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Review

Non-invasive Mechanical Ventilation in Lung Cancer: Physiological Principles and Clinical Utilization in Surgical and Non-surgical Settings

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Abstract

Non-invasive mechanical ventilation (NIMV) has emerged as a pivotal intervention for the care of individuals with lung cancer. NIMV offers substantial advantages in enhancing oxygenation, optimizing respiratory function, elevating pulmonary capacities, and facilitating patient comfort. NIMV's utility extends to enhancing clinical conditions that range from chronic obstructive pulmonary disease and emphysematous lung ailments to aiding patients with lung cancer facing acute respiratory failure. Furthermore, NIVM includes perioperative pulmonary rehabilitation. This approach is particularly relevant for individuals with limited lung capacity. Since both non-invasive positive pressure ventilation modes, including BiLevel positive airway pressure and continuous positive airway pressure, address the underlying pathophysiological mechanisms that contribute to postoperative respiratory failure, the proactive and early integration of NIMV has the potential to significantly enhance gas exchange and overall respiratory performance in meticulously chosen patients within the perioperative phase. Although non-intubated video-assisted thoracic surgery represents an interesting field of application for NIMV strategies, further studies are needed to optimize operative modalities. Lastly, NIMV has a pivotal role in the settings of intensive care and palliative care units, thereby cementing its versatile utility across various medical contexts.

KEYWORDS: Non-invasive mechanical ventilation, lung cancer, acute respiratory failure, chronic obstructive pulmonary disease, palliative use of non-invasive ventilation, non-invasive positive pressure ventilation, BiLevel positive airway pressure, continuous positive airway pressure

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INTRODUCTION

Lung cancer is the third most common malignancy. It is the primary driver of cancer-related fatalities on a global scale, affecting individuals regardless of gender.[1] The occurrence of acute respiratory failure (ARF), which leads to hypoxia with or without hypercapnia, becomes intricately woven with oncological factors, potential coexisting conditions like exacerbation of chronic obstructive pulmonary disease (COPD), and treatment-related complications. This interplay can significantly influence the clinical trajectory of patients undergoing surgical resection and those exploring non-surgical therapeutic options.[2] Moreover, ARF is a life-threatening condition that may manifest early in the course of the disease or become a prominent feature as the disease progresses to its advanced stages.[3]

In lung cancer patients, invasive mechanical ventilation (IMV) remains a widespread strategy for managing respiratory insufficiency issues. Despite improvements, this approach is burdened by a significant mortality rate, which can affect up to 50% of patients requiring postoperative care or other motivations.[4] Moreover, the emergence of complications like ventilator-associated pneumonia, barotrauma, and tracheal damage in this setting raises important concerns.[5]

Non-invasive mechanical ventilation (NIMV) has emerged as a critical intervention for the management of lung cancer, offering significant benefits in improving oxygenation, optimizing respiratory physiology, and enhancing pulmonary functions.[6] It is a powerful strategy for increasing patient comfort. This comprehensive approach involves

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the application of different techniques, which contribute to alleviating respiratory distress and enhancing the overall quality of life for individuals facing the challenges of lung cancer. NIVM can be useful in optimizing clinical conditions ranging from COPD and emphysematous lung disease to the management of lung cancer patients facing ARF. Furthermore, it extends to perioperative pulmonary rehabilitation (PPR), providing respiratory support during the perioperative phase for patients undergoing procedures such as intraoperative lateral decubitus position and one-lung ventilation, with a particular focus on those with limited lung capacity. Additionally, NIVM can be used to determine significance in non-intubated lung resections. Lastly, a notable role of NIVM is its utilization in intensive care and palliative care units.[7]

The purpose of this review is to explore the physiological foundations of the applications of NIVM techniques and their diverse fields of use.

1. Physiological Principles

Some evidence suggests that NIMV can effectively counteract a range of physiological and mechanical abnormalities linked to respiratory failure in individuals with lung cancer.[8,9]

A cascade of physiological changes can disrupt the delicate balance of oxygenation within the respiratory system in patients with lung cancer. These changes encompass different factors, prominently including ventilation-perfusion ratio (V/Q) mismatch and lung tissue alterations. Understanding these alterations is crucial for appreciating the role of NIVM in rectifying these challenges and sustaining optimal oxygen saturation (Table 1).

