Nonintubated Thoracoscopic Pulmonary Nodule Resection Under Spontaneous Breathing Anesthesia With Laryngeal Mask

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Objective: During the past 20 years, the use of video-assisted thoracoscopic surgery has increased as an important minimally invasive tool. To further reduce its invasiveness, after a preliminary experience, we decided to use a nonintubated spontaneous breathing general anesthesia, for video-assisted thoracoscopic surgery resection of lung nodule, using a laryngeal mask (LMA). This study aimed to verify the safety and the feasibility of this technique.

Methods: Twenty consecutive patients who underwent thoracoscopic wedge of lung nodule under spontaneous breathing general anesthesia with LMA are the subjects of this study. Clinical data, American Society of Anesthesiologists status, Adult Comorbidity Evaluation–27 score, and Revised Cardiac Risk Index score were recorded for each patient. General inhalatory anesthesia (sevoflurane) was given in all cases through an LMA, without muscle relaxants, thus allowing spontaneous breathing. All procedures were performed in the lateral decubitus position. The maximum and minimum values of end-tidal carbon dioxide tension and oxygen saturation were recorded during the procedure. The level of technical feasibility was stratified by the operating surgeon according to four levels: excellent, good, satisfactory, and unsatisfactory.

Results: There were 13 men and 7 women (mean age, 57 years). The mean induction anesthesia time was 6 minutes, whereas the mean operative time was 38 minutes. The values of oxygen saturation as well as minimum and maximum end-tidal carbon dioxide tension were 99.1%, 33.6 mm Hg, and 39.1 mm Hg, respectively. No mask displacement occurred. The mean operative time was 38 minutes (range, 25–90 minutes). The level of technical feasibility was defined as excellent in 19 cases and good in 1 case. No mortality occurred. Morbidity consisted of pleural effusion (one case), which was medically resolved. The mean postoperative stay was 3.5 days. Histopathologic results were one squamous cell lung cancer (lung primary), one adenocarcinoma (lung primary), five metastasis from colon cancer, four metastasis from breast cancer, three metastasis from renal cancer, three sarcoidosis, two amartochondroma, and one tuberculosis.

Conclusions: Our experience suggests that thoracoscopic wedge resection of lung nodule is safe and feasible under spontaneous breathing anesthesia with LMA. This technique permits a confident manipulation of lung parenchyma and a safe stapler positioning, without cough, pain, or panic attack described for awake epidural anesthesia, avoiding the risks related to tracheal intubation and mechanical ventilation.

Key Words: Thoracoscopy, VATS, Minimally invasive surgery, Lung wedge resection, Laryngeal mask, Lung nodule.

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Video-assisted thoracoscopic surgery (VATS) in the last 20 years has been improved for diagnostic and therapeutic procedures. General anesthesia with double-lumen intubation is generally considered mandatory for thoracic surgery and, above all, for VATS procedures. Nevertheless, intubation is related to several risks. First of all, there is the risk for iatrogenic tracheobronchial injuries related to orotracheal intubation. Although orotracheal intubation is a low-risk procedure, tracheobronchial injury is responsible for a high morbidity and mortality.1–3 In addition, there are the risks for volutrauma and barotrauma4–6 as well as the development of atelectasis in both the dependent and the nondependent lung.7,8 Thus, some authors investigated the role of awake thoracic surgery under sole thoracic epidural anesthesia (TEA) for thoracoscopic resection of lung nodules9,10 and for treatment of spontaneous pneumothorax.11 Nevertheless, this method was potentially associated with the risk for epidural hematoma or spinal cord injury. In addition, cough or panic attack could occur during the procedure, hampering surgical movements. In recent times, we decided to apply general anesthesia in spontaneous breathing with laryngeal mask (LMA) for treatment of spontaneous pneumothorax to avoid the risks related to tracheal intubation, to single-lung ventilation, and to epidural anesthesia.12 After this study, with gained experience, we decided to apply this technique also for thoracoscopic wedge resection of peripheral nodules, evaluating feasibility, safety, and efficacy.
MATERIALS AND METHODS

There were 20 consecutive patients who underwent VATS wedge resection for lung nodules under general anesthesia in spontaneous breathing. All patients signed a detailed consent form. This study was approved by the ethics committee. The purpose of this study was to verify the safety and the feasibility of LMA anesthesia in spontaneous breathing for VATS parenchymal resection of lung nodules.

