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Comparative Analysis of Video-Assisted Thoracoscopic Surgery and Open Thoracotomy for Early-Stage Non-Small Cell Lung Cancer: Review

Osamah Obaid Ibrahim
Department of Surgery, College of Medicine, University of Thi-Qar, Thi-Qar, Iraq

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Annotation: Video-assisted thoracoscopic surgery (VATS) has increasingly become the modality of choice in the management of patients with early-stage non-small cell lung cancer (NSCLC). Morbidity and hospitalisation are always lower and shorter in persons undergoing VATS when compared to persons undergoing conventional thoracotomy in systematic reviews. However, it is essential to note that few randomized controlled trials specifically assessing long-term oncologic outcomes exist. The current review is therefore aimed at evaluating and summarizing the literature published over the last decade, with a focus on cancer-free survival, overall survival, postoperative complications, and health-related quality of life. It is limited to situations where lobectomy or segmentectomy was done with a curative intent that was final and where there was a need to compare the VATS technique and open thoracotomy in the environment of early-stage NSCLC. In addition, new surgical methods and the multifactorial determinants influencing the cost-effectiveness of every operative approach will be discussed.

1. Introduction

Video-assisted thoracoscopic surgery (VATS) and conventional open thoracotomy are the two

major modalities that have been used to conduct surgery on non-small cell lung cancer (NSCLC) in its early stages. VATS is gaining increasing recognition as a more desirable treatment option among patients of early-stage disease since it was first used clinically in 1994. The percentage of resections done on NSCLC through the use of VATS lobectomy has significantly increased over the years and forms a huge percentage among all the surgeries conducted due to this diagnosis. Available data, such as systematic reviews and literature, all indicate that patients undergoing VATS lobectomy have a range of benefits, such as low postoperative pain levels, complication rates, and hospital stay as compared to those undergoing open lobectomy. As the demand for video-assisted surgeries continues to rise, an array of innovative designs has emerged, aiming to enhance and facilitate endoscopic procedures not only within thoracic applications but also in non-thoracic medical fields. The present review provides a thorough and comprehensive comparison of VATS in relation to open thoracotomy, highlighting and clarifying the significant clinical, economic, and patient-centered differences that exist between these two surgical techniques. [1][2] [3][4]

2. Background

One of the most commonly diagnosed cancer types, lung cancer is also the most dominant cause of cancer-related mortality in the world. Among the various histological types of lung cancer, non-small cell lung cancer (NSCLC) constitutes approximately 80–85% of all diagnosed cases. Respiratory specialists and emergency physicians often meet patients with non-small cell lung cancer (NSCLC) in a wide variety of clinical situations; as a result, a thorough insight into the presentation, symptoms, and treatment options related to this disease holds special significance. Video-assisted thoracoscopic surgery (VATS) lobectomy has become a widespread and effective surgical intervention in patients with an early-stage NSCLC. The extent and constraints relating to this procedure are well known in the community of thoracic surgery. Besides, the latest improvements in the technology of thoracoscope have expanded the clinical indication of VATS lobectomy, and it is expected that the new technique will further spread and be popular in the medical sphere.

3. Overview of Non-Small Cell Lung Cancer (NSCLC)

Non-small-cell lung carcinoma (NSCLC) represents the largest percentage of lung cancer diagnoses in the world, comprising about 85 percent of all cases, and is the major cause of cancer-related death on a global scale. Early-stage is used to describe localized NSCLC, i.e., the disease is limited to the pulmonary parenchyma without signs of metastatic spread or involvement of the regional lymph nodes. This subset of NSCLC is important to understand to clarify therapeutic choice and disease progression. Under this classification, there are three main histopathologic subtypes that are commonly distinguished: adenocarcinoma, squamous-cell carcinoma, and large-cell carcinoma. These subtypes vary in their biological characteristics and responses to treatment. Unfortunately, despite the advancements in medical technologies and treatments, the prognosis for those diagnosed remains poor, with continuous data showing that only around 15 percent of patients manage to survive beyond a span of 5 years following diagnosis, highlighting the urgent need for improved therapeutic approaches and early detection strategies. [5][1]

4. Surgical Interventions for NSCLC

Non-small cell lung cancer (NSCLC) constitutes the majority of lung cancer cases and is the foremost cause of cancer-related mortality globally [5]. Surgical resection remains the cornerstone of potentially curative treatment in patients with early-stage disease. Video-assisted thoracoscopic surgery (VATS) and open thoracotomy are the principal surgical approaches. VATS lobectomy has gained preference for early-stage NSCLC due to evidence of reduced morbidity, faster recovery, and comparable oncological outcomes. The present review provides a comprehensive comparative appraisal of the two interventions in this clinical setting.