Addressing V/Q mismatch is a key aspect of NIMV. Lung malignancy can cause imbalances between alveolar ventilation and the corresponding vascular perfusion required for efficient gas exchange. Factors such as tumors, inflammatory processes, and obstructions in the airways can perturb the airflow, directing it away from regions that are adequately perfused. This diversion contributes to the uneven distribution of oxygen uptake. Consequently, the resultant V/Q mismatch engenders suboptimal oxygenation levels, leading to hypoxemia and respiratory distress. Enhancing ventilation in alveoli that were previously underutilized due to V/Q alterations, NIMV, and especially non-invasive positive pressure ventilation (NIPPV) modes, such as BiLevel positive airway pressure (BiPap) and continuous positive airway pressure (CPAP), can assist in rebalancing the V/Q. This leads to more efficient oxygen uptake and carbon dioxide elimination since alveolar recruitment and augmentation of alveolar ventilation increase FiO_2 and reverse hypercapnia and acidosis.[10]

Main Points

- Non-invasive mechanical ventilation (NIMV) is effective in managing acute respiratory failure in patients with lung cancer, particularly those with specific conditions like chronic obstructive pulmonary disease.
- Key factors such as early initiation of NIMV, underlying cause of respiratory failure, and patient's functional status are critical indicators for the success of NIMV therapy.
- NIMV is a potential bridge therapy that can stabilize patients, allowing them to proceed to further cancer treatments that might have otherwise been delayed because of respiratory complications.
- Proper patient selection and continuous monitoring are essential for optimizing outcomes with NIMV, reducing the risk of treatment failure, and improving overall survival rates.
- Further high-quality research is needed to confirm the role of NIVM and to better understand the surgical strategies and long-term outcomes of this therapy in patients with lung cancer.

The V/Q mismatch is caused by complex lung tissue alterations. The presence of lung cancer can cause structural changes. Tumors can compress or invade the parenchyma of the lung, leading to reduced lung compliance and decreased functional lung volume. Additionally, inflammation and scarring induced by cancer can compromise lung tissue elasticity, further hampering efficient oxygen exchange.[11] Through carefully calibrated positive-pressure delivery, NIMV has the potential to exert a positive impact by improving pulmonary compliance. It can also prevent lung collapse by ensuring optimal lung inflation.

In the context of cancer, muscle fatigue, often called cancer-related fatigue, is a complex and multifaceted phenomenon that can affect various muscle groups throughout the body. It is a common and distressing symptom experienced by many individuals undergoing cancer treatment and those with advanced cancer. The exact mechanisms underlying muscle fatigue are not fully understood, but several factors, such as anticancer treatments, cancer-related Inflammation, metabolic changes, pain, and psychological factors, contribute to its development.[12] Despite this intricate context, NIMV can help avoid fatigue in respiratory muscles through a combination of physiological mechanisms that reduce the work of breathing and enhance overall respiratory efficiency. The key mechanism is reduced workload. The positive pressure reduces the effort required by the respiratory muscles, especially the diaphragm, to generate the necessary negative pressure for inhalation. By lightening the workload on these muscles, NIMV helps prevent muscle fatigue. Moreover, NIMV optimizes gas exchange and reduces the need for rapid, deep breathing, which can lead to muscle fatigue over time. It also helps maintain optimal lung volumes and compliance, making it easier for the respiratory muscles to function effectively and preventing lung collapse with atelectasis. The application of positive end-expiratory pressure reduces the workload required by the inspiratory muscles to initiate the next breath. In addition, NIMV provides intermittent periods of rest for the respiratory muscles. In other words, by assisting with breathing during moments of increased demand, NIMV allows the muscles to recover and regain their strength, thereby preventing sustained fatigue. Finally, NIMV can enhance patient comfort and reduce anxiety related to breathing difficulties.[13] This relaxation indirectly reduces the overall stress on respiratory muscles.[14] The combination of improved oxygenation and reduced work of breathing alleviates the respiratory distress often experienced by patients with lung cancer. This, in turn, enhances their comfort and quality of life.

