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Use of noninvasive ventilation in patients with heart failure

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ABSTRACT

Heart failure (HF) is a serious cardiovascular condition characterized by structural and functional changes in the heart, compromising its ability to pump enough blood to meet the body's needs. It manifests clinically through fatigue, dyspnea and water retention, often complicated by comorbidities such as obstructive sleep apnea and diabetes. This syndrome is responsible for high rates of hospitalization and high mortality, standing out as a significant challenge in global public health. The use of Non-Invasive Ventilation (NIV), such as CPAP and BiPAP, shows potential for improving respiratory and cardiac function, reducing respiratory work and improving oxygenation. However, the effectiveness of NIV depends on the individual's clinical condition and the adequacy of the ventilatory support provided.

Keywords: Heart Failure (HF), Non-Invasive Ventilation (NIV), Mortality, Comorbidities, Decompensation.

INTRODUCTION

Heart Failure (HF) is a cardiovascular disease where the heart has structural and functional changes that impair its ability to fill the ventricle and, therefore, cannot pump the volume necessary to meet the body's demands. In certain situations, cardiac output remains adequate, but blood ejection is left with high filling pressures, both at rest and in activities that involve effort (ARRUDA et al., 2022).

HF has been identified as an important public health problem, being considered an emerging epidemic with high mortality and morbidity, standing out as one of the main diseases affecting the heart and as the most important clinical problem today. Fatigue, dyspnea, and fluid retention are the three classic clinical manifestations of this disease, and obstructive sleep apnea, chronic lung disease, and diabetes are common conditions in HF patients, being negative factors for clinical prognosis (MARTINS, 2023).

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Despite the efforts and advances in the treatment of this syndrome, the evolution often presents episodes of decompensation, which is the main cause of hospitalizations, which leads to a prolonged time in bed due to characteristic signs and symptoms, such as pulmonary congestion, dyspnea, increased work of breathing, hypoxemia, deconditioning of skeletal muscles, increased intolerance to exertion, and predisposition to thromboembolic phenomena. in addition to increased mortality in these patients. This fact reinforces the importance and necessity of performing physical exercises in all phases of rehabilitation and in all HF classifications (GADELHA; SILVA; MACIEL, 2023).

HF is one of the main reasons for hospital admissions, with high morbidity and mortality rates worldwide. Mortality rates are 4 to 12% during the hospital stay, and 20 to 30% in the first year after discharge. In addition, hospital readmission rates are high, ranging from 20 to 30% in 90 days, and can reach 60% in one year. Progress in cardiovascular therapies has contributed to an increase in life expectancy, resulting in a higher prevalence of HF among the elderly population. Therefore, it is of great importance to deepen knowledge about epidemiology, diagnosis, and treatment, since this disease has great repercussions on the public health system, both in developed and developing countries (PETERSON et al., 2021).

In patients with HF, one of the resources used in the treatment is Non-Invasive Ventilation (NIV), capable of improving cardiac and respiratory performance through ventilatory modes, such as CPAP (*Continuous Positive Airway Pressure*) and BiPAP (*Bi-Level Positive Airway Pressure*). By providing a constant pressure during inhalation and exhalation, the CPAP mode increases residual functional capacity and opens collapsed or poorly ventilated alveoli, thus decreasing the intrapulmonary *shunt* and, consequently, improving oxygenation. The increase in Functional Residual Capacity (FRC) decreases the work of breathing and improves the pulmonary compliance of these patients (MARTINS, 2023).

In summary, NIV can provide a number of benefits to the cardiovascular system, including reduced work of breathing, improved gas exchange, reduced cardiac work, hemodynamic stabilization, and possibly reduced mortality in certain clinical settings. However, it is important to note that the efficacy of NIV depends on the specific clinical condition of the patient and the adequacy of the ventilatory support provided (ARRUDA et al., 2022).

OBJECTIVE

To verify the efficacy of the use of non-invasive ventilation in patients with heart failure, improving functional capacity, reducing symptoms such as dyspnea and fatigue, optimizing cardiovascular function, and may help during physical therapy treatment.