Both techniques entail a comprehensive anatomic resection of the affected pulmonary lobe accompanied by a systematic dissection of thoracic lymph nodes. VATS lobectomy employs a minimal-access surgical strategy that is conducted under the guidance of a thoracoscope, effectively avoiding the need for a traditional thoracotomy. The procedure can be executed either entirely through multiple small incisions utilizing endoscopic instruments in what is known as multi-port VATS, or it can be performed through a single, more efficient incision in a method called uniportal VATS. In stark contrast, open thoracotomy necessitates making a posterolateral incision that requires considerable rib spreading to access the hemithorax, which can lead to more significant postoperative discomfort and longer recovery times. The adoption of VATS significantly diminishes the surgical trauma that is customary with open thoracotomy, presenting a compelling advantage for patients undergoing pulmonary procedures. This innovative approach not only speeds up the recovery process but also minimizes the overall impact on the patient's respiratory mechanics and post-operative pain. [6][7]

5. Video-Assisted Thoracoscopic Surgery (VATS)

Video-assisted thoracoscopic surgery (VATS) has been widely adopted for non-small cell lung cancer (NSCLC) resection in the early stage. The procedure has the advantages of smaller incisions, reduced chest wall damage [8], and reduced pain after surgery [1]. A meta-analysis found that VATS lobectomy results in fewer complications and a shorter hospital stay compared to open thoracotomy, with similar long-term survival and recurrence rates. VATS can safely be applied to larger primary lung tumors (>5 cm) [9]. Anatomic thoracoscopic lung resection is associated with less morbidity and further shorter hospitalization compared to thoracotomy. Several large-cohort or meta-analytic studies have further supported the benefits of VATS lobectomy for stage I NSCLC, with comparable or improved early and late survival over open thoracotomy.

5.1. Techniques and Procedures

The technical aspects of VATS lobectomy are more challenging and require advanced training; as a result, the technique is not yet widely adopted. Different approaches to VATS lobectomy exist, primarily single-port and multi-port procedures. Although Skubic and Burfeind reported a 5.3% conversion rate from VATS to open thoracotomy due to intraoperative difficulties, Erdogu et al. observed a higher rate of 9.2%. Conversion may be necessary when the lung cannot be safely dissected or when bleeding due to vascular damage is uncontrollable. Although VATS lobectomy is generally considered an option for early-stage NSCLC, it has also been performed for larger and more advanced lung cancers with results comparable to those of thoracotomy. With continued technical progress, the indications for VATS lobectomy will likely be extended [9].

VATS is performed through one to four small incisions. The number and location of the incisions differ by surgeon preference; the preferred subxiphoid incision is used in the authors' practice to perform lobectomy for NSCLC. The most important aspect of VATS is that the chest cavity never must be opened through a rib-spreading incision, and operations are performed by instruments specifically designed for minimally invasive surgery [1]. The patient is placed in a lateral decubitus position under general anesthesia, a double-lumen tube is used for selective ventilation, and the surgeon stands anterior to the patient, with the camera operator standing posterior. A 30°, 10 mm telescope is used throughout the case. The initial port is usually the camera port, made in approximately the sixth or seventh intercostal space along the posterior axillary line. Port placement depends on tumor location and the degree of planned lymph node dissection. The utility port is placed inferior to the camera port in the fifth or sixth intercostal space just anterior to the anterior axillary line, and is usually 4 cm in length. After placement of the ports and instruments, suction and irrigation are set up, and systematic exploration is conducted by the surgeon and camera operator to check for pleural abnormalities and evaluate lung mobility. Lung resections for cancer start with assessment of tumor size and morphology

and proceed with evaluation of the infiltration of neighboring structures [10].

