



Four arm robotic double right segmentectomies S3 & S7–10 with fluorescence lung mapping

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Abstract: Segmentectomy is an increasing topic in the era of telemanipulation surgery as these advanced procedures require hand-wrist skills and visual control to be properly done. This procedure can be more challenging than lobectomy as it requires more hilum dissection and an accurate intersegmental plan definition. Despite the development of techniques and tools in the past decade, there is no change yet in gold standard for lung carcinoma resection. Nevertheless, tumor size less than 2 cm, N0 status and lung sparing needs are accepted conditions to perform segmentectomy rather than lobectomy. We present here a case of a 66-year-old woman who was diagnosed with two suspected metachronous lung carcinomas cT1N0M0 of right S3 and right basal pyramid revealed by hemoptysis. In this situation, the double segmentectomy was considered as the best strategy to avoid a right pneumonectomy for multiple stage 1 carcinomas. We describe and discuss the technical steps of the procedure using a four-arm completely portal approach with a Xi system (Intuitive SurgicalR, California) and the use of near-infrared fluorescence with indocyanine green intravenous injection for inter-segmental plan definition. In the step-by-step video we emphasize on the bimanual sewing and knotting technique to ensure a controlled and safe dissection as to reproduce an open surgery technique in a closed chest.

Keywords: Lung carcinoma; robotic surgery; ground glass opacity; segmentectomy; fluorescence

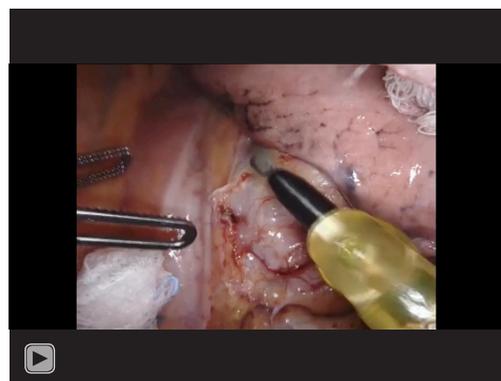
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Lung segmentectomy is an increasing topic in thoracic surgery. Either for ground glass lesion or at risk patient in purpose of lung sparing with anatomical resection and node harvest. The technology advances in imaging and surgical techniques are accompanying this rise as it offers pre-operative planning and per operative technical condition to perform a rigorous anatomical control and section of bronchial and vascular structure. The hand-wrist tool of the four-arm telemanipulation system gives the opportunity to the surgeon to realize open surgery approach and dissection. The benefit of minimal invasive surgery is well accepted and the debate between lobectomy or segmentectomy for less than two centimeter N0 lesion has shown equivalence in long term survival (1). Technical mastering of the tool and anatomical comprehension of patients anatomy are key points of these procedures setting.

We describe and present a video of a 66-year-old woman,



Video 1 4-arm robotic double segmentectomy right S3 & S7–S10.

heavy active smoker (40 packs per year) who was diagnosed with two suspected metachronous primary lung cancer stage 1 in the right lung (*Video 1*). The biggest lesion was a solid

