

Recent advances in video-assisted transthoracic tracheal resection followed by reconstruction under non-intubated anesthesia with spontaneous breathing

Katsuhiro Okuda, Satoru Moriyama, Hiroshi Haneda, Osamu Kawano, Tadashi Sakane, Risa Oda, Takuya Watanabe, Ryoichi Nakanishi

Department of Oncology, Immunology and Surgery, Nagoya City University Graduate School of Medical Sciences, Nagoya 467-8601, Japan

Correspondence to: Katsuhiro Okuda, MD, PhD. Department of Oncology, Immunology and Surgery, Nagoya City University Graduate School of Medical Science, 1 Kawasumi, Mizuho-cho, Mizuho-ku, Nagoya 467-8601, Japan. Email: kokuda@med.nagoya-cu.ac.jp.

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Tracheal resection followed by reconstruction is one of the most difficult procedures in the field of thoracic surgery. Right thoracotomy performed via a posterolateral incision is selected for middle and lower tracheal resection under general anesthesia. In order to develop a novel less invasive surgical procedure, it is necessary to devise methods to keep the operating field clear and to use better methods of anesthesia. Thoracic surgeons have attempted to improve surgical techniques, the approach, and methods of anesthesia in order to minimize the trauma to the patient and to reduce the incidence of postoperative complications, including respiratory complications.

The feasibility and efficacy of video-assisted transthoracic surgery (VATS) resection followed by reconstruction as a minimally invasive procedure for the treatment of tracheal disease has been reported (1-3). The number of reports on tracheal resection by VATS followed by reconstruction has been increasing since the publication of a report on the safety and feasibility of VATS tracheal resection (4).

With regard to the incision for the initial approach, almost all surgeons selected three or four ports plus one port for inserting a ventilation tube in the operation field. Tracheal resection and reconstruction by VATS or open thoracotomy are used to be performed under general anesthesia and cross-field endotracheal intubation is needed during end-to-end anastomosis. Traditional procedures are

associated with some problems that remain to be improved. There is a possibility of tracheal injury due to endotracheal intubation, and lung parenchymal injury (including pneumonia) can occur in the perioperative period as a result of mechanical ventilation (5,6). Furthermore, airway management during cross-field endotracheal intubation is complex as addition of port to insert the tube disturbs the operating field. To improve the above problem, Zhao *et al.* (7) reported that the interruption of ventilation with transoral endotracheal intubation in VATS tracheal resection and reconstruction eliminated the stress of cross-field endotracheal intubation, eliminating the need for a port for operating field ventilation.

Airway resection followed by reconstruction is typically performed under general anesthesia with single-lung ventilation because it is necessary to maintain a sufficient working space and to adjust the airway pressure for a leak test. In recent years, non-intubated thoracic surgery, which is associated with a lower rate of postoperative complications, especially airway complications, shorter hospital stays, and lower invasiveness in comparison to thoracic surgery with endotracheal intubation, has gradually been developed (8-11).

Li *et al.* (12) reported on tracheal procedures under non-intubated anesthesia with spontaneous breathing as a less invasive method of tracheal resection and reconstruction.

Furthermore, to decrease the patient's stress and invasiveness, Guo *et al.* (13) reported the performance of uniportal VATS for a tracheal tumor under non-intubated anesthesia with spontaneous ventilation as a less invasive procedure in comparison to tracheal procedures by 3- or 4-port VATS. Now, this procedure will be the least invasive approach for tracheal surgery.

Peng *et al.* (14) reported the outcome of non-intubated thoroscopic surgery for carinal reconstruction in a patient with an adenoid cystic carcinoma of the trachea. The pre-anesthesia preparation included the administration of midazolam and atropine 30 minutes before surgery, thoracic epidural anesthesia (TEA) was performed at the T6-7 level, and intravenous anesthesia was performed using remifentanyl, dexmedetomidine and propofol, to achieve sedation while maintaining spontaneous breathing. A laryngeal mask airway was inserted, and local anesthesia (lidocaine), an intercostal nerve block and a vagus nerve block were also used. They concluded that carinal reconstruction under non-intubated anesthesia was safe and feasible for selected patient and that it provided an ideal surgical field without any intraoperative tubing systems. Furthermore, the maintenance of spontaneous breathing makes airway reconstruction more anatomical. However, the method of anesthesia was complex; thus, the processes of preparation and surgery should be thoroughly discussed by the surgical team before the procedure.

Non-intubated thoracic surgery is more technically challenging than thoracic surgery under general anesthesia. However, the developments of anesthetic agents, anesthesia techniques and systems for monitoring the depth of anesthesia using the bispectral index (BIS), pulse oximetry, and end-tidal carbon dioxide have improved the safety of non-intubated thoracic surgery. There are several combination methods for achieving local and regional anesthesia. Local wound infiltration, serratus anterior plane blockade, selective intercostal nerve blockade, thoracic paravertebral blockade, TEA and the administration of lidocaine in the pleural space can be considered (15).

