The role of wet lab in thoracic surgery

Benedetta Bedetti[1], Philipp Schnorr[1], Joachim Schmidt[1], Marco Scarci[2]

[1]Department of Thoracic Surgery, Malteser Hospital, Bonn, Germany; [2]Department of Thoracic Surgery, University College of London Hospitals, London, UK

Contributions: (I) Conception and design: B Bedetti, M Scarci; (II) Administrative support: J Schmidt; (III) Provision of study materials or patients: P Schnorr; (IV) Collection and assembly of data: M Scarci; (V) Data analysis and interpretation: B Bedetti; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Benedetta Bedetti. Department of Thoracic Surgery, Malteser Hospital, Von-Hompesch-Straße 1, 53123 Bonn, Germany. Email: benedetta.bedetti@gmail.com.

Abstract: During the last three decades, minimally invasive surgery has become common practice in all kinds of surgical disciplines and, in Thoracic Surgery, the minimally invasive approach is recommended as the treatment of choice for early-stage non-small cell lung cancer. Nevertheless, all over the world a large number of lobectomies is still performed by conventional open thoracotomy and not as video-assisted thoracic surgery (VATS), which shows the need of a proper training for this technique. Development and improvement of surgical skills are not only challenging and time-consuming components of the training curriculum for resident or fellow surgeons, but also for more experienced consultants learning new techniques. The rapid evolution of medical technologies like VATS or robotic surgery requires an evolution of the existing educational models to improve cognitive and procedural skills before reaching the operating room in order to increase patient safety. Nowadays, in the Thoracic Surgery field, there is a wide range of simulation-based training methods for surgeons starting or wanting to improve their learning curve in VATS. Aim is to overcome the learning curve required to successfully master this new technique in a brief time. In general, the basic difference between the various learning techniques is the distinction between "dry" and "wet" lab modules, which mainly reflects the use of synthetic or animal-model-based materials. Wet lab trainings can be further sub-divided into *in vivo* modules, where living anaesthetized animals are used, and *ex vivo* modules, where only animal tissues serve as basis of the simulation-based training method. In the literature, the role of wet lab in Thoracic Surgery is still debated.

Keywords: Wet lab; thoracic surgery; education

Introduction

During the last three decades, minimally invasive surgery has become common practice in all kinds of surgical disciplines (1,2). Minimally invasive thoracic surgery is increasingly replacing open thoracotomy and recommended as the treatment of choice for early-stage non-small cell lung cancer (3). Nevertheless, all over the world a large number of lobectomies is still performed by conventional open thoracotomy and not as video-assisted thoracic surgery (VATS), which shows the need of a proper training for this technique (4). The VATS approach can be performed through multiple or single port. The use of this technique has proven to have a better tolerance for the patients, providing a faster postoperative recovery, less pain and fewer complications (5,6). Development and improvement of surgical skills are not only challenging and time-consuming components of the training curriculum for resident or fellow surgeons, but also for more experienced consultants learning new techniques.

The rapid evolution of medical technologies like VATS or robotic surgery requires an evolution of the existing educational models to improve cognitive and procedural

skills before reaching the operating room in order to increase patient safety (7). In addition, recent changes in the European Working Time Directive have led to the implementation of new standards in the working time pattern, decreasing the time for teaching residents in the operating rooms (8). All that indicates the urgent need for a more structured and focused training for the new emerging techniques.

Nowadays, in the Thoracic Surgery field, there is a wide range of simulation-based training methods for surgeons starting or wanting to improve their learning curve in VATS. Aim is to overcome the learning curve required to successfully master this new technique in a brief time.

In general, the basic difference between the various learning techniques is the distinction between "dry" and "wet" lab modules, which mainly reflects the use of synthetic or animal-model-based materials (9,10). Wet lab trainings can be further sub-divided into *in vivo* modules, where living anaesthetized animals are used, and *ex vivo* modules, where only animal tissues serve as basis of the simulation-based training method. In the literature, the role of wet lab in Thoracic Surgery is still debated.

