Minimally Invasive Surgical Oncology

www.misurgoncol.com

Minim Invasive Surg Oncol, 2017; 1(1): 1-11. **ISSN 2393-3828**

Review Article

Video-assisted thoracoscopic surgery for non-small cell lung cancer

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Abstract

The use of video-assisted thoracoscopic surgery (VATS) in the management of the non-small cell lung cancer was aiming to reduce the morbidity, mortality and hospital stay of the patients. VATS surgery allows for quicker return to the regular daily activity following thoracic surgeries in comparison to the standard form thoracic incisions. It is safe and carries minimal risks if it is performed in a well-established center and by an experienced thoracic surgeon.

Keywords: non-small cell lung cancer; video-assisted thoracoscopic surgery; lobectomy, thoracoscopy, minimally invasive lobectomy

Cite this article as: Abu Arab W. Video-assisted thoracoscopic surgery for non-small cell lung cancer. Minim Invasive Surg Oncol, 2017; 1(1): 1-11.

Background

The introduction of video-assisted thoracoscopic surgery (VATS) in the management of the non-small cell lung cancer (NSCLC) was aiming at reduction of the morbidity, mortality and hospital stay [1, 2]. It was documented that VATS surgery allow for quicker return to regular and daily activity following thoracic surgeries in comparison to the standard form thoracic incisions. The first VATS

lobectomy with anatomic hilar dissection was performed on 1992 [1-3]. This created a debate and many questions regarding the safety and benefits regarding this new technique in pulmonary resection especially in patients with pulmonary carcinoma. During this early era, there was no enough studies published to compare between the different approaches available for treatment of NSCLC, however recently, there are large published series that can provides data regarding the results and efficacy of the VATS resection in patients with NSCLC.

Surgical treatment for NSCLC

Surgical resection remains the corner stone for treatment of patients with operable early stages of NSCLC. Moreover, it is recommended for resectable stage IIIA NSCLC. Different types of surgical operative approaches are available at the moment. Nowadays, majority of operative interventions could be performed through VATS with similar oncological results to the open surgeries [4]. The main aim of surgery in treatment of the NSCLC is to achieve complete resection of the tumor and to get an intra-operative staging of lung cancer. Consequently, mediastinal lymph adenectomy or mediastinal lymph node sampling is an essential part of the surgery because it determines the prognosis. Moreover, it determines the need for adjuvant therapy administration.

The new multidisciplinary adenocarcinoma classification that was published in 2011 had presented the idea of adenocarcinoma in situ and the minimally invasive adenocarcinoma. Consequently, this allows for rethinking about the value of limited surgical resections for the early stages of NSCLC. A number of non-randomized retrospective studies have proposed the limited surgical resection for early stages NSCLC as an acceptable treatment, even when it is done via VATS [4].

Complete Resection (R0)

The main aim of the surgical treatment in patient with NSCLC is to achieve complete radical resection with safety margins (R0). The working group of the International Association for the Study of Lung Cancer (ISLAC) established specific criteria to be fulfilled to achieve complete radical resection [5]. Complete surgical resection was stated as complete excision of the primary tumor without leaving any residual tumor tissues; neither microscopic nor macroscopic; at the site of surgery. Moreover, a systematic or lobe specific lymph node dissection should be performed.

It is well known that the treatment of choice for early stages of NSCLC is surgical. There is a comparable value in survival between those patients who had pulmonary resection for NSCLC and the others who did not have surgery for some reasons. Those patients who had received treatment of NSCLC in the form of pulmonary resection had a better survival rates. Early stage disease and T3N1 NSCLC are considered definite indication for surgery [6].

Resectability and operability of a primary NSCLC depend on several factors that include clinical staging, intraoperative staging, and functional status of the patient. Hence, a detailed cardio-pulmonary evaluation of the patient is essential to determine the

operability and extent of resection [7].

Types of pulmonary resection for lung cancer

There are different types of pulmonary resection that could be performed for patients with NSCLC. Van Schil et al. [4] have summarized these types of pulmonary resection in their publication. Pulmonary resections could be divided into three main categories. The first one is the standard pulmonary resection which include either lobectomy, bi-lobectomy or pneumonectomy. The second main type of pulmonary resection is the lung parenchyma sparing surgery and it includes either segmentectomy or wedge resection or sleeve pulmonary resections. The third main type of pulmonary resection is extended pulmonary resections or en-bloc resection that may include resection of any other structure inside the chest beside the resection of the lung in order to achieve R0 resection margins.