Table 1. Physiopathological foundation of non-invasive mechanical ventilation in lung cancer

Process	Mechanism(s)	NIVM effects
V/Q ratio mismatch	Due to cancer itself, inflammation, and airway obstruction.	- Improved alveolar ventilation. - Improvement in V/Q.
Alterations in lung tissue	Reduced lung compliance and decreased functional lung volume.	- Improved compliance. - Increased FRC. - Enhanced recruitment. - Prevention of lung collapse.
Muscle fatigue	Anticancer treatments, cancer-related Inflammation, metabolic changes, pain, and Psychological factors.	- Reduced workload. - Improved lung mechanics. - Enhanced gas exchange. - Promotion of rest and recovery. - Increased patient comfort. - Reduced anxiety related to breathing difficulties.
Heart failure or fluid overload	Due to cancer itself and anticancer treatments.	- Reduced venous return. - Improved heart function.

NIMV: non-invasive mechanical ventilation, V/Q: ventilation-perfusion ratio, FRC: functional residual capacity

The effects on cardiac function have been extensively investigated for the treatment of cardiogenic pulmonary edema.[15] The effects manifest in a comprehensive array of outcomes. For instance, NIMV is a valuable intervention for patients with heart failure or fluid overload, particularly given that increased mean intrathoracic pressure leads to reduced venous return. On the other hand, a reduction in cardiac output/pulmonary perfusion induces a compensatory increase in right ventricular afterload.[13] In the postoperative setting, physiological investigations have demonstrated the effectiveness of BiPap and CPAP in enhancing lung aeration and arterial oxygenation. These interventions also reduce atelectasis without inducing adverse hemodynamic effects during the period following extubation.[16]

2. Management of Acute Respiratory Failure

In the context of lung cancer, ARF can stem from a range of factors. These determinants encompass the impact of the primary disease on lung function and the chest wall, pulmonary emboli, radiation-induced pneumonitis, aspiration events, treatment-related immunosuppression leading to sepsis or pneumonia, drug-associated toxicity, presence of concurrent conditions like heart failure, and exacerbation of COPD. Among these factors, COPD exacerbation is the most prevalent and observed cause of ARF[17] and is a leading cause of hospital admissions.[18]

When not contraindicated, for example in conditions of respiratory arrest or unstable cardiorespiratory status, in uncooperative patients, or for inability to protect the airway, NIMV can be a less invasive alternative for effectively managing respiratory distress and enhancing comfort in patients with cancer and ARF. The judicious selection of NIMV is guided by specific indications, ensuring its appropriate utilization in the context of lung cancer care.

Patients with lung cancer and pre-existing chronic respiratory conditions, such as COPD or interstitial lung disease, may experience acute exacerbations. NIMV can help stabilize respiratory function, alleviate distress, and prevent the need for IMV. This approach can serve as a bridge to recovery in cases of reversible respiratory distress, such as infections. It supports patients until their condition stabilizes and their lung function improves. Moreover, NIVM modes can be employed to prevent intubation in patients at risk of respiratory failure. Early initiation of NIMV may obviate the need for IMV, thereby reducing the incidence of complications associated with intubation. NIMV can also be employed to manage ARF while allowing bronchoscopy without endotracheal intubation (Figure 1).

Furthermore, according to the European Respiratory Society guidelines, prompt implementation of NIPPV is recommended for immunocompromised patients experiencing ARF.[19]

NIVM can be used to treat hypoxemic or hypercapnic respiratory failure. In the former condition, augmenting oxygenation and preventing the progression of respiratory failure are indicated, particularly in cases in which IMV is considered excessive. Impaired gas exchange can manifest as hypercapnic respiratory failure, which is characterized by elevated carbon dioxide levels. In this condition, calibrated NIMV interventions can help remove excess carbon dioxide, improve ventilation, and enhancing acid-base balance. Therefore, the significant benefit of NIVM is its ability to circumvent the need for intubation. It can be applied preemptively to prevent intubation in patients with respiratory failure. The timely introduction of NIMV might mitigate the requirement for IMV, thereby diminishing the complications associated with this approach. Considering the elevated mortality rate observed in the intensive care unit (ICU) among patients with cancer, adopting NIMV as an initial approach can be a favorable strategy for patients with lung cancer in the hospital ward. This approach is also useful for mitigating the potential complications associated with IMV.[9]