Dry lab

The advances in the experience with minimally invasive techniques and the introduction of new instrumentation that needed to be tested in a non-clinical environment and eventually discussed or improved by technicians or bio-medical engineers have led to the evolution of dry laboratories. These working environments are providing simulators such as box trainers and virtual reality (VR) simulators (11). But where laparoscopic surgery has undergone a rapid evolution of the simulation-based training methods for the training and assessment of technical skills in general surgical procedures, the parallel development of models for minimally invasive thoracic surgical procedures has not arisen in the same manner. The reasons behind this are probably multifactorial. Thoracic procedures are less standardisable and less frequently performed compared with their general surgical equivalents. Also, the number of residents trained is way smaller than in the general surgical programs. These aspects generate financial challenges for industries interested in developing such technologies (12). Regarding the Thoracic Surgery training, some studies aid the incorporation of VR simulation into established surgical training programs. For example, Solomon *et al.* tested the trainees on a VATS

right upper lobe resection simulation using a dedicated simulator for Thoracic Surgery procedures. They proved that VR simulation could reduce some of the limitations of existing training models (13). In general, various surgical simulators at different stages of development, assessment, and commercial manufacturing have been in use to date and more has to be done in this field in order to establish the importance of this kind of training for thoracic surgeons (14). Nevertheless, the reality and accuracy provided by wet labs is still not comparable to other kinds of simulation.

Wet Lab

VR simulation is a good teaching strategy, as it provides the chance of monitoring important surgical features, like economy of movement and tissue handling. Unfortunately, VR simulation systems are not a resource available in any center. Otherwise, using wet labs as teaching tool is often avoided because of the ethical concerns that are arisen by the employment of living animals in order to exercise surgical skills.

The use of animal tissues for teaching basic surgical skills is highly appreciated by medical students and trainees and it has been proved that its use improves greatly the learning of basic and advanced surgical techniques (14). The simulated environment of the wet lab is an ideal training platform, because the differences in animal anatomy promote critical thinking and knowledge retention in a risk-free clinical scenario (15). Wet labs can have a different educational focus accordingly to the experience of the group, who is working with it: students can learn basic surgical techniques, trainees and consultants can practice advanced surgical procedure like VATS lobectomies. Consequently, the aims of each wet lab can be modeled on the abilities and knowledge of the participants to increase the educational benefit and the utility of the acquired skills (16).

Swine is the most common category of animals used for this purpose. Sheep or dogs are also reported to be in use in some countries, in which the use of these animals for medical experimentation is permitted. The employment of swine in the teaching of surgical skills has spread in the last years and probably this practice will expand in the future due to the impossibility in most countries of using dogs in animal labs (17).

Swine have been already used for training in gastrointestinal, gynecological and cardiovascular surgery. Particularly in the thoracic surgical field, swine wet labs have shown some surgical learning advantages for residents

Video 1. Video showing the use of the 3D printed lungs in a session of video-assisted thoracic surgery (VATS) training

Benedetta Bedetti*, Philipp Schnorr, Joachim Schmidt, Marco Scarci

Department of Thoracic Surgery, Malteser Hospital, Bonn, Germany

Figure 1 Video showing the use of the 3D printed lungs in a session of video-assisted thoracic surgery (VATS) training (21). Available online: http://www.asvide.com/articles/1502

in *Thoracic Surgery* (18). The pig is not the ideal animal model, as it has a very small and short chest when compared with its whole size and the employment of bigger swine does not change the proportions. In fact, pigs heavier than 30 kg develop more muscles but do not significantly increase the size of their rib cage, so there is a smaller working space. Furthermore, the pleura and the parenchyma are very friable and may be easily torn causing bleeding. Sheep's anatomy is more similar to human anatomy as their chest is bigger, but sheep are more expensive and so less used.

Tedde *et al.* wrote in 2015 an interesting paper about their experience in swine wet lab for left VATS upper lobectomy (19). In this study, 40 swine were employed in a wet lab teaching video-assisted left upper lobectomy. One-lung ventilation was accomplished and a triportal VATS lobectomy was performed. The upper lobe vein, the bronchus and the branches of the pulmonary artery were dissected in this order as in the anterior approach. The conclusion of this paper is that performing a VATS lobectomy using swine is a good training strategy for thoracic surgeons.

Information about swine's anatomy is required before proceeding with the surgery. In fact, pigs have four pulmonary lobes on the right side and two on the left side. Generally, the lower lobes are bigger than the upper lobes (19). Surgical procedures like VATS lobectomies can be carried out on both sides. On the right side, the median lobe is the more adequate to work on because of its size, as it is not as big as the lower lobes. Same is for the upper lobe on the left side. In these lobes, the vascular structures and the bronchi are convenient for the dissection due to their diameter and their similarity to the human anatomy. In

addition, they can be reached easily from the fourth or fifth intercostal space (20).

VATS lobectomies in swine may be performed with one, two, three or four ports. The techniques with two or three ports are easier to perform in the swine and therefore the training is more effective. The uniportal or the four-port techniques are the most complicated, due to the small size of the swine's thoracic cavity.