Demographic and clinical data, such as age, sex, weight, body mass index, forced expiratory volume in 1 second, and comorbidities, were recorded for each patient. Comorbidity scores were recorded using the Adult Comorbidity Evaluation–27 scoring system. For the assessment of cardiologic risk, we used the Revised Cardiac Risk Index. The American Society of Anesthesiologists score was decided upon by the anesthesiologist for the evaluation of anesthesia risk. Inclusion criteria were nodule smaller than 3 cm, within 1 cm below the visceral pleura surface, and programmed for VATS wedge resection. Exclusion criteria were congenital or acquired oropharyngeal malformations, previous laryngeal operations, and risk for conversion to open surgery.

Anesthesiologic Technique

In all patients, a large venous catheter was positioned in a peripheral vein. Two-lead electrocardiogram findings, pulse oximetry monitoring values, and arterial blood pressure were recorded. Anesthesia induction was performed with intravenous infusion of propofol (2–3 mg/kg). An LMA was positioned after induction, and then general anesthesia was maintained using solely sevoflurane (minimum alveolar concentration, 1%–2.5%). The fraction of inspired oxygen was 50%. No muscle relaxants were used throughout the procedure, thus permitting the patient to breathe spontaneously. End-tidal carbon dioxide tension (ETCO2), oxygen saturation (SaO2), cardiac frequency, and blood pressure were constantly monitored throughout the operation. At the end of the procedure, inhalatory sevoflurane was discontinued, whereas the LMA was left in place. When the patient had regained consciousness and had executed the vocal order to open the mouth, the LMA was removed.

Surgical Technique

All patients were positioned in the lateral decubitus position. The camera was generally inserted at the seventh intercostal space on the midaxillary line. Then, two other port incisions were created on the basis of the site of the programmed resection. Nodules were visualized or localized with the use of instrumental palpation or endothoracic ultrasonography with a linear probe (Biomedical, Genova, Italy). At the end of the procedure, two chest drainages were positioned.

Data Analysis

For each patient, the maximum and minimum values of ETCO2, SaO2, peripheral blood pressure, and cardiac frequency were recorded. The anesthesia induction time (defined as the time necessary to induce anesthesia), operative time (defined as the time between skin incision and skin closure), and postoperative stay were recorded. Technical feasibility was stratified into four grades by the operating surgeon, based on his/her personal experience with traditional VATS: unsatisfactory, satisfactory, good, and excellent. The safety assessment included identification of complications occurring within 30 days of treatment. Statistical analysis was expressed in terms of frequency, mean, and range.

RESULTS

There were 13 men and 7 women, with a mean age of 57 years (range, 36–76 years). No patient was excluded because of age or comorbidities. The patients’ features are listed in Table 1. The mean anesthesia induction time was 6 minutes (range, 5–10 minutes). No intraoperative complication occurred. No mask displacement occurred. The mean level of SaO2 was 99.1 mm Hg (range, 80–100 mm Hg). In all cases, the level of SaO2 resulted as adequately high during the operation. No breathing depression occurred.

The mean maximum and minimum levels of ETCO2 were 39.1 mm Hg (range, 33–43 mm Hg) and 33.6 mm Hg (range, 32–38 mm Hg), respectively. The mean operative time was 38 minutes (range, 25–90 minutes). All nodules were successfully identified and resected. The level of technical feasibility was excellent in 19 cases and good in 1 case. There was no mortality. Morbidity consisted of a single case of pleural effusion, which was medically treated and resolved (grade I according to Clavien-Dindo classification). The mean postoperative stay was 3.5 days (range, 2–5 days). Histopathologic results of the resected nodules are listed in Table 2.