VATS tracheal resection and reconstruction under non-intubated anesthesia with spontaneous breathing is a superior procedure from the viewpoint of the patient's postoperative recovery and the reduction in airway complications. However, cases in which tracheal resection and reconstruction are required by patients for whom tracheal intubation is unsuitable are very rare; thus, these methods of anesthesia and surgical techniques are not recognized worldwide.

Li *et al.* (12) noted that the selection of patients for

VATS tracheal resection and reconstruction under non-intubated anesthesia should be strict to ensure the safety of the operation. Basically, non-intubated thoroscopic surgery under local and regional anesthesia is an alternative method for extending the surgical indications to include surgical treatment for pneumothorax and partial pulmonary resection for the diagnosis of solitary pulmonary nodules in patients in whom general anesthesia is contraindicated due to cardiopulmonary dysfunction (16). Thus, the criteria for selecting non-intubated anesthesia for patients undergoing VATS tracheal resection and reconstruction differ from the criteria for patients undergoing minor thoracic surgery. At a minimum, it is necessary to establish the optimum selection criteria for patients and the best method of preparing for surgical tracheal resection followed by reconstruction. When selecting patients who should undergo this procedure, we must also check the cardio-pulmonary function, tumor location, tumor size (the length of the trachea and carina resection), and the predicted operation time.

The previous studies on VATS lobectomy for lung cancer patients under non-intubated anesthesia investigated the feasibility and safety of non-intubated thoroscopic lobectomy using TEA, intrathoracic vagal blockade, and sedation (17,18). Although Chen *et al.* (17) reported that 3 of 30 patients in the non-intubated group required conversion to intubated single-lung ventilation due to persistent hypoxemia, poor pain-control and bleeding.

We previously reported the problems associated with non-intubated airway surgery (19). Briefly, the management of hypoxia while cutting open the airway, the management of hypercapnia, an adequate method for performing an air-leak test after reconstruction, the dropping of blood and secretions into the airway during reconstruction, the prevention of coughing during airway construction, and the limited experience in tracheal resection followed by reconstruction under non-intubated anesthesia are problems that remain to be solved.

To perform the tracheal resection followed by reconstruction under non-intubated anesthesia, the entire surgical team must be aware of the complications that can occur during awake thoracic surgery; the potential risks including hypoxemia, uncontrolled cough and severe bleeding. To prevent severe complications, the common criteria for conversion to thoracotomy or intubated anesthesia during surgery should be decided by the surgical team. Navarro-Martínez *et al.* (20) emphasized that responses to surgical and medical emergencies during non-intubated thoroscopic surgery must follow the crisis

resource management guidelines.

Li *et al.* (12) reported that VATS tracheal resection and reconstruction under non-intubated anesthesia with spontaneous breathing is a less invasive technique for tracheal surgery. The operating field is well maintained during tracheal suturing in the non-intubated, spontaneously breathing patient, which makes tracheal suturing easier, and which reduces the time required for tracheal suturing in comparison to cases requiring operative field intubation. In this point, this procedure may be ideal for both the patient and surgeon. The surgical team should have sufficient experience in tracheal surgery by VATS and non-intubated anesthesia with spontaneous breathing to be able to respond properly to surgical and anesthetic complications. Before beginning the tracheal procedure under non-intubated anesthesia, they should confirm the process of the procedure and the criteria for conversion to general anesthesia and not hesitate with such conversion. The anesthesiologist must be trained to intubate in the lateral decubitus position in case of an emergency during non-intubated thoracic surgery. The surgeons should recognize the limitations of non-intubated anesthesia, which are caused by the operation time and complications during the operation.

It is difficult to plan a randomized controlled trial to compare the postoperative mortality and complications (including respiratory complications) between non-intubated patients and intubated patients undergoing tracheal resection, because tracheal procedures are relatively uncommon. Because the reports on tracheal resection and reconstruction under non-intubated anesthesia with spontaneous breathing are limited to case reports, the feasibility and safety of this technique should be confirmed in a study after the accumulation of a suitable number of patients; furthermore, the institutions should be limited to those with sufficient experience in VATS tracheal surgery and VATS under non-intubated anesthesia with spontaneous breathing. The appropriate criteria for identifying candidates for this procedure should be established. If the results of such a study show that the procedure is safe, and that it is associated with fewer operative complications, and a better long-term prognosis, this procedure may spread throughout the world to become a standard procedure for tracheal resection followed by reconstruction.

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Footnote

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

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