A valid alternative to the use of real animal models, that can lead to ethical questions, as previously stated, are the 3D Printed "Biotexture Wet Models" for Surgical Training (Fasotec, Chiba 261-8501, Japan). The printed lung is wet, soft, and complete with tumors and blood vessels and can be very well used in simulations (*Figure 1*).

Conclusions

Wet labs, maybe combined with VR simulators, could be the answer to the increasingly demand of an improved training for VATS surgeons. Additional investigations are required to evaluate the efficacy of alternative methods of surgical skills education, such as inanimate models, which can be less expensive and therefore more accessible for more institutions.

Acknowledgements

None.

Footnote

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

References

1. Fingerhut A, Millat B, Borrie F. Laparoscopic versus open appendectomy: time to decide. World J Surg 1999;23:835-45.
2. Livingston EH, Rege RV. A nationwide study of conversion from laparoscopic to open cholecystectomy. Am J Surg 2004;188:205-11.
3. Howington JA, Blum MG, Chang AC, et al. Treatment of stage I and II non-small cell lung cancer: Diagnosis and management of lung cancer, 3rd ed: American College of Chest Physicians evidence-based clinical practice guidelines. Chest 2013;143:e278S-313S.
4. Yan TD, Cao C, D'Amico TA, et al. Video-assisted

thoracoscopic surgery lobectomy at 20 years: a consensus statement. Eur J Cardiothorac Surg 2014;45:633-9.

5. Vannucci F, Gonzalez-Rivas D. Is VATS lobectomy standard of care for operable non-small cell lung cancer? Lung Cancer 2016;100:114-9.

6. Bedetti B, Scarci M, Gonzalez-Rivas D. Technical steps in single port video-assisted thoracoscopic surgery lobectomy. J Vis Surg 2016;2:45.

7. Gallagher AG, Neary P, Gillen P, et al. Novel method for assessment and selection of trainees for higher surgical training in general surgery. ANZ J Surg 2008;78:282-90.

8. Depypere L, De Jonghe L, Peetermans W, et al. Does the Implementation of European Working Time Directive (EWTD) Have an Effect on Surgical Training in a Flemish Teaching Hospital Network? Acta chirurgica Belgica 2014;114:299-303.

9. Stelzer MK, Abdel MP, Sloan MP, et al. Dry lab practice leads to improved laparoscopic performance in the operating room. J Surg Res 2009;154:163-6.

10. Dunkin B, Adrales GL, Apelgren K, et al. Surgical simulation: a current review. Surg Endosc 2007;21:357-66.

11. Haluck RS, Satava RM, Fried G, et al. Establishing a simulation center for surgical skills: what to do and how to do it. Surg Endosc 2007;21:1223-32.

12. Marshall MB. Simulation for technical skills. J Thorac Cardiovasc Surg 2012;144:S43-7.

13. Jensen K, Ringsted C, Hansen HJ, et al. Simulation-based training for thoracoscopic lobectomy: a randomized controlled trial: virtual-reality versus black-box simulation. Surg Endosc 2014;28:1821-9.

14. Solomon B, Bizekis C, Dellis SL, et al. Simulating video-assisted thoracoscopic lobectomy: a virtual reality cognitive task simulation. J Thorac Cardiovasc Surg 2011;141:249-55.

15. Hubbell DS, Dwornik JJ, Alway SE, et al. Teaching gross anatomy using living tissue. Clin Anat 2002;15:157-9.

16. Drosdeck J, Carraro E, Arnold M, et al. Porcine wet lab improves surgical skills in third year medical students. J Surg Res 2013;184:19-25.

17. Swindle MM. Swine as replacements for dogs in the surgical teaching and research laboratory. Lab Anim Sci 1984;34:383-5.

18. Noda M, Mizuma M, Maeda S, et al. Presented at the 64th Annual Scientific Meeting of the Japanese Association for thoracic surgery: wet-lab training for thoracic surgery at the laboratory animal facilities. Gen Thorac Cardiovasc Surg 2012;60:756-9.

19. Tedde ML, Brito Filho F, Belmonte Ede A, et al. Video-assisted thoracoscopic surgery in swine: an animal model for thoracoscopic lobectomy training. Interact Cardiovasc Thorac Surg 2015;21:224-30.

20. Swindle MM, Horneffer PJ, Gardner TJ, et al. Anatomic and anesthetic considerations in experimental cardiopulmonary surgery in swine. Lab Anim Sci 1986;36:357-61.

21. Bedetti B, Schnorr P, Schmidt J, et al. Video showing the use of the 3D printed lungs in a session of video-assisted thoracic surgery (VATS) training. Asvide 2017;4:194. Available online: http://www.asvide.com/articles/1502