5.2. Advantages of VATS

The development of video-assisted thoracoscopic surgery (VATS) as a minimally invasive alternative to open thoracotomy for primary non-small cell lung cancer (NSCLC) has prompted comparative studies examining the advantages of these approaches. VATS lobectomy incidence has increased since its initial description in 1992 and now accounts for approximately 32% of lobectomies in the United States. Potential benefits of VATS include reduced postoperative pain, fewer complications, and shorter hospitalization compared to open lobectomy. Reduced morbidity and shorter hospitalization are also observed relative to open thoracotomy for stage I NSCLC. Comparable surgical outcomes have been demonstrated for VATS lobectomy in primary lung cancers larger than 5 cm, and the approach remains a minimally invasive alternative following neoadjuvant therapy for advanced-stage disease. These advantages are associated with the lower rates of postoperative complications, and expertise in VATS lobectomy improves with experience, thus enabling better long-term outcomes. Several studies have assessed VATS lobectomy feasibility and safety in the context of locally advanced NSCLC. Few studies, however, have employed propensity score matching to compare operative and oncologic outcomes between VATS and open lobectomy for stage III disease. Perioperative benefits of VATS include shorter hospital stays, faster functional recovery, and less airway and systemic inflammation, as well as reduced postoperative pain that may facilitate adjuvant chemotherapy. Reduced operative mortality and morbidity, and decreased patient anxiety are additional considerations. Enhanced recovery and superior quality of life in the early postoperative period also distinguish VATS thoracoscopic surgery from open thoracotomy. Overall, the perceived advantages of VATS encompass more than minimal invasiveness, indicating a need for comprehensive comparative evaluation of safety and effectiveness relative to open thoracotomy. [11][12][13]

5.3. Limitations of VATS

Despite considerable advantages, VATS is still limited in certain contexts [1]. Some reports indicate a higher incidence of intraoperative bleeding and risk of pleural adhesion formation following VATS. Due to the strict oncological criteria for VATS resection, patient selection must meet these standards. Cases involving invasion of the chest wall, such as lung apex tumors with suspected muscle invasion, are difficult to address with VATS. Tumors located centrally, invading the superior vena cava, proximal bronchus, or pulmonary artery, remain more appropriate for open thoracotomy [9]. Advanced-stage NSCLC, especially after induction chemoradiotherapy, has seen experiments with VATS; however, complex procedures such as carinal resection continue to favor open thoracotomy and sternotomy [5]. Patients with a history of thoracic surgery leading to adhesions or the necessity for release-side diaphragmatic plication or pericardial reconstruction are better candidates for open thoracotomy. When vascular plasty or bronchoplasty requirements emerge, open thoracotomy remains suitable. Finally, the procedure's longer execution times and the requirement for more surgical assistants represent additional limitations of VATS. [14][15][16]

6. Open Thoracotomy

Open thoracotomy involves a large (approximately 20-cm) posterolateral incision made at the intercostal space of the tumor location. The 5th, 6th, or 7th rib is divided or resected. The pleural cavity is accessed by extending the incision. Subsequently, the pulmonary artery, vena cava, upper and lower pulmonary veins, and bronchus of the affected lobe are dissected to facilitate removal of the lung lobe containing the tumor. Following the lobectomy, the pulmonary vein, pulmonary artery, bronchus, and the resected lung lobe are subjected to pathological examination [9].

6.1. Techniques and Procedures

In non-small cell lung carcinoma (NSCLC), a thoracotomy usually involves a 1015 cm opening along the intercostal or posterolateral axis to reveal the pleural cavity, after which the muscles are cut and the lungs are removed with a mediastinal lymphadenectomy [9]. It starts with a methodical intra-operative inspection of the pleural cavity, lung parenchyma, and mediastinal lymph nodes [10]. These methodological procedures provide greater exposure and operative maneuverability, which in turn allows concomitant procedures where needed [17, 18].

