Review Article

Surgical simulation for safe uniportal VATS

Alberto Sandri[1], **Alessandro Brunelli**[2]

[1]Department of Thoracic Surgery, Oxford University Hospitals, NHS Foundation Trust Headley Way, Headington, Oxford, UK; [2]Department of Thoracic Surgery, St James's University Hospital, Leeds, UK

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Correspondence to: Alberto Sandri, MD. Department of Thoracic Surgery, Oxford University Hospitals, NHS Foundation Trust Headley Way, Headington, Oxford OX3 9DU, UK. Email: sandri.alberto@gmail.com.

Abstract: An established trend in obtaining a radical anatomical resection through a safe minimally invasive approach has been observed in the recent years. However, since the establishment of the three or more ports video-assisted thoracic surgery (VATS), the interest in the uniportal VATS to lung lobectomy has been gaining a phenomenal and global interest from the thoracic surgeons. A specific training in the uniportal VATS approach is crucial to ensure safety and radical treatment. It should aim at giving the surgeon independence and self-confidence throughout the procedure. The learning curve for a surgical intervention, especially in VATS, whereby surgeons acquire expertise, poses important ethical and medico-legal issues since practice, training and instituting a new surgical procedure is predominantly done on patients who, often, are not totally aware or properly informed. In this field, the role of training becomes mandatory, and simulation is decisive, providing a technological "close to reality experience" and a "hands off the patient" but "hands on the procedure". A proper training aiming at safeguarding patients but at the same time promoting a standardised, close to reality experience to all thoracic residents during their training, and to those surgeons who wish to learn important advances in technical procedures (uniportal VATS), is presently important but will be a prerequisite in the near future. Industries in the thoracic field are encouraged to develop new technological advances [3D, virtual reality (VR)] which will allow a systematic, progressive, realistic and safe training in this global leap into uniportal VATS.

Keywords: Uniportal VATS; VATS simulation; simulation training; training; uniportal video-assisted thoracoscopic surgery

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Introduction

An established trend in obtaining a radical anatomical resection through a safe minimally invasive approach has been observed in the recent years. However, since the establishment of the three or more ports video-assisted thoracic surgery (VATS), the interest in the uniportal VATS to lung lobectomy has been gaining a phenomenal and global interest from the thoracic surgeons. As a matter of fact, since the publication of the first lobectomy performed by Gonzalez in 2011 (1), this technique was implemented, spread and improved to such an extent that, in expert and experienced hands, major surgical procedures (sleeve lobectomies, double sleeve lobectomies, awake surgery) are regularly performed (2). Given that results of a VATS lobectomy and lymphadenectomy for lung cancer are comparable in terms of oncological radicality to an open lobectomy (3-8) and meeting the aesthetic results for the patient, the technical issues faced by the operator and the assistant performing an uniportal VATS lobectomy and lymphadenectomy are secondary to none, reason why a proper training becomes essential (9,10).

