Scientific Research Publishing

Open Journal of Therapy and Rehabilitation, 2026, 14(1), 23-32
https://www.scirp.org/journal/ojtr
ISSN Online: 2332-1830
ISSN Print: 2332-1822

Applicability of High-Flow Nasal Cannula Therapy in the Pre- and Postoperative Management of Patients Eligible for a Lung Transplant Program: An Integrative Literature Review

Cristiano Gomes da Silva[1,2*], Cristina Luzia Viana Peixoto[1,2], Kenya Rodrigues Marques[1,2], Matheus Argolo Trindade Santos[2], Marta Santos da Silva Miranda[2], Thaissa Kalena dos Santos[2], Stella Andreza Menezes da Costa[2], Nildo Campos Rangel[3]

[1]Hospital São Lucas Copacabana, Rede Americas, Rio de Janeiro, Brasil
[2]Programa de Pós-Graduação em Fisioterapia Hospitalar, Procepi, Niterói, Brasil
[3]Excellence Serviços de Fisioterapia, Rio de Janeiro, Brasil
Email: *cristianofisio@hotmail.com

How to cite this paper: da Silva, C.G., Peixoto, C.L.V., Marques, K.R., Santos, M.A.T., da Silva Miranda, M.S., dos Santos, T.K., da Costa, S.A.M. and Rangel, N.C. (2026) Applicability of High-Flow Nasal Cannula Therapy in the Pre- and Postoperative Management of Patients Eligible for a Lung Transplant Program: An Integrative Literature Review. *Open Journal of Therapy and Rehabilitation*, **14**, 23-32.
https://doi.org/10.4236/ojtr.2026.141003

Received: December 12, 2025
Accepted: February 21, 2026
Published: February 24, 2026

Abstract

Introduction: Lung transplantation is a surgical procedure performed to replace one or both lungs, using donated organs. A commonly used procedure in the postoperative phase of lung transplantation is the use of a High-Flow Nasal Cannula (HFNC), which assists oxygenation and provides respiratory comfort to the patient. **Objective:** This paper aims to analyze the available scientific evidence on the use of high-flow nasal cannulas as a ventilatory support strategy in the pre- and postoperative management of patients undergoing lung transplantation. **Methodology:** This is a literature review study, where the search for articles was conducted in the PubMed, SciELO, CAPES Journals, and LILACS databases, between the years 2014 and 2024, published in Portuguese, English, and Spanish. **Results:** 31 records were identified, and 3 studies met the inclusion criteria. In lung transplant recipients readmitted to the ICU due to acute respiratory failure, HFNC was associated with lower treatment failure (need for invasive mechanical ventilation) compared with conventional oxygen therapy. During flexible bronchoscopy in post-lung transplant patients, HFNC reduced the frequency of oxygen desaturation episodes and avoided procedure interruptions. In lung transplant candidates undergoing constant-load treadmill testing, HFNC increased endurance time compared with a Venturi mask. **Conclusion:** Despite the limited number of

studies included in this review, the results showed that the use of therapy can reduce hypoxemia, especially post-operatively, and can also facilitate the rehabilitation process, increasing exercise tolerance.

Keywords

High-Flow Nasal Cannula, Lung Transplantation, Postoperative, Preoperative

1. Introduction

Lung transplantation is an advanced and complex surgical intervention that has become a relevant therapeutic option when clinical resources to restore pulmonary function have been exhausted. According to data from the Brazilian Association of Organ Transplantation (ABTO), lung transplantation is among the least frequently performed organ transplants in Brazil when compared with other organs [1] [2]. The Brazilian Transplant Registry (RBT) reports that between 2014 and 2024, 927 lung transplants were performed and that, in 2024, 187 adult patients were on the waiting list. In 2022, only 15 lung transplants were performed in the country, reflecting the high surgical complexity, limited infrastructure, and low organ donation rates [2].