COMMENTS

Bronchial intubation with single-lung ventilation was introduced at the beginning of the 1940s and required mechanical ventilation as well as muscle relaxants. It allowed undoubted and widely accepted advances in the thoracic fields, and above all, video-assisted thoracic surgery. Nevertheless, this was associated with
increased risk for pneumonia and impaired cardiac performance. In addition, the pressure (whether positive or negative), the inflation volume, as well as the cyclic opening and closing of the small airway units related to mechanical ventilation can cause damage to the lung parenchyma: barotrauma, volutrauma, and atelectrauma, respectively. Some authors reported that single-lung ventilation with muscle paralysis generally produces atelectasis in the dependent lung. However, the most severe risk is represented by tracheal injury, the most significant adverse event related to tracheal intubation. In 2005, Gómez-Caro Andrés et al reviewed 90 cases of iatrogenic tracheobronchial injury from seven series. Recently, some authors, in writing about their decennial experiences, reported approximately 30 cases of tracheal injury, whereas Minambres and colleagues, in a recent review, reported 182 cases of postintubation tracheal rupture during 40 years, with a high level of morbidity and high mortality rate (22%).

To avoid the abovementioned risks, together with our anesthesiologic team, we have evaluated the safety and the feasibility of VATS parenchymal resection under general anesthesia in spontaneous breathing with LMA. In 2007, a study of Cook and Gibson reported the successful use of LMA on a large cohort of patients, generally for peripheral and external surgeries but also for laparoscopic (12%) and open abdominal interventions (5%). In this article, LMA was safely used on patients as old as 101 years and weighing more than 100 kg. Other studies reported the efficacious use of LMA in cardiac and noncardiac pediatric surgery. However, only few data yet exist regarding its application in thoracic surgery. In a recent article, we evaluated the safety of LMA general anesthesia under spontaneous breathing for parenchymal resections for treatment of primary spontaneous pneumothorax. That study suggested that LMA anesthesia in spontaneous breathing permits a safe and effective VATS apicectomy: the operating space was adequately large, and the lung parenchyma could be safely manipulated.

After these promising results, we decided to extend LMA general anesthesia with spontaneous breathing to VATS wedge resection of lung nodule. In addition, we reasoned that the lower invasiveness of this technique would be more helpful in old patients with chronic obstructive pulmonary disease (COPD) and/or other comorbidities, in respect to the young ones affected by pneumothorax, described in the previous article. In fact, in this study, no patient was excluded from LMA anesthesia because of age or comorbidities. This technique was applied in patients until 76 years old, with a weight of more than 100 kg, with a high Adult Comorbidity Evaluation–27 grade or an American Society of Anesthesiologists status of 3, with poor respiratory function values, and unfit for major lung resection such as lobectomy or segmentectomy because of poor cardiopulmonary reserve. All procedures were successfully concluded. No mask displacement occurred. The $\text{SaO}_2$ and $\text{ETCO}_2$ levels measured during the entire operating time were adequate in all cases. Desaturation was not experienced, even in COPD patients with poor pulmonary reserve. In fact, the use of inhalatory anesthesia (sevoflurane) permits a “self-limiting” regulation of the anesthetic gas: any potential breathing depression produces a decreased level of alveolar concentration of anesthetic gas and, consequently, a decreased level of its blood concentration, thus limiting the breathing depression itself.