Safety, ethics and training in surgery

Each surgical act is intrinsically complex and has risks. Despite the best intentions and commitment to a safe practice and a high degree of technical competence, errors occur and, unfortunately, at patients' expenses. This is why a standardised approach to any surgical act has been endeavoured. Standardisation reduces the risk of error. Being a practice standardised means that the margin of error for that surgical outcome is lower. Thus, the concept of patient safety in surgery encompasses several aspects which include the standardisation of surgical procedures, theoretical knowledge and technical competence and skills, all of which have training as a common ground. Standardisation of a surgical procedure is a long process which begins with managing and learning from incidents/mistakes and to involve the building of systems to minimise the risks of surgery. The learning curve for a surgical intervention, especially in VATS (11,12), whereby surgeons acquire expertise, poses another important ethical and medico-legal issues since practice, training and instituting a new surgical procedure is predominantly done on patients who, often, are not totally aware or properly informed. Furthermore, how many cases per surgeon are required to obtain a level where the surgeon is confident to complete the operation with good results (i.e., effective and efficient and oncologically radical) in an average time and with a minimal risk for the patient? Although the surgeon is skilled, is it correct for him, to start a new surgical practice directly on a patient? Is it correct to train the trainees on a patient? Are the patients really aware and consented for this? Although supervised by skilled surgeons, is it correct for the patient to be exposed to an increased surgical risk because the VATS operation is performed for the first time by a junior doctor? Is it correct for a three port VATS surgeon to "try" the uniportal VATS on a patient for the first time? These are some challenging everyday examples of the ethical issues and medico-legal aspects that should be dealt with. Fortunately, this is no more the era where the physician does what is best for the patient without any obligation of the latter to claim transparency and involvement in the decision making (13). The ethical behaviour has always been part of thoracic surgical practice, and an ethical deliberation has only recently become an important component of our routine practice (informed consent, conflict of interest, and professional self-regulation) (14), but is not yet enough. In fact, judgments regarding the ethical challenges that surgeons frequently encounter in practice, is rarely taught explicitly during training and the training is evidently lacking this aspect, along its standardisation. How can this change and improve? Likely, technological innovations and advancement now available on the market will be much improved and cost-effective in the next years, making it possible to have plenty of sustainable and realistic hours of training onto machines/simulators, computers or virtual reality (VR) prior accessing a real patient. Of course, this will require a change in mind-set regarding training modalities and its sustainability (cost-effectiveness), but likely represents the correct answer to the ethical and medico-legal questions related to surgical training. Furthermore, a "technological" training will allow a gradual increase in case complexity and evaluation of surgical outcomes which will be thus achievable in a uniform way due to the possibility of recording the progresses made by the surgeons prior escalating to real patients. Technological and "off-patient" training (simulation) offer measurements of outcomes of a surgical intervention in order to be evaluated and confirm progression in surgical skills (15-18), which will aim at forming self-confident surgeons at the top of their learning curve thanks to a proficient training which safeguards the patients.

Importance of training in uniportal VATS

A specific training in the uniportal VATS approach is crucial to ensure safety and radical treatment. It should aim at giving the surgeon independence and self-confidence throughout the procedure. The setting of a uniportal VATS lobectomy is very different compared to a two or more ports VATS. In fact, apart the single and small anterior utility incision, the instrumentation is parallel to the camera and the vision is similar to an open approach. Also, working through the single small utility, both for the camera and for the instrumentation, may result in more complex manoeuvres for both the surgeon and the operator handling the camera, especially during the dissection of the hilar structures and passing the stapler trough the vessels. Furthermore, the management of a possible intra-operative complication (bleeding) may be more complicated than in a multi-port VATS setting (19,20). A "mind-set change" (9) is therefore prerogative to the surgeon approaching a uniportal VATS lobectomy, which requires specific training. As evidenced in the literature, a stepwise approach (thoracotomy to multi-port VATS lobectomy, from multi-port VATS to single port) is recommended in order to gain sufficient confidence with vision, dexterity

and dissection and to learn the tips and tricks and pitfalls of the technique (9,10,19,21). Therefore, the role of training becomes mandatory, in this field, especially for junior doctors. Nowadays, surgeons who want to learn and train in uniportal VATS have several opportunities which span from attending courses/conferences to video-training, preceptorships and proctorships. Simulation has made big progresses in these years, further steps should be invoked in order to provide a technological "close to reality experience" which should be cost-effective too, in order to spread and favour this training prior approaching directly a patient, therefore responding to the safety, ethical and medico-legal requirements.

Simulation training

The Cambridge online dictionary defines simulation as "a model of a set of problems or events that can be used to teach someone how to do something or the process of making such a model" (22). Simulation should play an important role in surgical training, especially in the uniportal VATS lobectomy, promulgating a possible step wise and uniform training in a safe environment. In fact, by learning in a step wise, safe and off-theatre fashion, a surgeon will then acquire the tips and tricks of the procedure by-passing the ethical and medico-legal aspects related to a direct and questionable hands-on patient training. Unfortunately, to date, there is no specific uniportal VATS simulator; mostly, simulators and training techniques which are available to the surgeon include: (I) courses with animal wet-labs; (II) human cadavers; (III) virtual simulators; (IV) synthetic models of human thorax and anatomy.

