Teaching video-assisted thoracic surgery lobectomy—using an *ex vivo* simulation model

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Abstract: Video-assisted thoracic surgery (VATS) is gradually replacing conventional open thoracotomy as the standard approach of many lung resections and thoracic surgical trainees and experienced surgeons must learn and master this technique. Simulation based training may be a good option to acquire or improve these advanced skills, however realistic and inexpensive simulators are not accessible or commercially available. We developed a low cost and hi fidelity simulation model using porcine heart-lung blocks.

Keywords: Video-assisted thoracic surgery (VATS); lobectomy; simulation; training

Introduction

The use of video-assisted thoracic surgery (VATS) has significantly increased in the past decades and nowadays it is considered the standard approach for many thoracic procedures, including some lung resections due to the clear evidence of improving patient outcomes (1-6). However, the thoracoscopic approach for anatomical lung resections is only used in a minority of patients (7) due to technical challenge for surgeons' especially surgical trainees and those surgeons having been trained before the exponential development of VATS. It is considered that an experienced consultant thoracic surgeon requires 30 lobectomies to obtain competence and to perform quality surgery; however, efficiency (shorter operative time and lower conversion rate) is obtained after 90 lobectomies (8). Learning tools such as observation of live surgery, surgical videos, and different types of simulation consisting of black-box training, wet lab or 3-D tailor made virtual lung are effective in the learning process, but time consuming, expensive and not accessible for all surgeons (9,10). For these reasons, we have developed an inexpensive, realistic and reproducible VATS lobectomy simulator.

VATS simulation model

Material

We use porcine heart-lungs tissue blocks which are commercially available in any pig slaughterhouse. They are harvested from animals previously slaughtered for human consumption. These blocks include the heart with intact pericardium, both lungs, the trachea and the oesophagus. We usually purchase 10–15 blocks and we preserve them in a freezer. The day before using the block, we take it out to allow the defrosting. Of course, the best quality tissue is obtained by using the "fresh" model; however the unfrozen blocks are also acceptable even if we lose some tissue qualities like elasticity. This method allows us to make use of the blocks whenever we want. The cost of each block is around 1€. Additional materials include 150 to 200 mL of generic brand ketchup, some drops of food coloring, two syringes and two silk sutures with an approximated total cost of 1€.

Model preparation (Figure 1)

To prepare the model, all mediastinal structures are preserved to create a realistic feel of intact hilum and mediastinum. The left upper lobe of the model is chosen for teaching how to perform a lobectomy for several reasons: (I) its anatomy is very similar to the human anatomy; (II) the right upper lobe bronchus comes directly off the trachea several centimeters above the carina, which makes difficult the dissection of the hilar structures; (III) the left upper lobectomy is often considered the most difficult to perform

Figure 1 Video-assisted thoracic surgery (VATS) lobectomy using an *ex vivo* simulation model. The first section of the video shows the model preparation. Next, the technique for performing the left upper lobectomy is shown (11).
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due to the second and third arterial branches, which can be difficult to visualize and treacherous to dissect, so that it can help to improve surgeon's skills.

All preparation and perfusion of the model is performed from the inside of the pericardium. The model is placed in a table in a supine decubitus position; the pericardium is opened and is reflected above the great vessels exposing the left side of the left atrium and main pulmonary artery.

❖ Preparation of the simulated blood. The perfusate is then prepared. We use colored red ketchup to simulate oxygenated blood and colored blue ketchup to simulate non-oxyginated blood. The thickness of ketchup is adequate to fill the lumen of all vascular system and, in case of injury, the leakage would be easily identificated by the appearance of pressurized ketchup in the operative field;

❖ Dissection of the left pulmonary artery and upper left pulmonary vein. The bifurcation between the left and right pulmonary arteries is identified. The left pulmonary artery is then dissected at the bifurcation and a 0-silk suture is passed around it. The left side of the left atrium is then dissected to encircle the upper left pulmonary vein in a similar fashion. Dissection is intentionally performed as far as possible away from the left hilum to retain the appearance of the mediastinum;

❖ Filling the pulmonary vascular beds. An arteriotomy is created on the main pulmonary artery and a catheter-tip syringe used to inject approximately 60 cc of the blue perfusate into the left pulmonary artery. As the

syringe is removed, the silk suture is tied to prevent back flow of the perfusate. An arteriotomy is then created at the base of the left atrial appendage. The catheter-tip syringe is used to inject approximately 60 cc of red perfusate into the upper left pulmonary vein and the suture around the left side of the left atrium is tied. The amount of perfusate needed is somewhat dependent on the size of the tissue block. Perfusate is injected until there is mildresistance, and appropriate distention of the vessels is confirmed by palpation at the hilum. Although you must consider that the perfusate spread to small branches after several minutes and the resistance and distention can decrease over time;

❖ Placement of the block in the simulation box. After preparation, the tissue block is placed with the left lung up in a thoracoscopic reusable training box. The tissue block is placed on an absorbent pad inside the box and held in place by its own weight requiring no formal fixation to the box for stability. We use a cubic black box of 40 cm of side which are usually used to keep the healthcare waste. Several holes can be cut in a side of the box to simulate the different combinations of incisions used in thoracoscopic lobectomy and to insert the camera. Although we have ordered a 3D printed thoracoscopic training box with ribs and simulated skin, the black boxes meet the original principle of an inexpensive system.

Total model preparation time is between 5 and 10 minutes per block.

Technique (Figure 1)

Steps to perform the left upper lobectomy:

❖ Dissection and division of the left superior pulmonary vein;

❖ Dissection and division of the first branch of the left pulmonary artery;

❖ Dissection and division of the left upper lobe bronchus;

❖ Dissection and division of the second branch of the pulmonary artery;

❖ Division of the parenchyma.

We considered that the simulator must be used as much as possible, but we recommend it to be used at least once per week by surgical trainees and we have the policy that a surgical trainee needs to complete at least 25 simulated lobectomies before starting VATS training in real patients. Besides this program can be a perfect complement to other

simulators, like virtual simulators or black boxes.

Conclusions

We have developed a teaching program based on training sessions with a simulation model which has been integrated in our team as a part of an incomprehensive plan of VATS lobectomy education. This model is an accessible, easy-to-prepare, low cost, hi fidelity and reproducible tissue simulator which allows for effective instruction to surgeons with widely varying levels of operative experience.

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None.

Footnote

Conflict of Interest: The authors have no conflicts of interest to declare.

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