Worldwide, the International Society for Heart and Lung Transplantation (ISHLT) reports that approximately 4500 lung transplants are performed annually, and this number has gradually increased over the years [3].

Lung transplantation is indicated for patients with advanced or end-stage lung diseases, with a high risk of death and refractory to other clinical interventions [4] [5]. The main indications include chronic obstructive pulmonary disease (COPD), pulmonary fibrosis, cystic fibrosis, bronchiectasis, sarcoidosis, and severe lung injury caused by COVID-19 [6].

Eligibility criteria for lung transplantation are related to a high risk of death (>50%), a high probability (>80%) of survival for at least 90 days after the procedure, and an expected survival of more than five years from a general medical perspective, provided that graft function is adequate [7]. The aim of transplantation is to extend the patient's life expectancy by restoring functional capacity and reducing mortality associated with end-stage lung disease [8].

Due to the clinical complexity of transplantation, integrated multidisciplinary teams are essential for pre- and postoperative management. In this context, physiotherapy plays a key role, contributing substantially to optimizing the functional and respiratory status of patients undergoing lung transplantation [9]. Systematic pulmonary rehabilitation provides benefits such as improved symptom control, increased survival, greater autonomy, and better quality of life, facilitating return to daily activities.

In lung transplantation, physiotherapy aims to improve chest wall expansibility,

prevent atelectasis and respiratory infections, reduce associated pulmonary complications, and optimize mechanical ventilation parameters. To achieve these goals, thoracic mobilization, range-of-motion exercises, and positional changes are employed to accelerate functional and respiratory recovery [10].

Patients undergoing lung transplantation have specific characteristics related to varying degrees of immunosuppression, graft-related particularities, and thoracic cage dimensions. These factors increase the complexity of ventilatory weaning and may result in short- or long-term respiratory failure after transplantation [11]. Delayed discontinuation of invasive mechanical ventilation, when associated with acute hypoxemic respiratory failure, prolongs intensive care unit (ICU) length of stay and increases infection risk. In this scenario, high-flow nasal cannula (HFNC) therapy emerges as a promising strategy capable of providing effective ventilatory support, improving oxygenation, and reducing the need for prolonged invasive ventilation [12].

HFNC is a noninvasive oxygen therapy system that has gained prominence in hospital settings due to its effectiveness in optimizing oxygenation and reducing respiratory effort. Developed in the early 2000s for use in neonatology, HFNC emerged as an alternative to face masks—often associated with pressure ulcers—by enabling high-flow oxygen delivery while preserving comfort and skin integrity [13] [14]. The device allows adjustment of the fraction of inspired oxygen (FiO_2 21% - 100%) and flow rate (30 - 60 L/min), delivering a heated and humidified gas mixture through wide-bore nasal cannulae [15]-[17].

Given the increasing use of this resource in ICUs for the management of severe respiratory symptoms, this study is relevant to better understand the effectiveness of HFNC in the perioperative context of lung transplantation, providing support for clinical practice and evidence-based decision-making.

2. Methods

The guiding question of this study was: "What is the effectiveness of high-flow nasal cannula in the respiratory management of patients undergoing lung transplantation in the pre- and postoperative period?".

Accordingly, the overall objective of this study was to analyze the available scientific evidence on the use of HFNC as a ventilatory support strategy in the pre- and postoperative management of patients undergoing lung transplantation. The specific objectives were: to identify the benefits of HFNC in preventing respiratory complications in lung transplant candidates; to describe the most commonly used HFNC protocols in this population; to compare clinical outcomes (e.g., length of stay, reintubation, and mortality) between patients who used HFNC and those who used other oxygen therapy or ventilation methods; and to discuss physiological mechanisms involved in HFNC effectiveness.