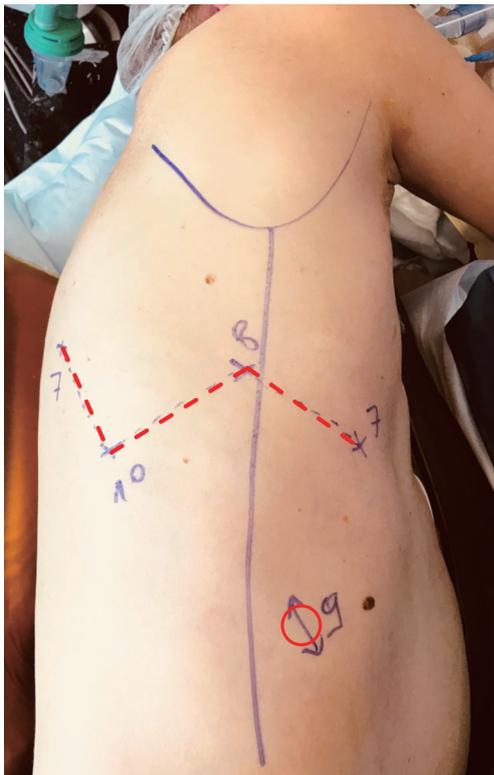


Figure 1 Port position for the right side approach, camera port in the 8th inter costal space (ICS), right hand in the 7th, left hand in the 10th and the third hand in the 7th with a decay of at least two fingers closer to the spine, the 15 mm port access is in the 9th ICS at the diaphragm insertion. The dot line shows the partial W shape of the setting.

17 mm nodule in the basal pyramid 3.6 SUV and the second one was in segment 3, centimetric and partially ground glass 1.4 SUV lesion. Regarding the N0 status and to avoid a right pneumonectomy for stage 1 multiple lesions, we considered performing a double segmentectomy of S3 and S7 to 10 with radical node harvest of the right lung using a 4-arm Da Vinci Xi system.

The robotic setting has been previously described (2,3). The port placement is shown in *Figure 1*. The same robotic setting is used whatever the procedure, as the same target zone are used either for hilum dissection or node harvest.

In our technique, we do not use any utility incision. As the procedure is done with a preserved and closed chest we can use insufflation (low pressure 5 mmHg) to enhance lung deflation and also be almost autonomous from the console to realize the procedure. As for now, and for some technical and cost reasons we do not use the robotic stapling.

First, as shown in the video, the axes of stapling for such procedure come from anterior and posterior side. The robotic stapler requires a 12-mm port, meaning we would have to use two of them for both right and left hand ports. The posterior port might be harmful for the patient, especially in women with smaller intercostal spaces. Second, in France the cost of robotic stapler is not affordable compared to the other stapler. This part of the procedure is therefore delegated to the assistant. The voice control from the surgeon leads the action of the stapler using simple code adapted to the image frame: forward/backward, clockwise/anticlockwise, up/down, left/right. The instruments also help to control the movement, bending, placement and stabilization of the stapler. The bending of the stapler matters, as does the axis of entrance for safety and quality purpose. The axis of the instruments must always be adapted to the axis of anatomical structures and not the opposite to avoid the risk of tissue or vessels tear described by Decaluwe *et al.* for video assisted thoracic surgery (4).

The strategy of resection was to realize all vascular and bronchial sections or ligation of both segments and to open their inter-segmental plans at last, in a row, after indocyanine green (ICG) injection (*Figure 2*). ICG is one of the last technical advances accompanying the rise of sublobar resection. The first application in thoracic surgery was described in 2010 (5). Its use is spreading and varies from nodule detection, segmental plan definition and even sentinel node detection. For lung mapping, a recent phase 2 study showed that the oncologic margin is increased by ICG use for segmentectomies (6). Two recent reviews report various ICG doses. The first, from Matsuura *et al.* paper report from 0.25 to 3 mg/kg (7). Okusanya *et al.* report 5 papers on the use of ICG for inter-segmental plan identification, and the range dose used were from 3 to 5 mg/kg (8). They also mention that for safety reason, as some anaphylactic shock have been described, the higher dose must not exceed 5 mg/kg. Nevertheless, there is no consensus on the dose to inject. Cerfolio's team describes the double use during a procedure. Firstly, for nodule detection, using a low dose injection through endobronchial navigation (0.5 mg) before surgery. And secondly, for lung mapping after segment dissection, then, they inject the rest of the bottle, that to say 9.5 mg (9,10). As the conditioning of the product is a 25 mg-bottled powder of ICG, in a simplification purpose, and after testing different doses, we have accepted a dose of 8mL for each patient, whatever the weight or sex, which means 20mg of ICG. A non-previously published detail that matters is the time of assessment of the plan after the