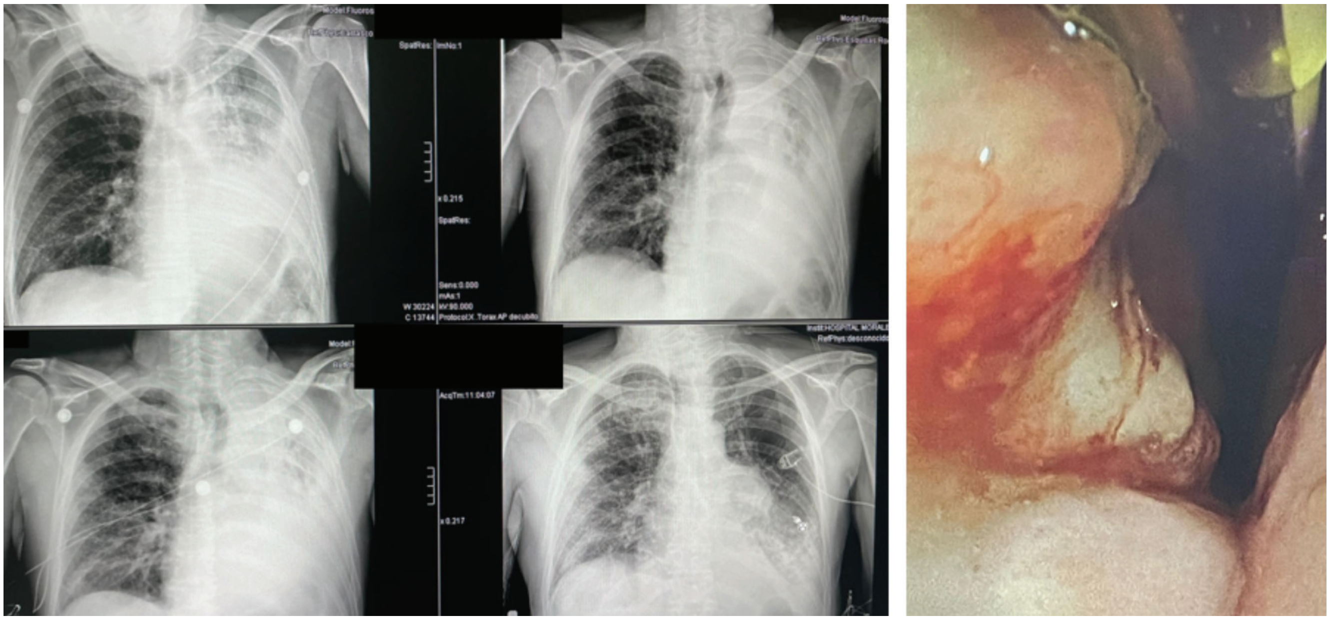

Figure 1. A 63-year-old male patient (left lung) with acute respiratory failure. BiLevel ventilation (IPAP: 25 cmH_2O; EPAP: 8 cmH_2O) during bronchoscopy. Chest X-rays at the start of the treatment (top images, the left with facial mask application), during (bottom left), and after the bronchoscopy (bottom right), with no endotracheal intubation

IPAP: inspiratory positive airway pressure

3. Perioperative Management

3.1. Preoperative Pulmonary Rehabilitation

The presence of COPD substantially increases the risk of perioperative pulmonary complications, and significant lung function impairment can contraindicate surgical treatment.[20] Preoperative implementation of NIMV strategies can enhance exercise tolerance, symptomatic well-being, and overall quality of life for patients with COPD undergoing lung volume reduction surgery.[21] This approach is particularly relevant for individuals with limited lung capacity. However, the precise impact of PPR on the clinical progression of patients with COPD or those with frailty stemming from various causes, characterized by impaired pulmonary function, and those undergoing lung cancer resection remains to be fully understood. This aspect is of paramount importance because the reduction in lung tissue can severely impede postoperative ventilatory function or diffusion capacity, increasing their vulnerability to post-surgical issues. As a result, clinical factors combined with findings from the preoperative assessment, such as forced expiratory volume in one second and single-breath predicted diffusing capacity of the lung for carbon monoxide, play a crucial role in determining operability.[22]