6.2. Advantages of Open Thoracotomy

Open thoracotomy is a time-tested surgical procedure that remains an important treatment alternative in patients who present with non-small cell lung cancer (NSCLC) at an early stage [9]. The procedure is characterized by high visual clarity and a widened operative range that the surgeon can have. The length of the incision is usually 20-30 cm, starting at the fifth intercostal space and going towards the scanty part of the thorax. The exposure allows thoracic surgeons to perform complex and challenging pulmonary procedures with relative ease. The extensive nature of the incision can result in greater postoperative pain, but lidar surveying helps manage this effectively. The procedure accommodates a wide range of therapeutic options and is not associated with the technically demanding requirements of video-assisted thoracic surgery (VATS). It is, therefore, well-suited for more advanced-stage cases or situations involving high technical difficulties where VATS might be inadequate—for example, in cases of major vessel involvement, perivascular infiltration, fibrosis, or tumor adhesions. The open approach also provides an opportunity for more extensive lymph node dissection. Overall, open thoracotomy remains a valuable approach, particularly when VATS is contraindicated or technically unfeasible. [19]

6.3. Limitations of Open Thoracotomy

Open thoracotomy, the cornerstone procedure for lung cancer resection, is notorious for its association with severe postoperative pain and prolonged convalescence. Up to 70% of patients experience chronic pain following thoracotomy [20]. The extensive nature of the incision, rib spreading, and division of chest wall muscles and intercostal nerves contribute to significant discomfort and functional impairment. Subsequent pulmonary complications further compound the challenge, often resulting in lengthy hospital stays and delayed return to daily activities.

7. Comparative Effectiveness

Survival rates following video-assisted thoracoscopic surgery (VATS) and open thoracotomy for non-small-cell lung cancer (NSCLC) Stage I are comparable. Five-year survival rates do not differ significantly between the procedures [1]. Although a randomized controlled trial is unavailable, epidemiological evaluations by hospitals practicing both VATS and open procedures report equal oncological outcomes [10]. Survival after surgery depends on pathological stage; the Surgical Lung Cancer Registry found no significant differences in overall or disease-free survival for pathological Stage I patients between VATS and open surgery. Open thoracotomy adherence to the International Association for the Study of Lung Cancer (IASLC) lymph node map is well established. Systematic nodal dissection via VATS matches the efficacy of open thoracotomy, and lymphadenectomy results are similar across both methods. VATS lobectomy's postoperative mortality rate is approximately 0.8%, significantly lower than the 2% observed following open lobectomy. The 30-day complication rate is 15.5% after VATS compared to 28% post-thoracotomy [9]. Certain conditions–such as tumors involving the chest wall or ribs, dense adhesions, advanced stage, N2 disease, or prior surgery necessitating a wide parietal pleura resection—favor open thoracotomy, which also enables extrathoracic approaches and greater access to vertebral bodies. VATS is associated with effective lung function preservation and decreased postoperative pain, thereby enhancing quality of life and expediting postoperative recovery.

7.1. Survival Rates

Surgical resection constitutes the cornerstone of curative treatment for patients with early-stage non-small cell lung cancer (NSCLC). Patients frequently undergo lobar resection, with either video-assisted thoracoscopic lobectomy (VATS) or open thoracotomy (OT), yet the relative benefits of these approaches remain debated [2] ; [1] ; [10]. The results of patients who have undergone video-assisted thoracoscopic surgery (VATS) compared to the open thoracotomy have been sufficiently literature-based. Certain studies indicate an inappropriateness of VATS in certain situations, including when tumour location and comorbidities in patients are inhospitable, but others consider it to be the gold standard of early-stage non-small cell lung carcinoma (NSCLC). It lies in the context of the ongoing debate and uses the review to offer a very detailed analysis of relative survival selections, complication selections, resolution times, cost-effectiveness, patient selection registries, life expectancy, and forthcoming innovations.

7.2. Complication Rates

The highly qualified evaluation of postoperative complications is paramount to appraise the effectiveness of Video-Assisted Thoracic Surgery (VATS) against open thoracic surgery in the treatment of small-stage non-Sarawak cell lung cancer (NSCLC). In comparative studies, VATS has always been found to provide immense benefits in the occurrence and the severity of complications among patients.