Lobectomy is considered the surgery of choice for cancers that are confined to a single lobe and it is the standard surgery that should be performed in such cases [8]. The role of lung parenchyma saving pulmonary resections or wide-wedge resection is being reconsidered for very early lung cancer following large screening programs for lung cancer. This is attributed to the findings of non-solid or partially-solid ground glass opacities, what is named as ground-glass opacity [9].

Thoracic approaches

The postero-lateral thoracotomy is the classical incision used for thoracic procedures. It is the preferred thoarcic incision for the majority of thoracic surgeons all-over the world to perform resection of lung cancer. Modifications has been done by some surgeons on this classical incision. If the situation is suitable, a muscle- sparing thoracotomy can be performed and it is more preferred than the classical muscle cutting posterolateral thoracotomy to preserve the latissimus dorsi muscle and hence the muscle power. Sternotomy can be used in patients requiring bilateral procedures, especially bilateral upper-lobe lung cancers. An extended incision such as a hemi-clamshell incision may be utilized in selected patients requiring an extended resection [4]. Nowadays, the use of the VATS is growing up to access the thoracic cavity and performing various thoracic interventions. McKenna et al. have reported around 0.8 % operative mortality in his series that included 1100 VATS lobectomies [1]. Moreover, the morbidity rate generally appears to be lower with the VATS approach rather than open thoracotomy approach [10].

Currently, VATS has become a standard approach for peripheral wedge resections and lobectomy for stage I NSCLC tumors. VATS pulmonary segmental resection is not performed on wide scale its possible benefits and restrictions still require further studies and evaluations [11, 12]. Although VATS seems to be valuable or even of more benefits than classical approaches used for NSCLC resections in terms of morbidity, length of stay and survival in comparison to an open approach, a large group of surgeons recommend further evaluation in large, prospective randomized trials [13].

Intra-operative systematic nodal dissection

Precise intraoperative systematic lymph node dissection is an utmost important step to provide an accurate non defective pathological TNM staging [14]. Poor prognosis is predicted in patients who had resected N2 disease with invasion of the highest mediastinal lymph node [4].

Graham et al. [15] have strongly recommended a systematic nodal dissection for precise N staging during thoracotomy procedure. In this procedure of nodal staging, the dissection of mediastinal, hilar and lobar lymph nodes is achieved in a systematic way. In the study performed by the same group, they reviewed 240 patients with clinical T1–3 N0–1 NSCLC. The mediastinoscopy was performed before surgery if the lymph nodes detected on CT-Chest are larger than 1.5 cm in diameter. The rate of exploratory thoracotomy without further resection was reported to be around 3%. Meantime, the pathological N2 disease was discovered in twenty percent of patients following the surgical resection.

Systematic lymph-node dissection is currently considered the gold standard for the accurate staging of nodal (N) disease and should be routinely performed, also when a minimally invasive approach is chosen [4]. In a non-randomized study that was performed by Keller et al. [16] and included 373 patients, complete mediastinal lymph-node dissection identified more levels of N2 disease in patients with stages II and IIIA NSCLC, and was associated with improved survival in comparison to systematic nodal sampling but only for right-sided lesions [16]. Only one prospective randomized trial has documented a survival advantage of complete mediastinal lymph node dissection [17]. In a recently published multicenter prospective clinical trial, patients with intra-operatively staged T1-2N0-non-hilar N1 NSCLC were randomized to lymph-node sampling versus systematic nodal dissection. The systematic nodal dissection has identified occult disease in 3.8% of patients, however it was not associated with a benefit in overall survival [18].

Quality of life following pulmonary resection for NSCLC

Patients may consider immediate postoperative complications as an acceptable risk, but most of them may not prepared to accept significant postoperative quality of life (QoL) impairments [19]. Many studies concentrated on the predictors of QoL following surgical resection of an early-stage lung cancer. Several parameters including the extent of resection [20-22], surgical approach used [23, 24], age of the patient [25- 27] and smoking status [28-30] are considered to be significant predictors.

The resection extent has a significant influence on the QoL. Several researchers had evaluated the QoL following lobectomy and pneumonectomy [20-22]. They stated that the primary limitations in the physical QoL component observed following both resections; lobectomy and pneumonectomy; are more clear and evident following pneumonectomy. Sublobar resections, indicated in stage IA patients with a tumour located in the peripheral zones of the lung and < 2 cm in diameter, are currently often performed. Although these procedures

imply a parenchyma sparing intent, QoL has rarely been reported after sublobar resections.