The role of PPR in lung cancer surgery is gaining recognition and constitutes an integral component of the enhanced recovery pathway.[23] Although evidence indicates that PPR can enhance preoperative pulmonary function and functional status, reduce perioperative pulmonary complications, and expedite postoperative recovery, study outcomes have not been consistently aligned.[24,25] The lack of standardized preoperative rehabilitation protocols regarding the NIMV approach and outcome assessment across different clinical settings further hinders the implementation of PPR. For example, Mujovic et al.[26] evaluated pulmonary function using spirometry, the 6-min walking distance test, and the Borg scale at three time points: upon admission, post-PPR, and after surgery. Recently, multimodal rehabilitative protocols have been implemented, including cardiorespiratory muscle training and breathing exercises, education, and pharmacological interventions. Surprisingly, approximately 40% of high-risk patients underwent surgery, achieving outcomes comparable to those of patients categorized as having a low risk of adverse events or mortality.[21] Consequently, many medical centers do not routinely employ PPR in these situations, owing to concerns regarding surgery delays and the absence of concrete evidence demonstrating the advantages of PPR for such patients.

3.2. Indications After Pulmonary Resection

Postoperative pulmonary complications are the primary causes of mortality and morbidity following lung resection. These complications include acute lung injury, acute respiratory distress syndrome (ARDS), and pneumonia. Additionally, within the domain of thoracic surgery, alongside postoperative pain, ARF is associated with compromised functionality of respiratory muscles. Changes in respiratory function manifest early after surgery, and diaphragm dysfunction may extend up to seven days, contributing to a notable decline in arterial oxygenation.[27] Moreover, minimally invasive thoracoscopic surgery necessitates the implementation of a one-lung ventilation technique, which has the potential to result in suboptimal lung expansion and persistent microatelectasis in the postoperative phase.[28] In this complex scenario, the proactive use of NIMV was proposed to effectively reduce the incidence of respiratory challenges during the crucial postoperative phase.[29] Postoperative NIPPV may effectively mitigate or prevent microatelectasis following pulmonary resection.

Overall, NIMV techniques can address a spectrum of challenges and potential complications during the recovery phase, providing targeted support to optimize patient outcomes (Table 2).

Following lung resection, for example, patients might encounter situations where gas exchange is compromised, leading to carbon dioxide retention. NIMV becomes a crucial intervention in such cases, as it helps maintain proper gas exchange dynamics by enhancing ventilation and oxygenation. In particular, NIMV helps overcome V/Q mismatch and facilitates the elimination of excess carbon dioxide. Moreover, it is useful for preventing postoperative complications. It helps maintain lung volume, prevent atelectasis, and promote alveolar recruitment. By ensuring optimal functioning of the remaining lung tissue, NIMV reduces the risk of respiratory complications such as pneumonia and ARDS. Moreover, in the aftermath of lung resection, patients might experience challenges related to secretion retention and excessive mucus production; thus, NIMV may help address secretion retention and mucus hypersecretion by facilitating effective airway clearance. Moreover, this approach can reduce the likelihood of postoperative respiratory infections and related complications.

