Review Article on Thoracic Surgery

Video-assisted thoracoscopic surgery lobectomy learning curve: what program should be offered in a residency course?

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Abstract: Video-assisted thoracoscopic (VAT) procedures are emerging for treatment of both benign and malignant thoracic diseases and substituting classical approaches, such as thoracotomies, thanks to several advantages concerning postoperative morbidity rates and overall patients' outcome (i.e., postoperative pain, chronic pain and quality of life). However, a VAT approach needs an established learning curve making procedures as safe as in open surgery. With regard of trainee surgeons, notwithstanding an increasing number of learning tools and strategies, such as simulation programs (i.e., black-boxes, wet labs, cadaver or animal labs, 3D virtual reality simulators) and direct observation both of live surgery and videos with a supportive evidence base from benchtop studies, there remains inconsistent adoption in surgical educations.

Keywords: Non-small cell lung cancer; video-assisted thoracoscopic surgery (VATS) lobectomy; simulation training; learning curve

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Introduction

Video-assisted thoracoscopic surgery (VATS) is nowadays considered an acceptable approach for treating early stage of non-small cell lung cancer (NSCLC) (1,2), as recommended by current evidence-based guidelines from the American College of Chest Physicians (3). As a result, VATS has progressively emerged as a gold standard for treatment of both benign (i.e., pneumothorax, stage II-III pleural empyema) and malignant thoracic diseases (i.e., lung cancer, esophageal cancer, mediastinal tumors), by substituting classical approaches, such as thoracotomies, thanks to an increasing and established evidence of several advantages. In particular, a VATS approach presents a decreased operative trauma with a subsequent reduction in both postoperative and long-term pain when compared to formal thoracotomy, without interfering with oncological and survival outcomes (4,5). Furthermore, early outcomes in hospitalization, morbidity rates and return to daily life preserving quality of life (QoL) result in a significant socio-economic impact with a significant reduction in health costs (1,6). However, despite the above-mentioned transition process towards minimally invasive procedures supported by these encouraging results there is still a considerable number of patients that although amenable for a VAT approach, undergo thoracotomy. In fact, as reported by the latest European Society of Thoracic Surgeons (ESTS) Silver Book, 27.4% of lobectomies was performed by VATS (7) while a report from the Danish Cancer Registry stated up to 53% of early stage NSCLC underwent video-assisted pulmonary lobectomy (8). Results showing how much a VATS approach still represents a real challenge for surgeons due to an unjustified preconception that comes from complexity, length of procedure and possible fearful complications, such as intraoperative bleedings or vascular stapling failures, that would require a rapid conversion in order to deal with them. Moreover, such events would be reflected in a lack of security in front of a classical approach with a perception of expose to medical and legal disputes (5).

Additionally, lack of time and to get involved in new techniques, although active training courses by scientific societies and industries have been established, results into a reticence in transition rather than the abandonment of standard techniques. Finally, another aspect to consider is the number of operated patients as a learning curve requires a high volume in order to acquire and maintain the skills, which is a fundamental and crucial aspect in the formation of a young surgeon.