An integrative literature review was carried out by collecting studies describing HFNC use in the pre- and postoperative phases of lung transplantation. The search was performed in PubMed, Scientific Electronic Library Online (SciELO),

CAPES Journals, and LILACS, including studies published between 2014 and 2024 in Portuguese, English, and Spanish. Given the scarcity of lung-transplant–specific HFNC studies, the search window was expanded to capture the earliest eligible transplant-specific evidence. For article selection, Health Sciences Descriptors (DeCS) and Medical Subject Headings (MeSH) were combined with the Boolean operators AND and OR, resulting in the following search strategy: "cânula nasal de alto fluxo" AND "transplante pulmonar" AND "terapia de oxigênio de alto fluxo" AND "pós-operatório" OR "pré-operatório" (Portuguese) and "high-flow nasal cannula" AND "lung transplantation" AND "perioperative care" OR "postoperative respiratory support" (English).

Inclusion criteria comprised articles addressing HFNC as a physiotherapy intervention and ventilatory support strategy with potential to improve oxygenation, prevent reintubation, reduce length of stay, and/or decrease respiratory complications and mortality. Exclusion criteria were: studies involving children and/or neonates; and studies that used HFNC in other clinical contexts (e.g., COVID-19, COPD, sleep apnea, among others).

3. Risk of Bias and Applicability

Two authors (CGS and NCR) conducted quality assessments of the included studies using the Newcastle-Ottawa Scale (NOS) for observacional studies. This scale is composed of 8 items that evaluate the quality of studies through three categories: selection of study groups, comparability between groups, and outcome assessment. Scores ranges form 0 to 9 stars, with studies scoring seven or higher generally considered high-quality. In addition to the overall classification, a more specific evaluation was also performed as follows: studies were rated as "good quality" if they scored 3 or 4 stars in selection, 1 or 2 stars in comparability, 2 or 3 stars in outcomes; "reasonable quality" if the study scored 2 or 3 stars in selection, 1 or 2 stars in comparability, 2 or 3 stars in outcome; and "poor quality" if study scored 0 or 1 star in slection, 1 or 2 stars in comparability, 0 or 1 star in outcome [18].

4. Results

Thirty-one articles were initially identified. After screening descriptors, titles, and abstracts, 15 articles were excluded: five due to incompatible descriptors, seven due to inadequate populations, and three because they did not involve HFNC as a ventilatory support strategy. After applying eligibility criteria, nine articles were excluded due to duplication, lack of full text, or not directly addressing the proposed topic. In total, seven articles were selected for full-text reading, and three studies met all inclusion criteria and were included in this review (**Figure 1**). The selected studies, comprising a total of 125 patiesnts, were all prospective study and each received a score of 7 points on the Newcastle-Ottawa scale (4 stars in selection, 0 score in comparability and 3 stars in outcome).

