between the three trocars. Suction catheter is not used only to suck fluids but mainly for retraction and exposure of structures. Vascular structures and pulmonary parenchyma are sutured with Sureform 45 Robotic Staplers® or with Hem-o-lok robotic clips. Lobectomy or segmentectomy are performed respecting the standard anterior approach (14) to the hilar structures and the fissureless technique (15), whenever possible. At the end of surgery, a single chest drain towards the apex is placed by the assistant surgeon.

Results

No intraoperative or perioperative mortality were observed. All procedures were completed with uniportal approach. We performed 22 lobectomies and 2 segmentectomies; systematic hilar and mediastinal lymph node dissection was accomplished in all patients but 3, the patients with secondary lesions (laryngeal and cervical cancer metastasis). Mean operative time at console including docking was 210 $\pm$ 63 minutes (range 120-350) (Table 2); in the last 10 cases the operative time was significantly reduced (180 $\pm$ 30 minutes) compared to the first 14 cases (232 $\pm$ 72 minutes) (p=0.02). No patient required blood transfusion and mean blood loss was 110 $\pm$ 35 milliliters. No patient required adjunctive administration of drugs to control postoperative pain, respect to our standard therapeutic strategy and no opioid drugs were administered. Furthermore, the mean score of NRS measured at the first postoperative day was 2.6 ($\pm$ 0.6), at third day was 1.6 ($\pm$ 0.7) and at discharge was 1.3 ($\pm$ 0.4), showing a constant decreasing. In 4 patients (16.7%) minor complications occurred: 1 prolonged fluid leak (> 350cc/day) solved spontaneously at day 6, 1 prolonged air leak solved spontaneously at day 8 and 2 atrial fibrillation treated with pharmacological cardioversion. Mean length of hospital stay was 5.2 $\pm$ 1 days (range 3-9). All patients performed an outpatient visit after 30 days from discharge and in all cases the functional recovery ranged from satisfactory to good; only two patients referred mild local paresthesia.

Discussion

Typical weakness of lung cancer patients had led surgical community to look for less invasive techniques. Nowadays U-VATS is the less invasive approach available in thoracic surgery and can be applied to the majority of thoracic surgery procedures, including broncho-vascular resection and reconstruction (3-4). Nevertheless, RATS experience is growing in many Thoracic Surgery Centers due to well know advantages such as 3D vision, lack of physiological tremor, stability of the camera

and a shorter learning curve compared to VATS. However, RATS technique is always described with 3 or 4 incisions plus a utility incision of 4 cm, resulting certainly more invasive than the uniportal incision used in U-VATS (13) and uniportal RATS is exclusively a newborn technique that is growing nowadays (10, 11, 12).

According to our experience with U-VATS and borrowing from the experience described in the literature (10, 11, 12), we started a Uniportal RATS program at the IRCCS *"Pascale Foundation"* National Cancer Institute of Naples.

The great maneuverability and adaptability of the *da Vinci Xi* robotic system® allows many tailored configurations that are of paramount importance using the system through a uniportal access. Docking the system in U-RATS is certainly faster than in standard RATS because of the single incision, but it should be performed very carefully to avoid potential fighting between the robotic arms. This can be obtained respecting a 10 cm distance between the robotic elbows and a working angle with the chest wall greater than the ones in U-VATS. As the operative arms must crossing each other inside the chest (Fig. 2), to avoid damage to the ribs, it is mandatory to work as much perpendicular to the target as possible. For this reason, differently from U-VATS in whom the instruments enter the chest wall anteriorly with a 45° angle, the surgical incision of U-RATS should be more posterior to allow the arms to work with a mean 70° angle with the chest wall (Fig 1A-B). Due to the intra-cavity crossing of the instruments, at touchpad console, the control setting should be modified changing the arm control, allowing the right master to control the left robotic arm and vice versa. Large movements of masters during surgery should be limited to avoid arms conflict.

Respecting these rules, vessels isolation is easy and always possible without any vessel tension or damage. However, the most time-consuming step of the procedure, in our experience, is represented by the vascular stapling, due to the dimensional mismatch between robotic staplers and thoracic anatomy. Most of all, left upper lobe artery branches or minor right upper lobe branches, can be safely managed with robotic Hem-o-lock clips applier, being smaller and easier to be introduced in the chest. Although the use of 45 Sureform Robotic stapler® is feasible, it is not easy to approach the vessels, avoiding external conflicts between arms and, of course, avoiding tension to the vessels. In this scenario, the best equilibrium can be found balancing the correct stapler angle with a counter-traction of the underlining lung parenchyma. The use of 30 Endowrist curved tip stapler® could be certainly helpful, but unfortunately was not available in our Institute, during the study period.

In our opinion, the learning curve of this technique in U-VATS experienced surgeons is quite fast and we found a significative shortening of the surgical time in the last ten cases ($p= 0.02$), thus confirming the well-known rapid learning curve of robotic surgery. We did not record any intraoperative complication that needed conversion, but in the case, the switch from U-RATS to U-VATS or thoracotomy is certainly quicker than in standard RATS, because to remove three arms from a single incision is very fast, without jeopardizing the safety of the patient.

The advantages of RATS have been extensively described in the literature (16, 17, 18) and were not the focus of our paper, but our experience with both techniques, U-VATS and RATS, showed a better postoperative pain control in U-VATS than in RATS patients. Starting from this statement and according to the frailty of our patient's population, we decided to evaluate the feasibility and the efficacy of U-RATS technique, combining the advantages of U-VATS to the well know advantages of RATS.

The evaluation of NRS scale was satisfying in our series and comparable to U-VATS patients in the early post-operative time as well as one month later, confirming that the number of chest incisions is directly related to the post-operative pain, supporting the early recovery.

This technique needs certainly to be tuned with a bigger patient's population but in our early experience we can conclude that U-RATS is certainly safe, feasible and comparable to U-VATS in

terms of post-operative pain results. It remains a time-consuming technique but the learning curve for skilled U-VATS surgeons is quite fast; furthermore, new suturing devices could simplify the surgical steps with a standardization and worldwide spreading of U-RATS.

Figure 1: A. U-RATS. Incision in middle axillary line with trocars perpendicular to the target
B. U-VATS. Incision anterior with trocars tangential to the target

Figure 2: A. External trocars vision
B. Vision of instruments crossing inside the chest

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