Robotic segmentectomy S7 + S8 with the use of indocyanine green (ICG): technical details

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Abstract: In the last few years, segmentectomy has become a popular alternative procedure with curative intent to standard lobectomy in selected cases, like peripheral ground glass opacities (GGOs) less than 2 cm or patients non suitable for lobectomy. In the setting of a minimally invasive surgery, use of the robotic system Da Vinci has proved to be a safe and feasible approach with better dexterity and lower length of stay compared to video-assisted thoracic surgery (VATS). Moreover, intravenous administration of indocyanine green (ICG) during surgery dramatically improve identification of targeted segment(s) thus sparing a certain amount of healthy lung with better conservation of respiratory function. We hereby show a step-by-step guide to perform a robotic-assisted segmentectomy of right S7 + S8 with the use of ICG for intersegmental plane identification.

Keywords: Segmentectomy; minimally invasive thoracic surgery; robotic; indocyanine green (ICG)

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Introduction

Since the introduction of the video-thoracoscope in 1990, minimally-invasive surgery has become a standard in early stage lung cancer thank to same long-term survival, less morbidity and shorter length of stay compared to open surgery (1). However, video-assisted thoracic surgery (VATS) suffer from 2-dimensional (2D) vision, long learning curve and restricted instrument's maneuverability thus leading to counterintuitive movements (2). Plus, use of low-dose CT scan allows detection of lung cancer at early stage and subsequently smaller in size (3). This rise questions about the modality of treatment of these lesions, that may be feasible of a more conservative approach such as segmentectomy. In this scenario VATS approach may be very challenging, leading surgeon either to choose a standard lobectomy or performing segmentectomies by open surgery. Robot-assisted thoracic surgery (RATS) can overcome these limitations thank to 3-dimensional (3D) visualization, shorter learning curve and better dexterity with same outcome and complications rate as compared to VATS (4). Moreover, RATS allow a shorter length of stay with even a cost-saving balance for the Institute (5). Intraoperative administration of indocyanine green (ICG) can also improve the visualization of intersegmental plane, reducing the inter-operator variability and increasing the safe margin (6). We hereby describe the technique for an S7

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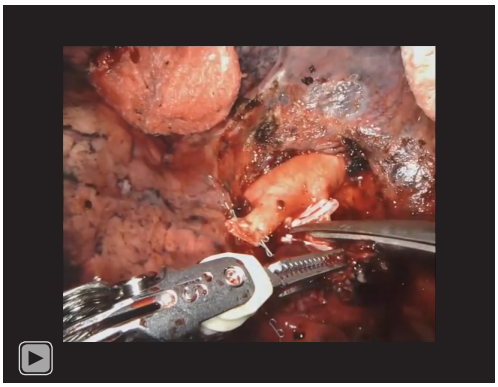

Video 1 A S7 + S8 segmentectomy step-by-step procedure with 3D bronchoscopy and vessels rendering.

+ S8 right lower segmentectomy with the use of ICG.

Surgical technique

Preoperative planning

The "Illustrated anatomical segmentectomy for lung cancer" atlas by Nomori and Okada is a reference text when planning this sublobar surgery, with a lot of very useful tips and tricks (7). Segmental bronchial and vascular supply is often subject to variations, as described by Gossot in his paper (8). Pre- or intra-operative bronchoscopy is a very useful tool for detection of any abnormality in the bronchial tree and multirow detector CT scan (MDCT) along with administration of intravenous contrast allows a better visualization of vessel anatomy and multi-planar reconstruction (MPR) offer sagittal and coronal views of the targeted arteries and veins (9). Surface and volume rendering softwares are game changers in this type of surgery, creating an explorable 3D model which can be even printed using a commercial 3D-printer (10).

Patient positioning and port placement

As for VATS, patient is placed in a lateral position along with hip flexed and pelvis fixed to operating table for more stability throughout the entire procedure. A 3–4-cm utility port is crafted at the IV or V intercostal space (ICS) on the anterior axillary line, while a camera-port is positioned at the VII ICS on the mid-axillary line. This position may be more lateral on the left side to avoid interference with the heart. Other 2 incisions are performed for the remaining arms at the level of VIII ICS on the tip of the scapula line and in the auscultatory triangle. CO_2 insufflation is not needed, with the only exception of obese patients, hyperinflated lung or high diaphragm.

S7 + S8 segmentectomy

Operation begin with the opening of the fissure and identification of A7 and A8 branches, which usually arise from the anterior face of the main PA and distally to A6. Before ligation and division of the arteries, check for the preservation of A4 and A5 arteries for the middle lobe. Beneath the transected vessels, station 11 lymph node are found around the targeted bronchus. Before stapling is possible to verify the correct segmentary bronchus with the use of intraoperative bronchoscopy and near infra-red (NIR) vision with Firefly™ mode, which allows the operator to see the bronchoscope tip-light through the bronchial tree as a greenish dot. Once vessels sutured, an intravenous bolus of 6–8 mL of diluted ICG (2.5 mg/10 mL) followed by a push of 10 mL saline solution is administered. With Firefly™ mode on green glow appears from mediastinal and lung tissue within 30 seconds from infusion, with maximum intensity in about a minute and fading slowly afterwards. Targeted segment appears with no enhancement and clear limit from remaining lobe in clearly visible. At this point, surgeon can easily mark the limits of intersegmental plain using bipolar forceps equipped on one arm by spot coagulation on transition line. Restoring normal view on our camera, completion with linear stapler is possible just following the marks we previously made on parenchyma (*Video 1*). Division of the pulmonary ligament and identification of the inferior pulmonary vein along with its segmentary branches its usually not required in this surgical approach. After removal of surgical specimen, the tumor is open to ass the distance from the margins, in selected cases frozen section of the margin is required to the pathologist. At the end of procedure, sterile saline solution is instilled inside chest and lung in inflated to check any air-leak on suture line. If present, aerostatic agents like collagen patch (Tachosil®) or cyanoacrylate vaporized glue (Glubran®) can be applied on parenchyma with effectiveness (11). Hemostasis of incisions is performed by extracting and checking ports one by one using equipped camera on Da Vinci from inside. A single chest tube is positioned through lowest incision and is usually sufficient to drain both air and liquid.

Conclusions

Segmentectomy is one of the greatest challenges of our time

in thoracic surgery, aiming to obtain excellent oncological results and preserving lung function. Ongoing trials will prove whether or not segmentectomy is equivalent to lobectomy in early stage lung cancer, until then indications to sublobar resection are limited to patients with <2 cm peripheral subsolid lung cancer, poor lung function or other comorbidities, multifocal lesions and lung resection after prior lobectomy (12-14). RATS is superior to VATS in terms of 3D visualization, ergonomics for the operator, maneuverability of instruments, tremor filtering and learning curve (15). Moreover, Toker *et al.* showed that with RATS is possible to harvest more N1-level lymph-node station although there is no difference in the number of lymph-nodes per station dissected compared to VATS or open approach (16). On the other side, initial cost of the Da Vinci surgical system is the main limitation to the widespreading of the robotic-aided segmentectomy, even if the cost-per-patient is inferior mainly due to a shorter in-hospital stay (5,17). In the next years, this limitation will be probably overcome by the introduction in the market of robotic surgical system manufactured by other companies. We may expect, also, a reduction in terms of cost for the disposable instrumentation thank to third-party supplier or refurbishing services (18).

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Footnote

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