METHODOLOGY

This is a descriptive study and literature review, including 4 case studies that investigated the use of NIV in adult patients diagnosed with HF, published between 2019 and 2023, in English and Portuguese. We excluded 15 articles that do not fit the theme and that are literature reviews. The following databases were used to search and select the articles: Medline/Pubmed, *Physiotherapy Evidence Database* (PEDro) and *Scientific Electronic Library Online* (SciELO).

LITERATURE REVIEW

PATHOPHYSIOLOGY OF HEART FAILURE

The pathophysiology of HF is complex and still poorly understood. HF-FEr (Heart Failure with Reduced Ejection Fraction) is common in elderly females and manifests several cardiovascular comorbidities, such as Arterial Hypertension (HTA), Atrial Fibrillation (AF), Coronary Artery Disease (CAD), Pulmonary Hypertension (PPH) and non-cardiovascular diseases, Diabetes Mellitus (DM), Chronic Kidney Disease (CKD), anemia and Chronic Obstructive Pulmonary Disease (COPD) (FERNANDES et al., 2020).

HF-FEp (Heart Failure with Preserved Ejection Fraction) and HF-FEr can manifest systolic or diastolic impairment and result from a complex diversity of cardiac, vascular and systemic dysfunctions, in addition to the contribution of several comorbidities (FERNANDES et al., 2020).

Cardiac injury is due to these conditions that result in myocardial stress. This stress triggers the activation of monocytes, which infiltrate tissues and turn into macrophages. As a result, there is an increase in pro-inflammatory cytokines in the diseased heart tissue, promoting an exacerbated inflammatory reaction that causes fibrosis of the heart muscle, cell death and consequently ventricular dysfunction. In addition, there is production of Transforming Growth Factor Beta (TGFβ), responsible for assisting in tissue damage, fibrosis, and myocardial remodeling. In view of the established myocardial destruction, neurohumoral mechanisms are activated in order to compensate for the deficient cardiac output, however, the adaptation is not effective, developing cytotoxic, procoagulant, proinflammatory and proproliferative effects, causing myocardial deterioration and increasing the overload of the cardiovascular system (SILVA; CALLEJAS, 2022).

NONINVASIVE VENTILATION (NIV) IN HEART FAILURE

Some therapies that complement physical exercise training can help patients with low functional capacity. NIV decreases inspiratory effort and dyspnea during exercise. In patients with HF, non-invasive ventilatory support using CPAP can reduce left ventricular afterload and improve functional capacity,

reduce the consequences of HF, and improve Quality of Life (QoL), assisting in inspiratory muscle work in individuals with HF (FIGUEIREDO, 2020).

The use of NIV has been a treatment choice seeking to increase arterial oxygenation, pulmonary compliance and reduce the work of breathing, seeking a significant improvement in tolerance in the practice of physical exercise due to its direct action on cardiorespiratory interaction, generating an adequate cardiac and respiratory response during exercise (COSTA; GARDENGHI, 2023).

The modes used in NIV are continuous positive pressure CPAP and bilevel BIPAP pressure. BIPAP is a frequently employed technique that operates with two distinct levels of positive airway pressure: a higher one during inspiration, known as IPAP or Ventilatory Support Pressure (PSV), and a lower one during expiration, called EPAP or Positive End Expiratory Pressure (PEEP). This configuration helps keep the airways and alveoli open, improving oxygenation and reducing pressure during exhalation. On the other hand, in CPAP mode, there is a single level of positive pressure that is kept constant on both inhalation and exhalation. Appropriate selection of ventilation mode and ventilatory equipment, particularly in the acute phase, is crucial for the success of NIV, considering the interaction between the interface, circuit, and ventilator (ALBUQUERQUE, 2023).

It can be applied without the aid of a mechanical ventilator, using an air or oxygen source and a mask equipped with a PEEP valve. Thus, ventilation using BIPAP mode seems to significantly improve cardiovascular response and fatigue during resistance exercise in patients with heart failure, and has been shown to be effective in increasing exercise tolerance in hospitalized patients with decompensated heart failure, and may help during physical therapy treatment (DI LEONE, 2020).

