



New innovations in minimally invasive surgery—video-assisted thoracic surgery innovations from uniportal to “robotic video-assisted thoracic surgery”: technical and future aspects

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Introduction

Minimal-invasive thoracic surgery mainly refers to a surgical technique involving the significant reduction of the wound access-related size. Mainly, scope surgery is the chief representative. The development of thoracoscope technique was initiated exactly one century ago by Jacobaeus (1). Diagnostic applications, such as pleural biopsy, was performed mainly by pulmonologists and, after 1990, blooming using of video-assisted surgical scope intervention all over the world led to more extensive applications to various kinds of thoracic disease. Since then, it has undergone a series of step by step modifications and improvement. Baseball diamond pattern [three-port VATS (video-assisted thoracic surgery)] introduced by Dr. Roviario was first used to suit operational needs (2), and gradually developed into two-port VATS techniques proposed by D'amico (3). Single port video-assisted thoracic surgery (SPVATS) has a history of more than 15 years (4). In recent, SPVATS has become an increasingly popular approach to mediastinal tumor resection and major pulmonary resection (5). Robotic-assisted thoracoscopic surgery (RATS) is another representative of minimally invasive surgery, which may help overcome difficulties associated with VATS by bringing high-definition 3-dimensional (3D) vision, movements with 7 degrees of freedom and physiological tremor filtration (6).

SPVATS techniques

The experience we acquired with the SPVATS technique

during the past years had gradually adopted as a standardized operation procedure:

- (I) Incision site: pivot of anterior axillary line and 5th intercostal space;
- (II) Equipments: 30-degree endoscope and long cured instruments;
- (III) Monitor and assistant position: video monitor is placed opposite to the surgeon and assistant stands with surgeon at the same side (*Figure 1*).

The main advances of SPVATS during the past years are related to improvements in surgical technique and implementation of new technology (curved tip staplers, energy devices, 3D and ultra-high definition view). Advances in visualization with the use of ultra-high definition monitors provided surgeons better operation view and vivid field of depth. Placing a 30-degree endoscope at the top side of wound give surgeons an overlook view of operation field, which is similar to open surgery. Long curved instruments were needed in single port surgery because it could reduce the possibility of instruments collision.

Image guided SPVATS

The National Lung Cancer Screening Trial has demonstrated that screening of high-risk populations with the use of low-dose computed tomography (LDCT) reduces lung cancer mortality. Based on the inspiring results, more and more small pulmonary nodules (SPNs) and ground glass opacity (GGO) lesions were found during

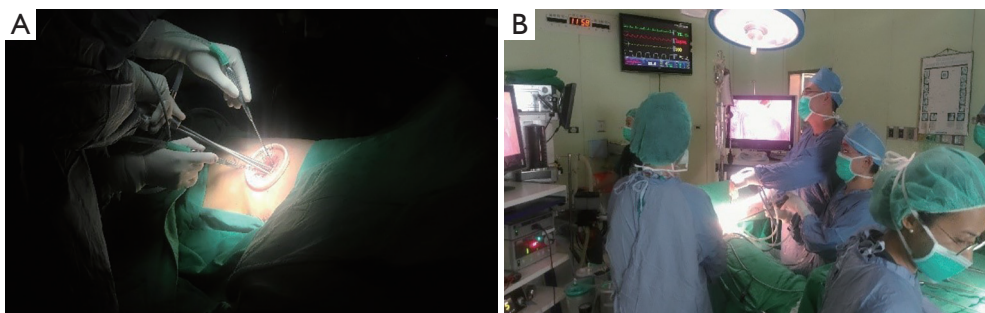


Figure 1 Operator and assistant position during single port VATS. (A) An incision 3 cm was made in the 5th intercostal space and a 10-mm, 30-degree thoracoscope was used; (B) surgeon and assistant stand at the same side in front of patient. VATS, video-assisted thoracoscopic surgery.

health examination or low dose CT screening program. Small pulmonary lesions <1 cm or those at a distance from the lung periphery, especially when deeper than 2.5 times the lesion diameter, can be difficult to locate by palpation intraoperatively, let alone GGO lesions. In recent two decades, preoperative CT localization was widely used in various kinds of occult lesions, including SPNs. However, dislodgment of the hookwire from its perinodular location was the major drawback. Pneumothorax, hemothorax, and air embolism were also common complications after preoperative CT localization. Ng *et al.* first published their experience about one stage operation of GGO lesion in hybrid operation room (7). In recent, Hsieh *et al.* also described their experience of single-stage localization and removal of small lung nodules through image-guided video-assisted thoracoscopic surgery (8). Combination of hybrid operation room and thoracic endoscope surgery might open doors to new techniques that can be potentially safer, more effective, and more economical for patients. Furthermore, fluorescence image-guided technique is a highly sensitive and specific imaging method that has the potential to identify imperceptible lesions intraoperatively. Mao *et al.* published their experience about indocyanine green (ICG)-fluorescent-guided exploration during VATS (9). With the combination of image guided localization techniques, SPVATS still has a lot of potential fields to develop its applications.

Tubeless SPVATS

Non-intubated anesthetic techniques have progressively become more effective and safe. This kind of operation overtakes many of the limits related to the invasiveness of the surgical procedures satisfying all the parts: patient,

surgeon, physician, nursing staff. Mineo *et al.* published their experience about 1,000 various kinds of surgery under non-intubated anesthesia, which provided substantial feasible and safety evidence for such kind an application in VATS surgery (10). Moreover, the highly innovative group from The First Affiliated Hospital of Guangzhou Medical University, China, led by Jianxing He, published an interesting study recently. Under highly selection of patients: SPNs <2 cm, body mass index (BMI) of less than 25; American Society of Anesthesiologists (ASA) grade of II or less; no history of prostate or renal disease and no parenchymal air leak at the end of surgery. No endotracheal tube, Foley, and chest tube was left at the end of surgery. It proves that tubeless SPVATS was feasible in selected patients. We still look forward for its further biological impact study in the future.

Robotic surgery

At the other aspect of minimally invasive surgery, robotic surgery develops rapidly in recent years. VATS and robotic thoracic surgery have shown better perioperative outcomes and equivalent oncologic results compared with thoracotomy. According to the National Comprehensive Cancer Network (NCCN) guidelines (version 5.2017) regarding non-small cell lung cancer (NSCLC) “VATS or minimally invasive surgery (including robotic-assisted approaches) should be strongly considered for patients with no anatomic or surgical contraindications”. With the revolution of robotic surgery system: perfect 3D view, more freedom of robotic arm than endoscope instruments, precise movement, and so on, it is easier to perform thoracic surgery by new generation robotic system. In addition, it is easy to detect isocyanides green labeled target or segmentectomy plan in

robotic surgery due to its well-equipped endoscope system. In addition, robotic system also has well-established visual spatial training program, which might reduce the learning time for the novice to be familiar with robotic surgical system. However, some disadvantages still exist in robotic system: high cost, the need of another consultant on the table, multiple incisions. Therefore, fusion innovation and existing advantages, SPVATS and robotic system, could be amalgamated and stretched. We truly believed single wound incision with flexible working instruments might be the future of thoracic surgery. We have to be open to the new therapies and the next robotic era. In the future of lung cancer treatment probably will be related to individual, genetic, selective molecular chemotherapy and microrobotics technology.

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