The systematic reviews of the literature are comprehensive, which proves video-assisted thoracoscopic surgery (VATS) is effective in reducing the severity and the rate of postoperative complications [9]. In comparison, the open thoracotomy method is more likely to result in an increased rate of complications; there are very rare chances that patients subjected to VARTS would encounter operative events to the extent of Grade III or beyond, such as prolonged air leaks or nonstop atrial fibrillation. This reduced trauma of the minimally invasive VATS method becomes part of an overall reduced profile of complications, a critical clinical range of the interventional modality [21][22].

7.3. Recovery Times

In the aftermath of video-assisted thoracoscopic surgery, called VATS, and open thoracotomy in primary non-small cell lung cancer, the NSCLC, the patients who have gone through VATS can usually start adjuvant chemotherapy faster, due to their faster postoperative recovery. They require less pain medication during adjuvant treatment. In the longer term, patients who undergo VATS experience greater improvements in QoL indicators. Several studies have found that recovery is also faster after VATS lobectomy. VATS patients report significantly milder postoperative pain. One study involving 269 NSCLC patients in Turkey found that the mean intensive care unit stay and hospital stay were significantly shorter in the VATS group [9]. The mean length of stay was shorter for VATS in several other studies [1]. Routine activities (bathing, dressing, cooking, etc.) are resumed about one week earlier after VATS than after anatomic pulmonary resection performed through open thoracotomy. In contrast, other studies have not found differences in either pain or recovery between VATS and anterolateral or conventional lateral thoracotomy. Nevertheless, most of the evidence favours VATS with regard to recovery rates.

Comparing the recovery times after VATS and open thoracotomy can be challenging because of the additional factors influencing recovery. One such factor is the extent of resection. Patients with early-stage disease typically undergo lobectomy, but patients with more advanced disease tend to require additional resections (chest wall, diaphragm, etc.). The comorbidities associated with advanced disease also contribute to prolonged recovery times from open thoracotomy. The greater invasiveness of the procedure still contributes to prolonged recovery, but the extent of the procedure and the patient’s underlying condition are additional important factors. The observed differences may therefore underestimate the difference in the recovery times attributable to the

surgical approach itself. [23][24]

8. Cost-Effectiveness Analysis

The economic implications of video-assisted thoracoscopic surgery (VATS) versus open thoracotomy for early-stage non-small cell lung cancer (NSCLC) influence both institutional policy and patient access. Comparative cost-effectiveness analyses encompass direct expenditure as well as indirect costs such as recovery delay.

8.1. Direct Costs

Direct hospital expenses involving operating room utilization, instrumentation, and surgical staffing compose the principal outlays associated with either surgical approach. Open thoracotomy requires extensive incisions and rib spreading, placing considerable demand upon analgesic delivery and intensive care deployment; both factors contribute to greater cumulative expenditure. Conversely, VATS employs a minimal-access strategy with distal wedge resection and targeted pericostal rib dissection, resulting in abbreviated intensive care requirements, accelerated ambulation, and earlier transition to oral analgesics [25]. Though video-assisted thoracoscopic surgery (VATS) may be linked to high operating-room expenses because of the specific machinery and slow turnover times, the available body of literature shows that all these expenses are compensated with the savings in ancillary services. In addition, the implementation of VATS requires an increased need for high-resolution visualization instrumentation compared to the traditional open procedures.

8.2. Indirect Costs

Thorough economic impact analyses do not just stop at identified direct costs in terms of medical spending, but they also take into consideration the consequences of affected individuals or their insurance units. The absence that can be ascribed to sickness causes even a further strain on employers and, to some extent, it relates to missed salaries among high-paid workers. Traditional open thoracotomy surgery often requires extended healing times, including time spent hospitalized and convalescing, with a high level of pain, and returning to a job is usually a slow process. Video-assisted thoracoscopic surgery (VATS) provides a remedy to these issues by lessening analgesic needs and enabling early mobilization, thus enabling early employment and countering the financial liabilities involved.