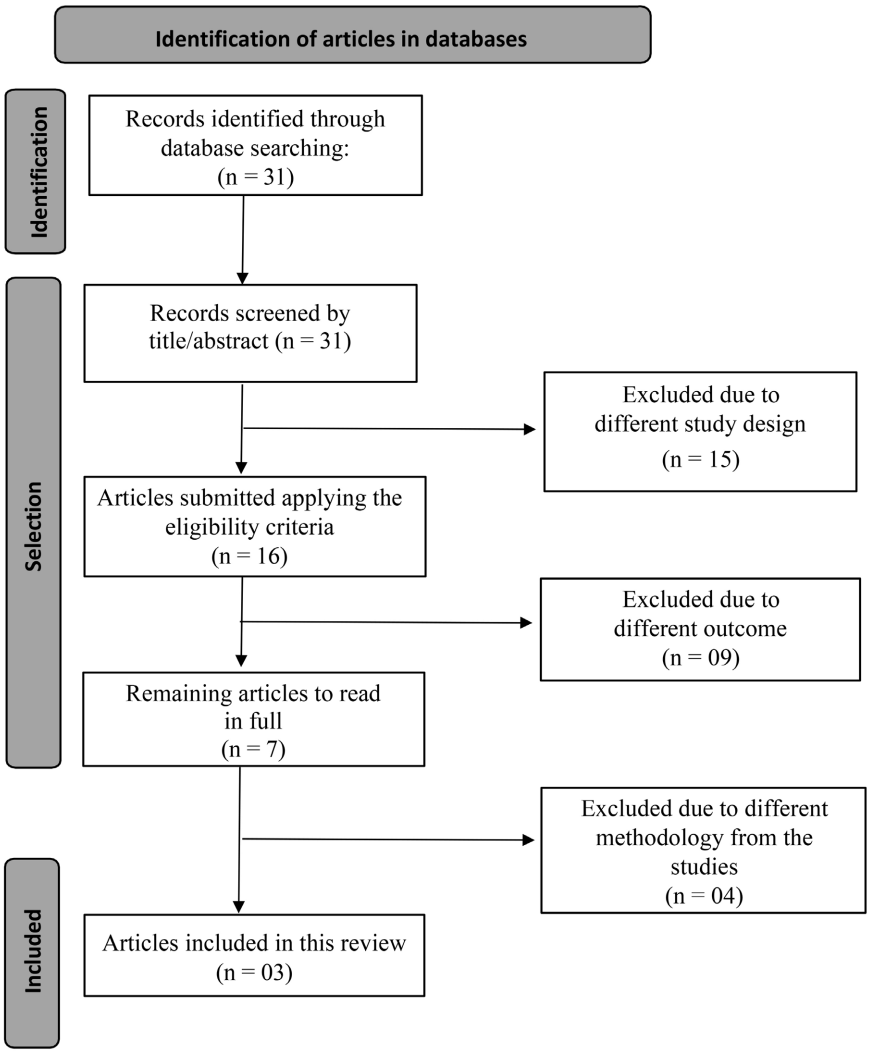

Figure 1. Flow diagram of the selection of studies included in the review.

Across the included studies, HFNC was delivered as heated, humidified high-flow oxygen, with FiO_2 titrated according to clinical targets. In lung transplant recipients readmitted to the ICU due to acute respiratory failure, HFNC was delivered using an Optiflow system with a median flow of approximately 50 L/min (45 - 60) and FiO_2 around 45% (35 - 50) at ICU admission, followed by individualized titration according to clinical response. In the flexible bronchoscopy trial, HFNC was applied during the procedure as heated, humidified high-flow oxygen; however, the study did not report detailed operational settings (flow, temperature) or a stepwise weaning approach. In the exercise crossover trial, HFNC (Optiflow™ MR850) was delivered at FiO_2 50% with a total gas flow of 50 L/min, with temperature and humidification provided by the device during the test; no post-intervention weaning strategy was reported.

Data from the included studies were extracted, organized, and qualitatively analyzed, focusing on understanding HFNC use in the perioperative phases of lung transplantation. Table 1 summarizes the main studies included in this review.

Table 1. Studies included in the review.