Among the different strategies, NIPPV plays a key role in postoperative NIMV. This NIVM modality delivers pressurized gas to the airway, increasing transpulmonary pressure, and expanding the lungs through a mask or interface, all while avoiding invasive routes, such as endotracheal tubes, oronasal tubes, or Tracheostomy. This technique enhances functional residual capacity (FRC) and reopens collapsed airways, resulting in improved oxygenation, reduced carbon dioxide buildup, and decreased respiratory effort. In particular, NIPPV encompasses two main types: CPAP, which employs a single pressure level during exhalation, and Bi-PAP, which utilizes two distinct pressure levels for both inhalation and exhalation, inspiratory positive airway pressure (IPAP) and expiratory positive airway pressure (EPAP), respectively. The key difference is that BiLevel variation can amplify tidal volume and potentially assist during the inhalation phase. Surprisingly, despite these potential advantages, a Cochrane analysis has revealed that the use of NIPPV in the postoperative phase following pulmonary resection does not appear to confer any additional benefits across various assessed outcomes. These outcomes included pulmonary complications, intubation rates, mortality, postoperative antibiotic usage, length of stay in the ICU, duration of hospitalization, and adverse effects linked to NIPPV. Nevertheless, it is important to highlight that the authors of the analysis acknowledged a certain degree of limitation in the quality of evidence presented. This assessment ranged from very low to low and moderate due to the relatively small number of studies available for analysis, as well as their limited sample sizes and infrequent occurrence of observed outcomes. Consequently, their conclusions remain subject to these inherent limitations,[30] and further studies are needed to confirm the findings of the analysis. The patient population that would benefit most from postsurgical NIVM is still being identified. In individuals who underwent pulmonary lobectomy, Okada et al.[31] initiated NIVM immediately after surgery until the morning of the postoperative day. They implemented Bi-PAP using the spontaneous/timed mode with an IPAP ranging from 6 to 12 cmH_2O and EPAP ranging from 4 to 6 cmH_2O. This intervention resulted in enhanced oxygenation, particularly noticeable among patients with a PaO_2/FiO_2 ratio of 300 or lower, those aged 70 years or older, individuals with a body mass index of 25 kg/m^2 or higher, and those undergoing one-lung ventilation for a duration exceeding 180 minutes. The results are highly significant, and they underline that patients with COPD could be good candidates for postoperative NIMV. Moreover, the age-related strength decline and reduced chest wall compliance impact respiratory muscle performance. Additionally, obesity can lead to impaired respiratory function due to restricted diaphragmatic movement, resulting in decreased FRC and elevated atelectasis risk.[32] Lastly, one-lung ventilation causes collapse of the surgical lung and may induce gravity-driven microatelectasis on the non-surgical side.[33]

During the postoperative phase, the utilization of NIVM extends to other areas of application. For patients transitioning from IMV, NIMV can facilitate weaning by gradually reducing ventilator support. This approach helps restore independent breathing while minimizing the risk of extubation failure.

Extended research should focus on the application of NIMV techniques in the context of non-intubated video-assisted thoracic surgery (NI-VATS). This surgical approach combines the advantages of non-intubated surgery with the benefits of minimally invasive techniques. Initially, NI-VATS was used for delicate patients in whom general anesthesia and/or orotracheal intubation was considered impractical. However, NI-VATS indications have progressively broadened to encompass various patient scenarios, as the procedure's safety and feasibility have been increasingly validated.[34] Progressive increase in pCO_2 levels during surgical procedures is a significant concern in anesthesiology. Consequently, an excessive elevation of pCO_2 (above 80 mmHg) is a prevalent factor leading to the decision for intubation.[35] These aspects can stimulate the utilization of NIMV techniques, although

Table 2. Potential advantages of non-invasive mechanical ventilation after lung resection

Process	Mechanism(s)
Improving gas exchange and CO_2 retention	NIMV can effectively ameliorate ventilation-perfusion imbalances, promoting efficient oxygenation and CO_2 elimination processes.
Prevention of complications	NIMV promotes alveolar recruitment and lung volume
Support in secretion retention and mucus hypersecretion	Improving airway clearance by mobilizing and expelling secretions
Weaning from mechanical ventilation	Gradual reduction in ventilator support

For example, pneumonia and acute respiratory distress syndrome.
NIMV: non-invasive mechanical ventilation