VATS courses with animal (swine, sheep) wet-labs are among the most utilised due to a live (perfused) tissue although the anatomy differs compared to human's. Specific courses in uniportal VATS have been endeavoured with wet-labs, which aim at obtaining the most realistic and close to human's anatomical dissection of tissues (23-26). However, several deterrent aspects of training in wet-labs include the implicit costs of a wet-lab, difficulties in managing the single lung ventilation, anaesthesia and possibly keep alive the swine in order to perform as many lobectomies as possible on a single alive animal (27). This however clashes with ethical aspects too, to an extent where this is not allowed in some countries. Lately, *ex vivo* heart-lung block swine models have been utilised in order to train specifically in uniportal VATS decreasing the costs since the block was harvested after non-thoracic experiments and reutilised (28-30). On the other hand, thoracoscopic lobectomy and lymphadenectomy have been described on human cadavers (31), however, cadavers offer a proper but unrealistic anatomy due to the non-perfused tissues and preservation technique, are not readily available and raise ethical concerns too. For these reasons, most of the attention is drawn to virtual simulators and synthetic models of human thorax and anatomy. Interest in dry laboratories is increasing in thoracic surgery and include box trainers and VR simulators. Various surgical simulators have been in use to date, with encouraging results for the trainees compared to the animal models (32,33). With the establishment of new technologies and augmented reality (3D), virtual simulation will become cost-efficient granting a wide-spread and a possibility to train in uniportal VATS in a safe, step wise and monitored fashion. Likely, in a near future, courses by experienced surgeons will be held with several participants at the same time, with each participant connected to a VR simulator and performing virtual lung lobectomies under the guidance of the senior surgeon, who would in the mean time perform the same operation and giving hints and tips throughout the procedure, thus introducing the possibility of "hands off the patient" but "hands on the procedure", therefore learning on the virtual field the necessary basic skills for the uniportal VATS through a direct and technological interaction with the experienced surgeons. This would be a step forward—a technological improvement—to the present still valid and important observerships, where a single surgeon performs the operation and several surgeons observe the operation either in theatre or by watching screens through a live connection with the possibility of interacting with the operating surgeon, divulgating the operation technique and skills.

A valid alternative to the use of real animal models and to VR simulation, which is still lacking behind as previously stated, are the non-biologic synthetic simulators, which in some cases simulate the torso, the human lung anatomy with the tumour, venous and arterial perfusion and the lymph node stations. This simulator may be used in a surgical theatre (no biological contamination) and with surgeons' instrumentation and staff with the possibility of repeating the procedure several times, thus mimicking the operator in the real life setting (3D printed "Biotexture Wet Models" for Surgical Training Fasotec, Chiba, Japan) (34,35).

Conclusions

As interesting paper by Sommer, entitled "Pilot training:

what can surgeons learn from it", points out important similitudes which bind the pilots' world to surgeons', in fact "*both work in a 'real-time' three-dimensional environment under high physiological and psychological stress*, *operating expensive equipment*, *and the ultimate cost for error is measured in human lives*" (36). This is the reason why checklists and simulations in aeronautics are reality since many years, with findings suggesting that simulation practice allows good decision-making skills (37). Several steps have been done in the medical field following the aeronautic experience (WHO checklist, protocols, etc.), but more needs to be done to establish a simulation training, as in case of pilots. A proper training aiming at safeguarding patients but at the same time promoting a standardised, close to reality experience to all thoracic residents during their training, and to those surgeons who wish to learn important advances in technical procedures (uniportal VATS), is presently important but will be a prerequisite in the near future. Industries in the thoracic field are encouraged to develop new technological advances (3D, augmented reality) which will allow a systematic, progressive, realistic and safe training in this global leap into minimally invasive thoracic surgery.

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Footnote

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