Author/Year	Objective	Methods	Conclusion
Roca *et al.*, 2015	To compare the clinical course of lung transplant recipients readmitted to the ICU due to acute respiratory failure, treated with two different oxygen support therapies (conventional oxygen therapy vs HFNC).	A total of 37 patients received conventional oxygen therapy or HFNC according to the attending physician's criteria. Treatment failure was defined as the subsequent need for invasive mechanical ventilation. HFNC protocol details: Optiflow system; median flow approximately 50 L/min (45 - 60) and FiO_2 approximately 45% (35 - 50) at ICU admission; therapy subsequently titrated by the attending physician.	HFNC oxygen therapy is feasible and safe and may reduce the need for mechanical ventilation in lung transplant recipients readmitted to the ICU due to acute respiratory failure.
Ben-Menachem *et al.*, 2020	To assess HFNC use and its association with a lower frequency of desaturation events in the immediate postoperative period after lung transplantation (during bronchoscopy).	A total of 76 post-lung transplant patients were divided into two groups receiving either HFNC or low-flow nasal oxygen. The patient and the bronchoscopist were blinded to group allocation. HFNC protocol details: heated, humidified high-flow nasal oxygen during bronchoscopy; specific flow and temperature settings were not reported in the study.	Hypoxemia occurred less frequently in post-lung transplant patients who received HFNC during bronchoscopy. Additional studies are needed in other high-risk populations undergoing longer bronchoscopy procedures.
Rocha *et al.*, 2024	To compare the effects of HFNC and the Venturi mask on exercise tolerance in patients eligible for a lung transplant rehabilitation program.	Twelve lung transplant candidates requiring oxygen during exercise performed two randomized treadmill endurance tests seven days apart, one with HFNC and one with a Venturi mask (both with FiO_2 50%). Outcomes included endurance time (primary), heart and respiratory rate, oxygen saturation, peripheral lactate, dyspnea, and lower-limb fatigue. HFNC protocol details: FiO_2 50% with a total gas flow of 50 L/min during constant-load treadmill testing; humidification and temperature provided by the device.	HFNC increased exercise tolerance compared with the Venturi mask in lung transplant candidates, and both systems were effective in preventing peripheral oxygen desaturation.

5. Discussion

The analysis of the selected studies indicates meaningful progress in HFNC use in the lung transplantation setting, in both the pre- and postoperative phases. Available evidence suggests that HFNC is a promising ventilatory support strategy, providing clinically relevant benefits in different situations related to lung transplantation.

In the clinical trial included in this review, [19], HFNC therapy in lung transplant recipients readmitted to the ICU due to acute respiratory failure showed better outcomes than conventional oxygen therapy. There was a reduction in the need for invasive mechanical ventilation and improved patient survival. The risk of progression to mechanical ventilation was 1.5 times higher in the group receiving conventional oxygen therapy, whereas HFNC reduced the absolute risk of ventilation by 29.8%.

A prospective study [20] evaluated HFNC use during bronchoscopy in post-

lung transplant patients and demonstrated a lower occurrence of hypoxemia episodes in patients treated with HFNC. This strategy improved safety and tolerance during the procedure, avoiding interruptions and contributing to respiratory stability in high-risk patients undergoing invasive interventions.

Another study [16] compared exercise tolerance in lung transplant candidates using HFNC versus a Venturi mask. Endurance time was 357 seconds longer with HFNC, suggesting that the device may provide more efficient oxygenation during physical effort. These findings are relevant for pretransplant rehabilitation, potentially contributing to better functional recovery in the postoperative period.

The physiological mechanisms discussed in this section are theoretical and derived from the broader HFNC literature. They should not be interpreted as outcomes directly demonstrated in the three lung-transplant–specific studies included in this review; rather, they are presented to contextualize potential pathways through which HFNC could influence clinical and functional endpoints in this population. From a physiological standpoint, HFNC may offer perioperative benefits in lung transplantation through mechanisms beyond increasing oxygen delivery. A central mechanism is the ability to provide high flow with a more stable inspired oxygen fraction, reducing oxygen dilution by room air in patients with high inspiratory demand, tachypnea, or irregular breathing patterns. In postoperative hypoxemia, greater predictability of effective FiO_2 may contribute to improved oxygenation control and less clinical fluctuation [21]-[23].

Another relevant mechanism is the reduction of anatomical dead space in the upper airways by flushing residual exhaled gas from the nasopharynx and proximal regions, thereby decreasing CO_2 rebreathing and making alveolar ventilation relatively more efficient for the same ventilatory volume. This effect may favor a lower respiratory rate and improved ventilatory efficiency, which is particularly pertinent in patients with shallow, rapid breathing in the immediate postoperative period [24].