spontaneous breathing is mostly supported by high-flow nasal cannula (HFNC) oxygen therapy.[36] Conversely, certain physiopathological data associated with the procedure should be carefully assessed. For example, during NI-VATS, spontaneous ventilation and effective diaphragm contractions are sustained. This position ensures ideal V/Q matching in the dependent lung. Nevertheless, lateral decubitus positioning and iatrogenic pneumothorax resulting from pleural cavity opening can induce notable alterations in the V/Q, occasionally provoking respiratory disturbances that are often transient but potentially perilous. Additionally, in non-intubated procedures, distinctions in ventilation dynamics arise compared with mechanical ventilation pendulum due to spontaneous breathing and the absence of one-lung ventilation mechanisms. First, carbon dioxide rebreathing. In the dependent lung, a portion of the inhaled air volume is exhaled into the non-dependent lung during expiration, and is then re-inhaled by the dependent lung during the subsequent inspiration phase. This pendulum-like motion has the potential to trigger hypoxia and hypercapnia. This phenomenon can cause conversion to orotracheal intubation.[37] Furthermore, while hypercapnia can pose a concern during non-intubated surgery, there exists a significant degree of tolerance for this condition. In fact, the concept of permissive hypercapnia is anticipated to enhance V/Q through hypoxic pulmonary vasoconstriction, which in turn augments parenchymal compliance and facilitates direct dilation of small airways.[38] Given these considerations, additional research is required to refine the procedural aspects of HFNC and NIVM implementation.

A special concern is the potential for intrabronchial pressure induced by NIPPV to increase pulmonary air leaks. Prolonged air leakage is a primary complication of lung surgery. This factor significantly influences the duration of postoperative hospitalization, the rate of ICU readmission, and in-hospital mortality.[39] Clinical investigations have shown that this complication could occur in up to 10% of patients who undergo NIPPV.[31] Therefore, this condition should be carefully treated before starting NIMV therapy.

4. Non-invasive Mechanical Ventilation Support in Palliative Care Units

In the context of cancer care, promoting the integration of NIMV as a crucial element within palliative approaches has emerged as a prominent and compelling suggestion. This directive gains particular significance in its targeted focus on ameliorating dyspnea, a distressing symptom that is widely encountered by individuals grappling with cancer-related challenges.[40] The strategic integration of NIMV into the broader framework of palliative care endeavors not only to elevate the overall quality of life for these patients but also to offer tangible relief from the burdensome effects of compromised respiratory function. On these premises, the guidelines recommend the use of NIMV for dyspneic patients with terminal cancer for palliation.[19]

In addition to addressing dyspnea, there are additional advantages that prove especially beneficial in managing patients within the context of palliative care. NIMV offers a viable strategy to potentially improve outcomes and decrease the necessity for ICU admission. In a previous study, Gristina et al.[41] found that among patients with hematological malignancies who were admitted to the ICU due to respiratory failure, NIMV was associated with lower mortality rates than IMV. In another retrospective study conducted on patients with cancer, including those with solid tumors and admitted to medical ICUs for immediate or delayed NIMV for ARF, 57.5% were discharged from the ICU, and 42.5% were discharged from the hospital. On the contrary, among those who required IMV, only 1 was discharged from the hospital.[42] Therefore, during the terminal stages of lung cancer, NIMV can offer comfort care by alleviating dyspnea and respiratory distress, enhancing patient comfort, and allowing peaceful end-of-life care. Skillfully employing NIVM in advanced lung cancer cases, Kızılgöz et al.[9] achieved a remarkable decrease in ICU admissions and a notable extension of survival. Particularly significant is the study's impressive hospital discharge rate of 71%, encompassing the entire study cohort (n = 42). Results are applicable regardless of the disease stage, particular cellular subtype involved, or underlying factors contributing to the respiratory condition.

CONCLUSION

In the management of patients with lung neoplasms, NIVM has various potential applications. By addressing pre-existing lung conditions, facilitating surgical maneuvers, and promoting postoperative recovery, NIMV contributes to a holistic approach that optimizes surgical outcomes and patient well-being. For those ineligible for surgical resection, this approach can enhance respiratory performance, demonstrating utility across diverse clinical contexts, including palliative care. Therefore, as the understanding of NIMV's potential continues to evolve, its role in perioperative lung cancer care remains a dynamic area of exploration and innovation. High-quality clinical studies are required to evaluate the roles of different NIVM strategies and to determine the best timing to initiate therapy.

Footnotes

Authorship Contributions

Concept: M.C., A.M.E., Design: M.C., A.M.E., Data Collection or Processing: M.C., Analysis or Interpretation: A.M.E., Literature Search: M.C., Writing: M.C.

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