No intraoperative complications were observed. The operative time resulted as being adequately short, and the level of surgeon satisfaction was generally high. The nondependent lung was completely deflated (Fig. 1), even in the emphysematous patients: an open pneumothorax was created after performing the thoracoscopic accesses; thus, an adequate operating space was obtained for movements of thoracoscopic instruments. The lung parenchyma was safely manipulated, and the cough reflex was never observed (Fig. 2). The cough reflex, which can hamper surgical maneuvers, was instead present in the studies of Pompeo et al, who described their experience with awake TEA in cases of pneumothorax or wedge resection of pulmonary nodule. They obtained good results, although cough occurred in 14% of
cases, permitting the risk for dangerous involuntary movements of instruments.\textsuperscript{11} In a recent study, Chen et al\textsuperscript{21} reported the results of the awake TEA technique for performing 30 VATS lobectomies, using an intrathoracic vagal blockade to impede the cough reflex. The vagal blockade was achieved by infiltration of 2 mL of 0.25% bupivacaine adjacent to the ipsilateral nerve, creating a cough reflex inhibition for approximately 3 hours. However, in this series, one case of persistent hypoxemia and one case of poor epidural anesthesia pain control required conversion to intubated single-lung ventilation. These side effects are related to the fact that the patients were not asleep but mildly sedated at a communicable and cooperative level, responding to commands. These and other adverse events, related to the awake condition, were also reported by Pompeo et al.\textsuperscript{9-11} These were thoracic pain at trocar sites (9.5\%).\textsuperscript{9,21} requiring additional local anesthesia, and panic attack (6\%–9.5\%). Both of these facts, which bring about the necessity of calming the patient and frequently comforting him/her, were completely absent in our experience because the patients were completely asleep. Furthermore, in respect to the TEA technique, with or without vagal blockade, LMA in spontaneous breathing is free of the possible but severe risks associated with epidural hematoma or spinal cord injury. In recent times, Katlic and Facktor\textsuperscript{22} described an experience similar to ours. They used deep sedation and local anesthesia, without tracheal intubation or epidural anesthesia, on a large cohort of VATS procedures, including 40 parenchymal resections. Nevertheless, their high dosage of fentanyl seemed to be potentially associated with breathing depression, such as that described in the study of Chhajed et al.,\textsuperscript{23} in which hypoventilation occurred. With this method, patients experienced hypercapnia (up to 77 mm Hg) and desaturation.\textsuperscript{23} In our series, the presence of LMA permitted a safe and easy management of any possible breathing depression with the use of manual ventilation, such as that reported in our previous article when total intravenous anesthesia was used.\textsuperscript{12}

However, this study has some limitations: first, the small series, and second, the assessment of technical feasibility that can be influenced by surgical personal skill. An important key point is represented by patient selection. A careful patient selection is essential to reduce the possibility of conversion to open approach, both for technical and for oncological reasons. From the technical point of view, patients with tenacious pleural adhesions or with nodule unsuitable for VATS resection must be excluded. From the oncological point of view, patients with a suspected need for lobectomy must be referred to traditional anesthesia: LMA anesthesia was applied for clinically benign lesions or suspected metastatic or suspected primary malignant lesions in patients unable to tolerate lobectomy or segmentectomy.

Laryngeal mask anesthesia in spontaneous breathing for VATS wedge resection seems to be feasible and safe, allowing a suitable manipulation of pulmonary parenchyma without cough reflex, even in emphysematous or COPD patients, avoiding the risks related to orotracheal intubation.

\textbf{REFERENCES}


The first large-scale reports of performing video-assisted chest surgery (VATS) using local anesthesia emerged in the midportion of the first decade of this century; in 2004, Pompeo and Mineo reported their positive results in their prospective randomized trial to the 40th Annual Meeting of The Society of Thoracic Surgeons. They used mask ventilation and epidural to achieve analgesia during the VATS procedure. Then, again, an awake VATS series was presented to the 46th Annual Meeting of The Society of Thoracic Surgeons; Mark Katlic presented the results from the Geisinger Clinic, where mask ventilation was again used, but this time, local anesthesia rather than epidural was used to achieve procedure-related analgesia (Katlic MR, Facktor MA. Video-assisted thoracic surgery utilizing local anesthesia and sedation: 384 consecutive cases. Ann Thorac Surg. 2010;90:240–245). He reported on 384 consecutive patients with no deaths and minimal complications. In this Innovations article, the group from Pisa reports their technique of using a laryngeal mask ventilation to support patients during simple VATS procedures, with excellent results. As with the other reports, their technique appears to be safe in a heterogeneous group of patients. In a recent review of regional analgesia VATS procedures, numerous techniques have been described in the literature; there appears to be a role in performing minimally invasive surgery and it appears to be safe, but the best way to achieve analgesia remains to be determined (Steinthorsdottir KJ, Wildgaard L, Hansen HJ, Petersen RH, Wildgaard K. Regional analgesia for video-assisted thoracic surgery: a systematic review (Eur J Cardiothorac Surg. 2014;45:959–966).