In addition, physiological studies have shown that HFNC may be associated with reduced inspiratory effort and work of breathing, improving parameters related to ventilatory load in acute hypoxemic respiratory failure. This behavior may have clinically relevant implications in early rehabilitation and physiotherapy by favoring a more economical breathing pattern that may be better tolerated during mobilization and exercise, although extrapolation to the specific lung transplantation scenario should be interpreted cautiously [25] [26].

Finally, gas heating and humidification are important HFNC components and are associated with greater comfort, improved tolerance to support, and potential benefits for airway hydration and secretion management. In post-transplant patients, in whom bronchial hygiene and adherence to support can influence clinical course, these mechanisms provide physiological plausibility for HFNC as an advanced oxygen therapy strategy, despite the limited number of transplant-specific studies [22] [23] [25].

Although available evidence remains limited, HFNC has been associated with potential benefits across different phases of care for transplant candidates and re-

cipients, including stabilization of acute respiratory failure, support during diagnostic procedures, and possible improvement in functional capacity in the pre-transplant period. Its ability to deliver continuous heated and humidified oxygen flow may optimize oxygenation and reduce respiratory effort, promoting greater patient comfort.

However, methodological limitations exist in the reviewed studies, such as small sample sizes and heterogeneity of protocols. These factors reinforce the need for further clinical studies with greater methodological rigor and larger samples. Additionally, robust data in the preoperative phase remain scarce, representing a relevant gap given the potential benefits of HFNC during this critical period.

The identification of only three eligible studies may reflect a true scarcity of lung-transplant–specific evidence on HFNC. However, it may also indicate potential selection bias related to database coverage and/or the use of restrictive descriptors. Future updates could broaden the keyword strategy (e.g., "high-flow nasal oxygen," "nasal high-flow," "Optiflow"), expand the number of databases searched, and consider grey literature to minimize the risk of missing relevant studies.

Therefore, future research—especially controlled randomized clinical trials—is essential to consolidate HFNC effectiveness and safety as a perioperative ventilatory support tool in lung transplantation. Strengthening this scientific basis may help optimize clinical outcomes, reduce complications, and improve the quality of care delivered to this population.

6. Conclusions

Across the three included studies (total n = 125), the current evidence on HFNC in the perioperative management of lung transplantation remains insufficient and is of low-to-moderate certainty. Although potential benefits have been reported, such as improved oxygenation and respiratory stability, fewer desaturation episodes during bronchoscopy, improved exercise tolerance in candidates, and lower treatment failure in ICU readmissions, these findings should be interpreted as preliminary. This is primarily due to small sample sizes, heterogeneity in HFNC settings, protocols, and outcome definitions, and residual confounding related to predominantly nonrandomized designs.

Therefore, the available evidence is not adequate to support strong or broadly generalizable recommendations for routine HFNC use across all lung-transplant candidates or recipients. Importantly, more research is still required before HFNC can be confidently incorporated into standard perioperative care pathways. Future studies should include larger samples and rigorous designs, ideally multicenter randomized trials or robust prospective cohorts, with standardized HFNC parameters, clear weaning protocols, and predefined clinically relevant outcomes such as reintubation, ICU and hospital length of stay, graft-related complications, and mortality, to clarify effectiveness and safety and to identify the patient subgroups most likely to benefit.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Oliveira, F.D.B.D., Guimarães, G.P., Calderari, Y., Corrêa, L.L., Castro, A.M.D., Machado, H.P., *et al.* (2023) Aspectos atuais sobre a seleção dos pacientes candidatos ao transplante pulmonar. *Research, Society and Development*, **12**, e99121143832. https://doi.org/10.33448/rsd-v12i11.43832

[2] ABTO (2023) Registro Brasileiro de Transplantes: Dimensionamento dos transplantes no Brasil e em cada estado (2016-2023).

[3] International Society for Heart and Lung Transplantation (ISHLT) (2023) The 2023 ISHLT Guidelines for Mechanical Circulatory Support: A 10-Year Update. *Journal of Heart and Lung Transplantation*, **42**, e1-e222.