NIV is subject to interruptions, this technique should not be used in patients who are totally dependent on mechanical ventilation to stay alive. Therefore, patient cooperation is of paramount importance for the success of NIV, limiting its use in patients with agitation and low consciousness. Complex arrhythmias, severe hemodynamic instability, characterized by the use of vasopressor amines, are contraindications for the use of NIV. Patients with abdominal distention or vomiting should not use NIV due to the risk of aspiration (REIS et al., 2019).

For the use of NIV, patients must be able to maintain the patency of the upper airway, as well as the ability to mobilize secretions and the integrity of swallowing mechanisms, thus decreasing the rate of intubation and mortality. Facial trauma, airway bleeding, acute injury, and the immediate postoperative period of esophageal surgery are considered limitations to the use of NIV (REIS et al., 2019).

The use of noninvasive ventilation in patients with HF aims to improve gas exchange, decrease respiratory load, and may contribute to the reduction of dyspnea, exercise tolerance, and increased cardiac output. Therefore, it becomes an alternative to increase arterial oxygenation, reduce respiratory work, and

pulmonary compliance, due to its sensitive action on cardiorespiratory interaction, and thus generating a better respiratory and cardiac response during exercise (FIGUEIREDO, 2020).

Using ventilatory support together with aerobic training aims to reduce the work of breathing and develop the physical performance of patients by increasing oxygenation in the peripheral muscle microcirculation and improving local blood flow, also improving oxygenation due to the increase in transpulmonary pressure, thus facilitating alveolar ventilation. NIV can act to increase intrathoracic pressure, with a decrease in left ventricular transmural pressure, helping to improve cardiac function, reducing preload and afterload, and relieving HF symptoms (FIGUEIREDO, 2020).

RESULTS

Table 1 **–** Results of NIV use in HF patients. Legend: IPAP – Positive Inspiratory Airway Pressure; EPAP – Positive Pressure at the End of Expiration; CVR – Cardiovascular Rehabilitation; NIV – Non-Invasive Ventilation; HRmax – Maximum Heart Rate; FVC – Forced Vital Capacity; HF – Heart Failure; CPAP - Continuous Positive Airway Pressure; AE – Aerobic Exercise; TIUCI – Length of Stay in Intensive Care; ICU – Intensive Care Unit; ICU – Intensive Care Unit. COPD – Chronic Obstructive Pulmonary Disease; HRV – Heart Rate Variability; BP – Blood Pressure; HR – Heart Rate; SpO2 – Oxygen Saturation; Lower limbs – lower limbs; BIPAP – Two-Level Positive Airway Pressure; IG – Intervention Group; CG – Control Group; DBP – Diastolic Blood Pressure; NiPPV – Non-Invasive Positive Pressure Ventilation; COPD – Chronic Obstructive Pulmonary Disease.

Author / year	Sample	Methodology	Results
PEREIRA; OLIVEIRA; PEREIRA (2023)	N: 1 patient Male	Appointments: 8 weeks, 2 times a week, 50 minutes. Parameters: *Bilevel*, with IPAP of 12 cmH2O and EPAP of 6 cmH2O. CVR: Aerobic exercise associated with NIV and resistance exercise between 40% and 70% HRmax intensity.	Improvement in FVC >5.26% in sleep quality and a 6-point reduction in the Epworth Sleepiness Scale after the CVR program.
SILVA et al. (2023)	N:1 patient Female	Appointments: 2 weeks, 1 time a week, 30 minutes. Parameters: CPAP, 10cmH2O, with nasal mask. CVR: Exercises with a CG-04 stationary bike without load and without the use of CPAP, monitoring the behavior of BP, HR and SpO_2 in the 1st and 2nd week.	Improvement of blood pressure response, HR and SpO2 with aerobic exercise with CPAP.
DI LEONE (2020)	N: 23 patients Male & Female	Appointments: November 2018 to March 2020, daily, 15 minutes. Parameter: IPAP ranges from 5 to 15cmH2O and EPAP from 5 to 10cmH2O. CVR: Aerobic exercise on a portable cycle ergometer of the lower limbs and NIV BIPAP. IG performed exercise and NIV simultaneously and CG performed separately every day until discharge from the ICU.	The IG had a shorter length of stay (6.3 ± 4.7 days) in intensive care and a reduction in DBP (-10.8; CI -19.7 to -2.0) at the end of the protocol when compared to the CG.