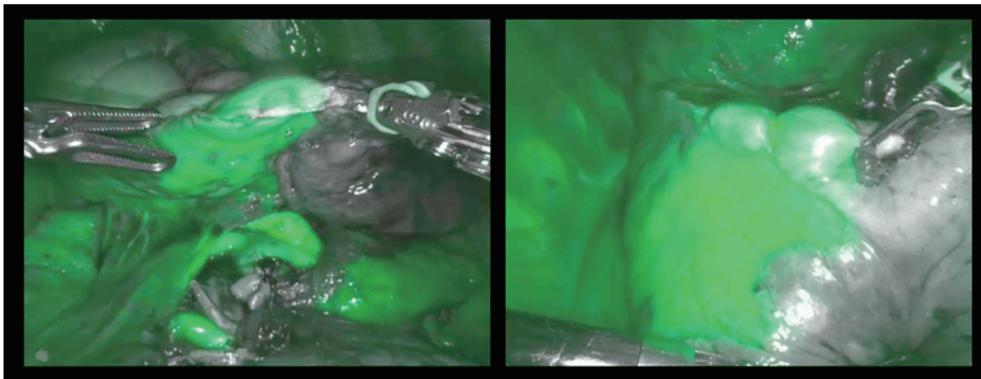


Figure 2 Intersegmental plan definition after ICG perfusion and Firefly™ vision, left image S2/S3 plan and right image S6/S7–10 plan. ICG, indocyanine green.

injection (*Figure 2*). In our practice we have stated to wait 20 seconds with no scientific but empirical underlying. In fact, after a longer period, we have experienced some spreading of the product, especially due to lung manipulation, even as gentle as gauze pushing of the parenchyma. Moreover, cardiac output after few minutes washes out the product. We also advise to check this partial wash out of ICG at the end of the procedure to be sure of the venous patency on the remaining segments. Peripheral lung dystrophy impairs ICG diffusion as the concentration of vessels is lowered in those emphysematous sectors. Thus, the use of double check; ventilation and ICG perfusion, might increase ICG low vision in those patient and therefore must be avoided.

During such procedure, the frozen section of the lobar and inter-lobar nodes is mandatory to assess a N0 status. As shown on the video, the CT scan was revealing multiple nodes in 4R, 10, 11 and 12 (for each lobes) zones. For timing question, the radical node harvest of those zones was not shown in the video but was obviously done to confirm the N0 status. It is very important to avoid clinical upstaging for those patients as it appears to be a risk factor of cancer related death as reported by Nguyen *et al.* (1).

Our robotic setting and operative conduct is standardized and applied whatever the resection scheduled, making it simple and reproducible. The partial W setting of the robotic ports allows a visual and conflict less instruments control of the whole chest cavity target zones with a 30-degree camera. As stated in the video, the placement of the third arm is critical as its use is mandatory for advanced procedures. Its position is higher than the left hand port and at least two-finger width closer to the spine. Thus, no conflict is encountered between the two back instruments.

The third hand is a key for exposition, as it stabilizes the visual field. Due to 10-time magnification and the heartbeat, movements in the chest are emphasized. As the vessel dissection is more advanced for those procedures, the exposure and non-direct lung stabilization are essential for a safe and controlled vascular dissection. The “manual” ligation of vessels is also a key point for safety concern, as the versatility of the hand-wrist instruments allows to respect the axis of the vessel whatever its direction, and for hard skills concern, as it warrants a routine realization of fundamental gesture for thoracic surgeon.

As a conclusion, mastering of the tool is mandatory for performing such advanced procedures. The more distal the dissection is the more “manual” targeting and ligation of vessels are required. Fluorescence imaging is the best tool so far to define an accurate inter-segmental plan after section of vascular and bronchial structures. Multiple segmentectomies is an interesting option for N0 patients with multiple ground glass opacities or less than 2 cm lesion in different lobe to avoid pneumonectomy.

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