The effect on QoL has been evaluated for the muscle-sparing versus the non-muscle-sparing thoracotomy, and even that of the minimally invasive thoracic surgery. The effect of the muscle-sparing thoracotomy is mostly seen on the physical QoL component. Patients who had muscle sparing thoracotomy had improved shoulder function and less thoracic pain compared to those who had non-muscle sparing thoracotomy [31]. The profits of VATS that were proved over thoracotomy in terms of QoL are mainly found directly following surgery at the immediate postoperative period. Almost, there was no valuable difference detected in QoL following the 4th postoperative day [32]. Landreneau et al. [33] have stated that patients who had VATS experienced less degree of pain on the first two days postoperatively in comparison to those who had a muscle-sparing thoracotomy.

Several authors prospectively evaluated QoL after lung-cancer surgery in elderly patients. Generally, age above the 70 years was found to be an important risk factor for impairment of the physical QoL component. Moreover, the recovery is not guaranteed until several months postoperatively [20].

After lobectomy and pneumonectomy, the emotional component returns to baseline following the first 3 months after surgery in elderly patients [34]. Myrdal et al. have evaluated the effect of smoking on postoperative QoL at 6 months [29]. Patients who continued smoking after lung-cancer surgery had significantly lower scores for the emotional QoL component than former smokers and non-smokers. Contrarily, Sarna et al. [30] could not confirm the smoking status as predictive for postoperative QoL. In a recent study, it was concluded that smoking cessation is beneficial at any time point prior to lung-cancer resection [28]. Current smoking at the time of surgery is associated with a longer impairment of QoL functioning as well as symptom scores [4].

There is a debate on the effect of induction and adjuvant chemotherapy or radiotherapy on QoL following surgery for lung cancer [35-37]. Authors who evaluated the effect of chemotherapy on the QoL of lung-cancer patients, in both non-surgical and surgical patients concluded that in non-surgical patients, chemotherapy was associated with worse QoL unless the patients responded to treatment [38]. Paull et al. [37] reported that exposure to postoperative chemotherapy was a risk factor for poor QoL after surgery for early-stage lung cancer. However, Fiedler et al. who evaluated the QoL after pneumonectomy comprising early- as well as advanced-stage lung cancer; did not confirm the previous results [36].

Surgical quality control

One is unable to perform a uniform judgment of surgical quality. This is because the thoracic surgery comprises a large variety of different procedures which may prove to be technically challenging, such as extended resections of the superior sulcus, sleeve resections, intra-pericardial procedures, etc. Hence, the overall mortality is only a crude parameter and risk stratification. Moreover, dedicated anaesthesiological, intensive-care and nursing management

is required to obtain the best postoperative results; thus team management will not only determine the short-term results but also the long-term outcome [4].

The hospital volume may be a critical determinant. Luft et al. [39] demonstrated that mortality after open-heart surgery, vascular surgery and prostatectomy decreases with increasing number of procedures performed. Specifically speaking on the number of pulmonary resections, mortality was lower in those centers performing more than 24 interventions on a yearly basis. Moreover, mortality of lobectomy was significantly lower when performed by a thoracic surgeon compared to a general surgeon [40].

In addition, centralization of care seems to be the logical consequence in improving short-term and long-term results. Thoracic surgeons should be more implicated in randomized clinical trials that compare the newly introduced treatment modalities –as stereotactic radiotherapy or radiofrequency ablation – to the classical surgical procedures in use. Furthermore, they should also be ready to adjust themselves to a new, continuing changing environment. Multidisciplinary collaboration and large scale prospective studies are necessary to update current diagnostic and therapeutic algorithms ensuring optimal patient care in thoracic surgery [41].

