Editorial

Evolution of uniportal video-assisted thoracoscopic surgery: optimization and advancements

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Enhanced recovery after surgery (ERAS) programs have been developed to improve patient outcomes and speed up their recovery after thoracic surgery. Amongst these ERAS care elements, multiportal video-assisted thoracoscopic surgery (VATS), fastened mobilization, and early chest tube removal have been recognized as independent predictors associated with improved patient outcomes (1). However, as of the publication of these ERAS guidelines in 2018, several innovations in thoracic surgery have made their debut worldwide in clinical practices, one of which is the uniportal VATS technique. Compared to the conventional multiportal VATS technique, the theoretical advantages of uniportal VATS encompass reduced surgical trauma, lower pain scores, less morbidity, and inherent faster recovery (2). On the contrary, opponents of uniportal VATS argue that it could be associated with compromised survival outcomes, but this has not been supported by sufficient evidence (2,3). Furthermore, an increased risk of inferior surgical outcomes due to the complexity of the surgical technique and its associated learning curve has been suggested (2). Another disadvantage of uniportal VATS, reported by Pan *et al.* (2024), is the potential increased risk of tissue damage, thermal burns, and chest tube placement through the same single incision causing poor tissue healing (4). Therefore, Pan and colleagues introduced a modified suturing technique in the *Journal of Thoracic Disease* for the uniportal VATS technique aiming to enhance postoperative wound healing. This study is an excellent example of striving for the best possible patient care, looking beyond the substantial improvements in traditional clinical outcomes (e.g., hospitalization, chest tube duration, complications, and survival) to refine each aspect of thoracic surgery care.

History of thoracic surgical access

Thoracic surgical access has undergone several major advances through the centuries after the first successful partial lung resection was performed by Dr. Theodore Tuffier in the late nineteenth century using a posterolateral thoracotomy in an aseptic clinical practice (5). Even though

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a thoracotomy provides excellent surgical exposure, these incisions are experienced as the most painful incisions in general surgery. Therefore, the Swedish physician Hans Christian Jacobaeous introduced thoracoscopy in 1910 to minimize the pain related to surgical access and used a modified cystoscope with a simple candle as a light source to perform thoracic pneumolysis for tuberculosis (6). Even though it was used in Europe around the 1920s, it was only being implemented worldwide as VATS after the technical advances of the rod lens solid-state video systems, micro-cameras allowing for a panoramic view, and new endoscopic instruments such as a linear stapler (7). Traditionally, VATS is performed using two or three incisions of 0.5–1 cm for the surgical instruments and one utility port incision of 4 cm for tissue removal, also known as multiportal VATS. Based on the randomized-controlled VIOLET trial by Lim and associates (2022), multiportal VATS has been proven to result in less pain, paresthesia, morbidity, and faster recovery without compromising oncological outcomes (8). Nowadays VATS is being recommended as the standard surgical approach for lung resections worldwide.

During the last three decades, minimally invasive thoracic surgery has transitioned from the traditional three or four ports to thoracoscopic surgical access via only a single incision of 4 cm. The uniportal VATS technique was introduced in 2004 by Rocco and colleagues (9) for minor thoracic procedures (e.g., sympathectomy and lung biopsy). Because minimally invasive surgery was initially developed for urogynecology and gastrointestinal surgery (10), surgical instruments had to be created specifically for uniportal VATS to be able to perform the surgery via this small single-incision for more complex thoracic procedures. Especially after the invention of the longer, more narrow-shafted, double-hinged minimally invasive (thoracic) surgical instruments, Gonzalez-Rivas and associates (2011) presented the single-incision technique for a pulmonary lobectomy almost five years later (11) and surgeons could comfortably reach any area of the thoracic cavity whilst introducing several instruments through the same surgical access. Thereafter, more complex thoracic procedures including segmentectomies, and bronchial and arterial sleeve lobectomies were being performed via uniportal VATS (12).

To date, more studies are being reported on uniportal compared to multiportal VATS anatomical resections, showing its superiority in complication rate (3), length of hospital stay (3), postoperative pain scores (3), and non-inferiority in (long-term) oncological safety (13). However, current evidence on recurrence and survival rates needs to be corroborated by more randomized-controlled trials as these are still limited (2,3).

Uniportal VATS technical advancements

The least invasive approach in thoracic surgery offers practical advantages over multiportal VATS. As the geometric configuration of uniportal VATS favors a translational approach to the instruments along a sagittal plane in the direction of two parallel lines from a craniocaudal perspective (2,14), a more open-surgery field of view avoids instrument interference and allows for an adequate pulmonary dissection. Moreover, the recent industry advances in specifically designed instruments for uniportal VATS continue to optimize these instruments. Specific uniportal VATS instruments (for example the Scanlan® VATS instruments) were introduced over a decade ago. Their main features consist of the longer and thinner shaft, as well as the double articulation points (inside and outside the chest). In recent years, these instruments have undergone further development, and their use has been expanded for a variety of purposes.