Comment

The time needed and the minimum number of procedures to get familiar with a new surgical technique for a young surgeon has been discussed in many reports (9-11). Another fundamental aspect is to consider how to teach and how to acquire autonomy that will allow surgery to be performed safely for both patients and operating teams. In fact, it would hardly be a direct superficial and not carefully approach to the patient without any dexterity in basic movements or procedures reflecting in a patient's safety and ultimately in an increased risk of legal repercussions. In this regard, it is therefore necessary to adopt risk-free based teaching strategies in dedicated platforms such as simulation tools (black-boxes, wet labs, 3D virtual reality simulators) and dedicated models (animals or cadaver) accompanied by direct teaching in the operating room ("visual acquisition process") (12,13), in order to achieve skills necessary to undertake a gradual transition from traditional open surgery towards a "second generation of VATS surgeons". A simulated training, as a complementary moment in the formation of a young surgeon, not only allows the acquisition of necessary skills but also the execution of fearsome steps, such as vascular dissections, in a total safety and dedicated environment and under an experienced tutor's control. About this, such a program has a cognitive aspect at different levels according to trainee's experience and allows the execution from the simplest to the most complex procedures, improving not only the technique but also the effectiveness of the surgical gestures which result in a significant reduction of the operating times (14-16). Important parameters of a learning program are "construct validity", as the ability of simulators to discriminate between users of different skill levels and "content validity" as decision-making processes and virtual-reality (VR) surgical simulators are thought to facilitate the acquisition of cognitive and technical skills in early stage trainees. However, despite supportive evidences from many studies, there remains inconsistent adoption in surgical education. Furthermore, though a significant improvement both in performance and dexterity by the adoption of VR simulators has be proved in the operating room (17), the impact on thoracic patient outcomes remains to be quantified due to the lack of consistent and dedicated models for thoracoscopic procedures (18). In addition, due to its peculiarities (access, triangulation, optics and technique), VATS claims for procedure-specific environments (12,19). In this regard, the Thoracic Surgery Societies have recognized their current training limits and are working towards implementing and developing dedicated programs (20). Since earlier experiences with black-box simulators, many programs have been proposed and accomplished. As reported by Meyerson *et al.* (21) in a simulation program on a porcine model involving 100 participants, reported black-box training had some peculiarities such as in costs and was highly effective in identification of vessel injuries or technical errors with high quality of tissue planes, though anatomic accuracy was less than cadavers with an easier identification of vessels due to the absence of significant lymph nodes. For these reasons, the model was considered a low fidelity one. The transition from black-boxes towards virtual-reality simulators has been widely investigated by Jensen *et al.* (12). The authors included 28 surgical trainees with minimal experience in video-assisted procedures (less than three supervised procedures) and randomized them into two braces (black-box *vs.* VR groups). All participants trained to a predefined scenario in an abdominal model without any time limit. After procedures completion, overall skill acquisition was evaluated according to time and errors. Surprisingly, the black-box group was significantly faster than VR group both with and without penalty time (26.6 *vs.* 32.7 min, P=0.032 and 29.6 *vs.* 35.5 min, P=0.043, respectively). Moreover, according to errors, no difference in bleeding and anatomical errors were found. According to the authors, results reflected a lack of tactile feedback in VR group when compared to the black-box one, in which participants had better feeling both with real instruments and with tissues by applying the correct required forces for procedures. For these reasons, no significant advantages between 3D virtual reality simulators and black-boxes were described. In this regard, authors claimed for a dedicated model for VATS in order to provide an effective simulator-training programs. Jensen *et al.* (18) showed in 2015 a dedicated thoracic lobectomy VR simulator demonstrating good face and content validity, and a positive outlook from expert trainers. However, this was associated with poor construct validity for its automated matrices across a large cohort stratified by experience. Moreover, this first dedicated VATS VR simulator (Lapsim®, Surgical Science, Göteborg, Sweden) allows only performing a right upper lobectomy. Anyway, its peculiarities provide trainees simulated practice in each step including hilum dissection, vessels identification, vascular and bronchial stapling and bleeding control. The simulator allows controlling skill and dexterity acquisition by analysing surgical aspects, such as coordination, precision movements, handling and use of arms. However, due to its cost and its necessary management investments, its diffusion is limited to a few centers. Regarding wet labs, they are often avoided due to ethical and legal concerns, due to the use of animals only for exercise purpose, although the benefits of their use have been demonstrated both in the teaching of basic techniques and learning more complex surgical procedures (22). A wet lab is ideal due to its high anatomical and tissue variability depending on the animal model and therefore needs a preliminary theoretical process in order to recognize and handle them. The subject of anatomical variability is also one of the major purposes in the formation of a young surgeon since they are not uncommon in daily practice. In addition, wet labs have a high degree of usability adapting to the skills and knowledge of practitioners depending on pre-determined degrees of difficulty and model preparation (23). Concerning with the animal models in thoracic surgery, swine are the most common ones. As for other surgical specialities (such as visceral surgery), they are preferred due to their anatomical peculiarities and similarities with human ones making skill acquisition process easier for residents (24). Tedde *et al.* (25) in their experience on 40 swine-model left VATS upper lobectomy demonstrated that performing VATS lobectomy on swine was effective in a thoracic surgery program; on the other hand, they confirmed that the use of animal models could not ignore an exhaustive knowledge of their anatomical characteristics. About cadaver model, Hoksch *et al.* (26) suggested that it was only a useful stepping off point for VATS learning curve due to operation is done under ideal conditions (i.e., no bleeding, no one-lung ventilation, lungs without adhesions or inflammation).

Conclusions

Modern surgical training claims trained professionals ready to face fearsome complications. Acquiring skills, therefore, remains a critical point in the formation process of a young surgeon and it cannot disregard with a correct and exhaustive knowledge of the minimally invasive surgery and its techniques, without abandoning traditional approaches. In fact, it would be a mistake to focus on video-assisted procedures without having full mastery of open surgery. In this regard, the role of residence courses plays a crucial role in solving both a legal and above all a social responsibility. Therefore, simulation programs should be a cornerstone for young trainee surgeon for a full and complete professional. In conclusions, simulation has passed the old concept of “observing and learning” for a new “observing and doing for learning”.

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Footnote

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

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