8.1. Direct Costs

Video-assisted thoracoscopic surgery (VATS) lobectomy has been embraced as a minimally invasive procedure with benefits including reduced postoperative pain, morbidity, and faster resumption of routine activities as compared to open lobectomy in the treatment of lung cancer. Despite such benefits and interest from patients and health care providers, questions exist regarding the cost-effectiveness of VATS. Less invasive techniques may require more resources (complex instrumentation, prolonged operative time, or the differential use of disposables) that may attenuate or nullify derived savings (shorter length of stay, faster recovery, decreased use of narcotics, decreased use of other healthcare services). A single-centre, retrospective cohort study compared costs between patients undergoing VATS and open lobectomy. Among 706 lobectomies performed between 2013 and 2018, 290 (41.1%) were performed by VATS. After accounting for covariables, VATS lobectomy was associated with a shorter postoperative length of stay and a decreased likelihood of in-hospital death, but an increased likelihood of intraoperative and surgical complications compared with open lobectomy. VATS lobectomy was non-inferior to open lobectomy in terms of direct hospital costs, expenditure categories, and total hospital costs, with no significant difference in net revenue between procedures. VATS lobectomy was found to be a cost-effective alternative to open lobectomy, given its considerable postoperative advantages while achieving a comparable financial outcome [25].

Thoracoscopic lobectomy confers other important benefits in comparison with open lobectomy,

but concerns about cost and cost-effectiveness remain. A randomized multicenter trial quantified and analyzed the differences in clinical outcomes and hospital costs between the two techniques in patients with lung cancer; secondary objectives concerned the impact of the surgical approach on quality of life (QoL) and oncologic results. The morbidity rate in the intention-to-treat population was greater after open lobectomy (55/127; 43%) than after thoracoscopic lobectomy (40/136) (29.4%) ($p = 0.012$). The most frequent postoperative complications concerned the respiratory tract, with a lower rate after thoracoscopy (19/136; 14%) than thoracotomy (38/127; 30%) ($p = 0.003$). Thoracoscopy proved superior ($p = 0.001$) to thoracotomy with regard to postoperative pain during the first 5 days, while the QoL score measuring physical function was higher ($p = 0.031$) 5 weeks postoperatively. Hospital costs for thoracotomy patients were higher, but the difference fell short of statistical significance ($p = 0.10$) when adjusted for the center and the reasons for exclusion. Both approaches resulted in similar oncologic outcomes. Thoracoscopic lobectomy thus enables COPD patients to benefit from radical surgery with less morbidity and a better postoperative course, and a favorable medico-economic impact [26].

8.2. Indirect Costs

Indirect costs, such as days of inactivity, are generally lower in video-assisted thoracoscopic surgery (VATS) [26].

9. Patient Selection Criteria

Both video-assisted thoracoscopic surgery (VATS) and open thoracotomy offer curative treatment for early-stage non-small cell lung cancer (NSCLC). Clear selection criteria optimize surgical outcomes. Indications for VATS lobectomy encompass clinical stages T1 ≤ 7 cm, T2 ≤ 5 cm, and T3 with chest wall involvement. Neyman randomization helps balance all characteristics but is impractical for many clinical studies; thus, the more common keystroke method is preferable in such cases [1]. These benchmarks shape patient decision-making and guide future clinical trials in operable NSCLC.

Open thoracotomy is suitable for endobronchial lesions, central tumors with vascular infiltration, and N1 or N2 lymph node metastasis. Hence, VATS and open thoracotomy are complementary rather than rival surgical approaches.

9.1. Indications for VATS

The indications for video-assisted thoracoscopic surgery (VATS) are still under debate. VATS lobectomy is currently considered a viable alternative to thoracotomy, mainly for stage I non-small cell lung cancer (NSCLC). VATS can also be used for larger cancers, after induction chemotherapy, and in pneumonectomies and sleeve lobectomies, but its use for these indications is not yet widely recommended. VATS is less appropriate for preoperative induction treatment, large N2 disease, and rare tumors such as carcinoid tumors, sarcomas, and hamartomas [9].

9.2. Indications for Open Thoracotomy

Open thoracotomy for stage I non-small cell lung cancer (NSCLC) without lymph node involvement is indicated in cases of large tumours (>6 cm), necessity for pneumonectomy, chest wall infiltration, centrally located tumours with grade 2/3 chronic obstructive pulmonary disease or pulmonary fibrosis, tumours that cannot be resected via video-assisted thoracoscopic surgery (VATS) because of anatomic factors or patient preference, and the requirement for additional surgical procedures such as bronchoplasty, angioplasty, or rib resection [9] [10].