[4] Jatene, F.B., Pêgo-Fernandes, P.M. and Medeiros, I.L.D. (2009) Transplante pulmonar. *Revista de Medicina*, **88**, 111-122. https://doi.org/10.11606/issn.1679-9836.v88i3p111-122

[5] Afonso Júnior, J.E., Werebe, E.D.C., Carraro, R.M., Teixeira, R.H.D.O.B., Fernandes, L.M., Abdalla, L.G., *et al.* (2015) Lung transplantation. *Einstein* (*São Paulo*), **13**, 297-304. https://doi.org/10.1590/s1679-45082015rw3156

[6] Rosa, F.R.P.D.A.C., Gomes, M.J.D.A., Menezes, A.G.G.D., Resende, G.B.D.O., Cunha, I.A.M.F., Peixoto, S.R., *et al.* (2023) Seleção de pacientes ao transplante pulmonar: uma revisão integrativa de literatura. *Research, Society and Development*, **12**, e29312240344. https://doi.org/10.33448/rsd-v12i2.40344

[7] Camargo, P.C.L.B.D., Teixeira, R.H.D.O.B., Carraro, R.M., Campos, S.V., Afonso Junior, J.E., Costa, A.N., *et al.* (2015) Lung Transplantation: Overall Approach Regarding Its Major Aspects. *Jornal Brasileiro de Pneumologia*, **41**, 547-553. https://doi.org/10.1590/s1806-37562015000000100

[8] Ferreira, L.L., Martines, B.A.R., Correia, J.R. and Cavenaghi, O.M. (2018) Perfil clínico funcional de pneumopatas em avaliação fisioterapêutica pré-transplante pulmonar. *ConScientiae Saúde*, **17**, 72-78. https://doi.org/10.5585/conssaude.v17n1.7853

[9] Florian, J., Rubin, A., Mattiello, R., Fontoura, F.F.D., Camargo, J.D.J.P. and Teixeira, P.J.Z. (2013) Impact of Pulmonary Rehabilitation on Quality of Life and Functional Capacity in Patients on Waiting Lists for Lung Transplantation. *Jornal Brasileiro de Pneumologia*, **39**, 349-356. https://doi.org/10.1590/s1806-37132013000300012

[10] Dos Santos, L.R. and Da Fonseca Maia, A.B. (2023) Atuação da fisioterapia no transplantado pulmonar—Revisão sistemática. Repositório Institucional do UNILUS 2.

[11] Leal, S. (2014) Early Postoperative Management of Lung Transplantation. *Minerva Anestesiologica*, **80**, 1234-1245.

[12] Masclans, J., Zapatero, A. and Sacanell, J. (2017) High-Flow Oxygen Therapy in Post-Lung Transplant Patients. *Archivos de Bronconeumología* (*English Edition*), **53**, 182-183. https://doi.org/10.1016/j.arbr.2017.02.002

[13] Shoemaker, M.T., Pierce, M.R., Yoder, B.A. and DiGeronimo, R.J. (2007) High Flow Nasal Cannula versus Nasal CPAP for Neonatal Respiratory Disease: A Retrospective Study. *Journal of Perinatology*, **27**, 85-91. https://doi.org/10.1038/sj.jp.7211647

[14] Helviz, Y. and Einav, S. (2018) A Systematic Review of the High-Flow Nasal Cannula for Adult Patients. *Critical Care*, **22**, Article No. 71.

https://doi.org/10.1186/s13054-018-1990-4

[15] Roca, O., Hernández, G., Díaz-Lobato, S., Carratalá, J.M., Gutiérrez, R.M. and Masclans, J.R. (2016) Current Evidence for the Effectiveness of Heated and Humidified High Flow Nasal Cannula Supportive Therapy in Adult Patients with Respiratory Failure. *Critical Care*, **20**, Article No. 109. https://doi.org/10.1186/s13054-016-1263-z