GOULART et al., (2020)	N: 14 patients Male.	Appointments: 2 appointments on the same day, with an interval of 1 hour. Parameters: NiPPV, with face mask, 8 and 12cmH2O, IPAP from 4 to 6cmH2O and EPAP from 2cmH2O. RCV: High-intensity constant load exercise, at 80% of the maximum work rate.	>SpO2 (NiPPV: 94.7 ± 3.5% vs Sham: 92.7 ± 5.2%), blood flow velocity (NiPPV: 33 ± 18 vs Baseline: 20 ± 14), reduced work of breathing, > vascular reactivity after exercise, and > exercise tolerance (> SS - NIPP: 72 ± 38 vs Baseline: 43 ± 25) in subjects with HF and COPD.

DISCUSSION

The findings of the present study demonstrated that HF is considered a public health problem, which can be associated with a sedentary lifestyle, and is accompanied by a variety of pathologies resulting from the absence of physical exercise. Physical inactivity is one of the greatest risk factors for death in patients with heart disease and, in this context, moderate exercise can generate longer survival in patients with chronic HF, as proven in the study by Di Leone (2020), which demonstrates that implementing aerobic exercise protocols associated with NIV are of paramount importance to reduce the length of stay of patients with HF in the ICU and generate a reduction in Diastolic Blood Pressure (DBP) after the implementation of the protocol. However, there were no changes in the length of hospital stay. In agreement, the study by Pereira et al. (2023), demonstrated that the regular practice of physical exercises, such as aerobic exercises in conjunction with NIV, and resistance exercises provide a variety of notable therapeutic effects, exceptionally the restructuring of the vascular, renal, and neural systems. Frequent exercise contributes to the reduction of oxidative stress, increases vagal tone, reduces sympathetic activity, reverses arteriolar remodeling, and decreases peripheral vascular resistance. All these factors will help to reduce blood pressure and control pressure levels, in some cases, obtaining results superior to the use of medications, which can even influence sleep and have an increase in slow waves.

Corroborating the study by Di Leone (2020), the study by Silva et al. (2023) showed benefits of physical exercise in patients with HF, with a lower elevation in blood pressure during such practice and, with the use of CPAP, an improvement in oxygenation during aerobic exercise, thus demonstrating that aerobic exercise has good results if linked to NIV.

NIV has been shown to be an alternative to increase arterial oxygenation, reducing the work of breathing and increasing tissue oxygenation, corroborating the study by Goulart et al. (2020) who showed improved benefits in endothelial function, better distribution of blood flow to the peripheral muscles, providing the individual with greater tolerance to physical exercise by associating NIV and high-intensity exercise.

In the present study, it was evidenced that the cytotoxic, procoagulant, pro-inflammatory, and pro-proliferative effects cause myocardial deterioration and increase the overload of the cardiovascular system, justifying the analysis used by Silva et. al. 2023 when previously administering CPAP in HF demonstrated a reduction in respiratory distress in patients, generating less cardiac work during exercise and a reduction in system overload cardiovascular. In agreement with Pereira et al. (2023), it was demonstrated that NIV, when associated with physical exercise, helps reduce dyspnea, improve saturation, and increase tolerance to exertion.

In this context, the appropriate use of NIV can increase the comfort of HF patients with a consequent impact on their quality of life. In acute HF, NIV with CPAP effectively reduces morbidity and mortality. The II Brazilian Guideline on Acute Heart Failure recommends the use of CPAP in patients with HF; however, little has been documented about the mechanism and specific action of this method in the various HF settings, highlighting the importance of this review for the scientific contribution.

CONCLUSION

HF stands out for being one of the main cardiac syndromes with high mortality and morbidity rates, thus standing out as a significant public health problem. Based on this and the clinical manifestations presented by the disease, quality of life and vascular and cardiopulmonary conditions, especially, are widely affected.

Thus, physical exercise, associated with the use of NIV, stands out as necessary conducts in the treatment of patients with HF, as they are responsible for generating vascular, cardiac, respiratory, renal and neural effects capable of modifying the clinical conditions of this individual, promoting health, improvement in functional capacity, reduction of symptoms such as dyspnea and fatigue, optimization of cardiovascular function and daily quality of life.

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