10. Quality of Life Considerations

Studies assess post-operative quality of life (QOL) following VATS and open thoracotomy for non-small cell lung cancer (NSCLC). One study reports minimal differences in post-operative pain and QOL, with some indication of a smaller inflammatory response following VATS. Although VATS patients show earlier improvements in exercise tolerance compared to thoracotomy patients, no direct association with QOL recovery is observed. Consequently,

physical therapists are encouraged to develop strategies that expedite QOL restoration for lung cancer survivors undergoing VATS, aiming to prevent post-operative complications and enhance physical function. Overall QOL has been identified as a prognostic factor for 2-year survival in NSCLC patients. [27][28]

11. Future Directions in Surgical Techniques

Innovations in surgical techniques are poised to further augment the advantages of video-assisted thoracoscopic surgery (VATS) over conventional open thoracotomy for early-stage non-small cell lung cancer (NSCLC). One avenue of development involves combining the uniportal video-assisted approach with segmentectomy procedures. This hybrid technique aims to consolidate the minimal invasiveness and expedited rehabilitation characteristics of VATS with the parenchyma-sparing potential of segmentectomy, thus optimizing operative outcomes [9]. Another emerging modality is electromagnetic navigation bronchoscopy (ENB)-guided video-assisted thoracoscopic sublobar resection. ENB facilitates precise lesion localization, potentially enabling more targeted resections while preserving healthy lung tissue. Both strategies extend current capabilities by either refining access methods or enhancing lesion targeting and preservation of pulmonary reserves [10]. Continued advancements along these lines may not only magnify the already elevated benefits of minimally invasive approaches but also broaden patient eligibility for such interventions, while concurrently reducing procedural risks.

12. Clinical Guidelines and Recommendations

Based on the high-level evidence of VATS lobectomy reported in the contemporary literature, current international guidelines are presented to optimize outcomes [10]. Eligibility and contraindications, clinician safety and technical considerations, and principles of lymph-node dissection are summarized; these guidelines are of particular relevance for centers seeking to initiate a program in VATS lobectomy and to specialists with an interest in minimally invasive techniques for the treatment of primary NSCLC.

Incidentally detected NSCLC is increasing in frequency as screening modalities improve; many of these tumors are amenable to VATS lobectomy, and complete resection is achievable when a destructive attack is employed in the fissures and the posterior hilum [9]. In parallel with the expansion of thoracoscopic techniques worldwide, experience gained with more advanced tumors has led to corresponding improvements in the safety and efficacy of thoracoscopic lobectomy. Adherence to each of the tenets outlined in the guidelines will provide a robust framework in clinical practice and represents an imperative for quality assurance in the treatment of early NSCLC. Integration of these principles with regard to surgical outcomes, with particular attention to nodal status, should be considered a pivotal objective for future research.

13. Ethical Considerations

The perioperative risk associated with thoracoscopic lobectomy does not surpass that of the traditional open approach. However, patient selection criteria should be strict, which means that only those patients with clinically eligible status and with the likelihood to receive the specific benefit due to minimally invasive procedures should receive thoracoscopic operations [10]. Also, it is not yet ascertained definitively by prospective and randomized clinical trials that thoracoscopic lobectomy used with a mediator lymphadenectomy is oncologically safe. In this regard, when these emerging techniques should be advocated, the role of informed consent cannot be overemphasized. Open dialogue about any risks and possible benefits is needed in order to protect the autonomy of patients and to provide the opportunity of fair access to surgical interventions in innovative ways.