The single 4-cm incision minimizes tissue damage and the inherent risk of wound infections in contrast to the three to four incisions by the multiportal VATS approach (15). Moreover, the uniportal VATS technique uses fewer intercostal spaces, reducing the risk of intercostal nerve compression and chronic pain (16). However, the limited access area of the uniportal VATS technique for multiple surgical instruments may risk poor or delayed wound healing due to repeated skin extrusion as suggested by Pan and colleagues (4). To minimize tissue damage during the uniportal VATS technique, wound protectors can be used to protect the soft tissue and surrounding structures, such as the intercostal nerve. Moreover, other suturing techniques in literature have reported favorable wound healing outcomes, such as the modified uniportal VATS suturing technique by Pan *et al.* (2024). In contrast to the traditional discontinuous vertical mattress suture, this technique uses a single head barbed absorbable suture (4). As a result, the risk of surgical wound infections was significantly lower and 30-day scar aesthetics were improved. However, the study was limited by its retrospective design (e.g., selection bias) and information on prophylactic antibiotic administration was lacking.

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Optimization of chest tube placement

Another important factor that contributes to poor wound healing may be the placement of the chest tube through the same single incision. An underlying theory suggests that placement of the chest tube through the uniportal VATS incision compromises the muscular plane reconstruction following in unesthetic scar formation and potentially increases the risk of wound infection (17). It may also contribute to the malfunctioning of the chest tube due to potential suboptimal angulation between the chest wall and the pleural cavity. As a result, some surgeons use an additional incision for chest tube placement that is more aligned with the skin layers aiming to prevent the aforementioned concerns. However, it is doubtful whether this risk is lower than the risk of a wound infection associated with a second incision providing access to the thoracic cavity. Furthermore, the chest tube size should be minimized as it may affect wound healing. A smaller chest tube diameter could promote tissue recovery, however, the drainage efficacy (e.g., malfunction, more postoperative complications) should not be compromised (1). As a final point, the question of whether chest tube drainage after lung resection is necessary cannot be ignored as it has been the subject of debate for quite some time (1,18). Promising results of chest tube omission have been reported after thoracoscopic wedge resections and anatomical lung resections in selected patients (18).

Uniportal VATS in clinical practice

Uniportal VATS could best be learned from experienced surgeons via uniportal VATS courses, utilizing VATS simulators (e.g., Ethicon Stupnik VATS Simulator), dry and animal wet lab sessions, and visitations in ultra-high-volume centers (19,20). The initial learning phase for uniportal VATS lobectomy based on surgery duration lies between 14 to 60 procedures, depending on the prior experience of the surgeon (i.e., thoracotomy, multiportal VATS, and minor uniportal VATS procedures) (21). Complication-based learning curves report no unacceptable high complication rates during the initial learning curve; thus, patient safety is not compromised learning this new technique. Remarkably, some surgeons have found it easier to learn the uniportal VATS technique as compared to the multiportal approach as the surgeon's hands and eyes are working in the same plane (19). A recent publication has also revealed that junior thoracic surgeons were found to have a shorter learning curve compared to senior thoracic surgeons (22). This raises the question of whether future thoracic surgeons should preferably be trained in uniportal VATS rather than multiportal VATS.

For successful implementation of the uniportal VATS program, it is important to train and inform the complete surgical team, from the senior surgeon colleagues to the anesthetists, scrub nurses, and other allied specialties such as pulmonologists and oncologists (20). To maintain proficiency with the uniportal VATS technique, annual follow-up courses should be attended and a high annual case volume should be pursued as the annual hospital case volume is significantly associated with postoperative patient outcomes (23). Therefore, centralization of care may be beneficial for improving patient outcomes and reducing clinical variability.

Future perspectives

The next step in optimizing minimally invasive surgery may be the uniportal robot-assisted thoracic surgery (RATS) technique (24). The benefits of RATS include improved visualization, surgical instruments with seven degrees of freedom (i.e., more maneuverability), as well as ergonomic benefits for the thoracic surgeon in the docking station. The uniportal RATS technique was developed in collaboration with the pioneers of the uniportal VATS technique. As proposed by these surgeons, staplers can be placed more carefully across the anterior incision with the robot avoiding the risk of vascular avulsion, and in case of uncontrolled bleeding, uniportal RATS allows for a quick emergent conversion by rapid undocking. Moreover, the articulating surgical instruments have a fixed position that allows for a stable extended range of motion being able to rotate around a fulcrum point, which therefore could reduce tissue damage surrounding the thoracoscopic portal site and intercostal nerve injury. These initial results of uniportal RATS are encouraging, however, more (long-term) high-level evidence is required to corroborate its clinical advantages and cost-effectiveness in comparison with the uniportal VATS technique. The direction for future thoracic surgery should further focus on optimization and advancements with an emphasis on tubeless minimally invasive surgery (e.g., chest tube omission, no urinary catheter, no central venous line, and awake non-intubated thoracic surgery) to facilitate faster recovery (25).

In conclusion, as shown by Pan and colleagues (4), enhancing perioperative care follows from multiple

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small incremental improvements and serves to improve health outcomes satisfying the patient's needs. Aside from optimizing the surgical suturing technique, the future of thoracic surgery should focus on minimizing tissue damage by operating as least invasive as possible, as well as improving perioperative care with wider employment of tubeless thoracic surgery and adhering to ERAS principles while further enhancing the safety and oncological outcomes of the patient.

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