[16] Rocha, E.M.M., Rodrigues, G., MontAlverne, D.G.B., Pereira, E.D.B., Monteiro, F.M.L., Holanda, M.A., *et al.* (2024) Impacto da cânula nasal de alto fluxo em comparação à máscara de venturi na tolerância ao exercício em candidatos a transplante de pulmão: Um ensaio clínico randomizado cruzado. *Brazilian Journal of Respiratory, Cardiovascular and Critical Care Physiotherapy*, **15**, e00372024. https://doi.org/10.47066/2966-4837.2024.0004pt

[17] Da Silva Coelho, B.N.L. (2022) Efeitos da cânula nasal de alto fluxo em pacientes adultos com COVID-19. *Revista de Casos e Consultoria*, **12**, e27341.

[18] Stang, A. (2010) Critical Evaluation of the Newcastle-Ottawa Scale for the Assessment of the Quality of Nonrandomized Studies in Meta-Analyses. *European Journal of Epidemiology*, **25**, 603-605. https://doi.org/10.1007/s10654-010-9491-z

[19] Roca, O., de Acilu, M.G., Caralt, B., Sacanell, J. and Masclans, J.R. (2015) Humidified High Flow Nasal Cannula Supportive Therapy Improves Outcomes in Lung Transplant Recipients Readmitted to the Intensive Care Unit Because of Acute Respiratory Failure. *Transplantation*, **99**, 1092-1098. https://doi.org/10.1097/tp.0000000000000460

[20] Ben-Menachem, E., McKenzie, J., O'Sullivan, C. and Havryk, A.P. (2020) High-flow Nasal Oxygen versus Standard Oxygen during Flexible Bronchoscopy in Lung Transplant Patients. *Journal of Bronchology & Interventional Pulmonology*, **27**, 259-265. https://doi.org/10.1097/lbr.0000000000000670

[21] Diab, S. and Fraser, J.F. (2014) Maintaining Oxygenation Successfully with High Flow Nasal Cannula during Diagnostic Bronchoscopy on a Postoperative Lung Transplant Patient in the Intensive Care. *Case Reports in Critical Care*, **2014**, Article ID: 198262. https://doi.org/10.1155/2014/198262

[22] Dysart, K., Miller, T.L., Wolfson, M.R. and Shaffer, T.H. (2009) Research in High Flow Therapy: Mechanisms of Action. *Respiratory Medicine*, **103**, 1400-1405. https://doi.org/10.1016/j.rmed.2009.04.007

[23] Spoletini, G., Alotaibi, M., Blasi, F. and Hill, N.S. (2015) Heated Humidified High-Flow Nasal Oxygen in Adults: Mechanisms of Action and Clinical Implications. *Chest*, **148**, 253-261. https://doi.org/10.1378/chest.14-2871

[24] Möller, W., Feng, S., Domanski, U., Franke, K., Celik, G., Bartenstein, P., *et al.* (2017) Nasal High Flow Reduces Dead Space. *Journal of Applied Physiology*, **122**, 191-197. https://doi.org/10.1152/japplphysiol.00584.2016

[25] Mauri, T., Turrini, C., Eronia, N., Grasselli, G., Volta, C.A., Bellani, G., *et al.* (2017) Physiologic Effects of High-Flow Nasal Cannula in Acute Hypoxemic Respiratory Failure. *American Journal of Respiratory and Critical Care Medicine*, **195**, 1207-1215. https://doi.org/10.1164/rccm.201605-0916oc

[26] Goligher, E.C. and Slutsky, A.S. (2017) Not Just Oxygen? Mechanisms of Benefit from High-Flow Nasal Cannula in Hypoxemic Respiratory Failure. *American Journal of Respiratory and Critical Care Medicine*, **195**, 1128-1131. https://doi.org/10.1164/rccm.201701-0006ed