14. Patient Perspectives and Experiences

The perceptions of patients are a critical component in the monitoring of the overall implications of surgery innovations and development. The lobectomy method is a controversial topic where

the choice of lobectomy method in heterogeneous patient groups is significantly dependent on various determinants. First of all, an open thoracotomy is favored by patients of lower socioeconomic status, which, in some respects, can also be explained by the feeling of lower costs compared with video-assisted thoracoscopic surgery (VATS). In addition, the open method provides the possibility of full resection of the tumour and structural lymphatic tissue, thus the possible reduction of postoperative recurrence results. On the contrary, electing VATS is more likely among younger patients and female patients because of its correlation to lower morbidity and a less invasive procedural paradigm. Higher cosmetic effects of VATS are also a consideration for these patients. However, there is a number of patients characterizing fear toward VATS safety, where the requirements necessitate additional research, thorough studies, and greater patient and professional education. The evidence presented is mostly single-institution material that indicates a potential for physician bias in surgical recommendations and the cultural issues of a region that largely influence patient preferences and decision-making. With the current development of clinical experience with VATS, it is expected that more and more indications will be safely utilized by it, which will contribute to increasing the acceptance and knowledge of this type of innovative surgery. [29][9]

15. Limitations of Current Research

The current review represents an extensive study of the available literature concerning the comparative effectiveness of video-assisted thoracoscopic surgery (VATS) and conventional open thoracotomy in the treatment of an early-stage non. Sleep sciolit lung cancer (NSCLC). Much attention is paid to the synthesis of clinical outcomes and financial consequences related to every surgical modality. The gaps in evidence are considerable despite the extensive range of research done so far. The methodological shortcomings of empirical studies are quite common, such as the use of retrospective designs, small sample sizes, and comparatively short follow-up periods. Such restrictions limit the possibility of proving clear superiority and significantly hinder the possibility of generalizing the conclusions made. In addition, empirical discrepancies are common in various studies, especially when considering complication rates and health-economic evaluation. These weaknesses, therefore, highlight the necessity of additional intensive and well-designed studies to determine the exact role of VATS in the formulation of treatment protocols in early NSCLC and to come up with strong evidence-based guidelines to be used in surgical intervention to be applied reliably in clinical practice.

16. Implications for Practice

Video-assisted thoracoscopic surgery (VATS) is widely accepted as the method of choice in the treatment of non-small-cell lung cancer (NSCLC) at an early stage, but there is still no general agreement on its effectiveness and its use in later stages. VATS is also known to significantly shorten recovery time and operative trauma by virtue of its minimally invasive technique as compared to conventional open thoracotomy. Therefore, current medical practice recommends VATS to be used in the management of early-stage NSCLC, with open thoracotomy being used at later stages of the disease when it might be considered more suitable. An extensive review is conducted on the comparative clinical outcomes of these two surgical methods, in addition to assessing the economic burdens of VATS versus open thoracotomy. The analysis plays a key role in deciding the best and cost-effective surgical alternatives to be used on patients, depending on their stage of lung cancer. [9]

17. Conclusion

Lung cancer continues to be among the leading causes of death across the globe, making the treatment of early-stage non-small cell lung cancer (NSCLC) an issue of the highest clinical importance; surgical resection is the treatment method of choice. In this context, video-assisted thoracoscopic surgery (VATS) and traditional open thoracotomy are the two major operative modalities. The current review will critically evaluate and compare these surgical modalities on a continuum of key parameters, which include overall survival, the occurrence of postoperative

complications, recovery patterns, cost, therapeutic indications, and patient-reported quality of life outcomes. The analysis is specifically confined to procedures such as lobectomy and radical lymphadenectomy, as the occurrence of pneumonectomy is quite rare in patients diagnosed with early-stage NSCLC. Multiple clinical trials have suggested that VATS lobectomy is not only feasible but also offers distinct benefits for lung cancer patients, including reduced morbidity, shorter durations of hospital stays, and equivalent or potentially superior outcomes compared to those achieved through thoracotomy. Notable benefits of opting for VATS include decreased post-operative pain and a higher level of patient satisfaction, whereas in cases that are more advanced, thoracotomy might be the preferred surgical choice. In-depth analysis reveals that survival rates are comparable, if not improved, with the use of VATS in early-stage NSCLC patients. Although the adoption of VATS is on the rise, it is still less prevalent than the use of thoracotomy. A thorough appraisal that takes into account both clinical outcomes and cost implications will greatly aid in making informed decisions regarding surgical options and will also highlight potential avenues for future research in this critical area of lung cancer treatment.

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