VATS lobectomy

Definition

The exact definition of VATS lobectomy carries some debate around it concerning some issues. These issues include the rib spreading, instrumentations used and the anatomic dissection. On contrary, most surgeons agree that VATS lobectomy include incision less than 10 cm; moreover some surgeon limit the incision to 5 cm; without use of rib spreader and the procedure should include an anatomic dissection of the pulmonary vessels and lymph node sampling or dissection. In addition, the surgeon should visualize the dissection on the monitor; not through the incision. The instrumentation used during VATS procedure is an important issue that should be put into consideration. The use of standard open instruments or disposable minimally invasive instruments does not matter and should not be a part of the definition of VATS lobectomy. Patients who had lobectomy and lymph node dissection via complete VATS had less blood loss, faster recovery and short hospital stay. However, they had longer operative time in comparison with patients who had lobectomy through open procedures [42]. Patients who had complete VATS lobectomy were compared to those who had lobectomy via open thoracotomy regarding 5 years survival and the recurrence rate. The 5 years survival in complete VATS group was 96.7% and that of the open techniques 97.2 % and there was no difference in the rate of recurrence among both. Nowadays, VATS lobectomy is an acceptable cancer operation for patients with peripheral non-small cell lung cancer that is less than or equal to two centimeters in diameter with same long term survivals as an open surgery. Classical VATS surgery is performed via three or four ports in the thoracic wall. However, a recent advent in thoracoscopic surgery have brought uniportal VATS in use. In

such procedure, a small incision of 5 centimeters is made; and again no rib spreader is used; from which all instruments are introduced inside the chest cavity.

General approach for VATS lobectomy

Generally, steps for lobectomy should be the same whatever the approach. The arteries, veins and bronchi should be dissected and individualized and each is ligated individually. Moreover, lymph node sampling or dissection should be performed for intra-operative staging [43].

With recent improvement in technology and its availability, most of lobectomies can be performed now via VATS with a small conversion rate into open surgeries. VATS lobectomy is growing fast nowadays as the patients ask for the procedure and the thoracic surgeons gain an understanding of the techniques to perform the procedure.

Indications and contra-indications for VATS lobectomy

To perform VATS lobectomy for NSCLC, you should select the patient well to achieve good results. There are certain indications for VATS lobectomy that include clinical stage I lung cancer and the ideal patient for VATS lobectomy is that with peripheral tumor T1N0, tumor size should be less than 6 cm in diameter and the patient should be physiologically operable.

In contrast, there are some relative contra-indications that include nodal disease, pancoast tumor, chest wall or mediastinal invasion, need for sleeve lobectomy, neoadjuvant chemotherapy and neoadjuvant radiation therapy. These relative contra-indications differs according to the skills of the surgeon with VATS and also according to the experience of the center with VATS surgery. Moreover, VATS lobectomy is absolutely contra-indicated in patients with nodal disease that densely adherent to the vessels, presence of chest wall or mediastinal invasion (T3 or T4 tumor), and in patients who had received neoadjuvant chemotherapy and radiation therapy.

Technique of VATS lobectomy

The most important issues to preserve your VATS procedure is to remain stick to the conditions applied to the procedure where the classical VATS is consisting of two small skin incisions; 1 cm each; and the utility incision that is should not exceed 6 cm in length. Moreover, the rib spreader should not be used. The fissure, bronchus and pulmonary vessels that are larger than 0.5 cm should be transected with endoscopic stapler while the smaller ones are tied or clipped. The resected lobe should be extracted inside the specimen bag through the utility incision to minimize the contamination of the incision with malignant cells.

Mediastinal lymph node dissection should be a part of the VATS lobectomy. Mediastinal lymph node sampling or dissection should be completed via VATS. In a study performed to compare between VATS mediastinal lymph node dissection and mediastinal lymph node dissection through thoracotomy, it was found that a good lymph node dissection can be performed through VATS [44].

Safety of VATS lobectomy

Several studies [1, 45-48] have evaluated the morbidity and mortality related to VATS lobectomy. The morbidity rate ranged in those studies between 2.3% to 22% while the

mortality rate ranged between 0.5 % and 1%. These values means small rates of morbidity and mortality.

Thoracic surgeon should realize that conversion from VATS lobectomy to thoracotomy is not a failure of the VATS procedure. Conversion may be necessary for several reasons such as centrally located tumor, or unsuspected T3 tumor that is attached to or invading several structures inside the chest cavity.

Intra-operative bleeding during VATS surgery can be dangerous; however; with meticulous dissection and manipulation its occurrence is rare with an experience surgeon. Significant bleeding was reported in 1% of patients who were included in one study [49].

Conclusion

In conclusion, VATS lobectomy is safe to perform for NSCLC in hands of an experienced surgeon. It has the same long term survival as with thoracotomy incision. Furthermore, it has more benefits in terms of short hospital stay and less post-operative pain.

Conflict of interest

The authors have no potential conflicts of interest to disclose.

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