Non-Invasive Ventilation as a Method of Airway Clearance and Overnight Ventilation for Patients with for Cystic Fibrosis; Systematic Review

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Abstract

Study aim: This review aim to explore the effects of NIV on airway clearance during sleep in individuals with cystic fibrosis.

Method: In this study we adhered to the Preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement. We focused on studies including individuals with CF, regardless of age, who were identified based on clinical criteria, or genetic analysis with any kind of respiratory failure. We included original studies.We searched the literature for publications published up until 2015 using PubMed, Cochrane, MEDLINE, and Embase.

Result: we included four publications in this investigation. Three trials contain 27 participants investigated NIV as a breathing strategy at night. The outcomes of two single-night trials and the final experiment, which lasted six weeks, are presented separately. Two of these research utilized a nasal mask, while one utilizeface mask. In one investigation, NIV was evaluated as an airway clearing method.

Conclusion: In patients with severe cystic fibrosis, noninvasive positive pressure breathing lowers sleep-related hypoxemia and hypercapnia without interfering with sleep. Uncertainty surrounds the long-term advantages and compliance of noninvasive positive pressure breathing.

Keywords: Cystic Fibrosis, Non-Invasive Ventilation, Airway Clearance

Background

Despite being a multisystem illness, respiratory failure is the main cause of mortality in cystic fibrosis. The lungs and respiratory pump inability to sustain proper gas exchange is known as respiratory failure, and it is typified by anomalies in arterial blood.Sputum retention, hyperinflation, increased dyspnea,ventilation perfusion mismatch, and weakened respiratory muscles are all consequences of severe airway blockage and inflammatory processes in cystic fibrosis. This causes reflex hypoxic vasoconstriction, which raises blood pressure in the pulmonary circulation, and strains the right ventricle(1).

Non-invasive ventilation may help manage CF patients acute respiratory failure and may also help manage respiratory failure by stabilizing or reversing hypoxemia and hypercapnia by enhancing alveolar ventilation, lowering respiratory muscle fatigue, or both (2,3). To accurately represent the effectiveness of NIV on respiratory failure in CF, separate measures may be required since the precise processes by which NIV causes these changes may differ in acute and chronic illness.

When respiratory neuromuscular output declines in CF patients exacerbate these changes and cause nighttime hypoventilation before respiratory failure manifests during the day, NIV was also used during sleep (4). Although nocturnal oxygen supplementation reduces hypoxaemia, it has not been demonstrated to impact the course of CF illness (5). Additionally, there is evidence that using oxygen treatment may make hypercapnia worse (6,7). By supporting nighttime ventilation, NIV has been suggested as a way to reverse this process temporarily and halt the onset of respiratory failure. This review aim to explore the effects of NIV on airway clearance during nighttime in individuals with cystic fibrosis.

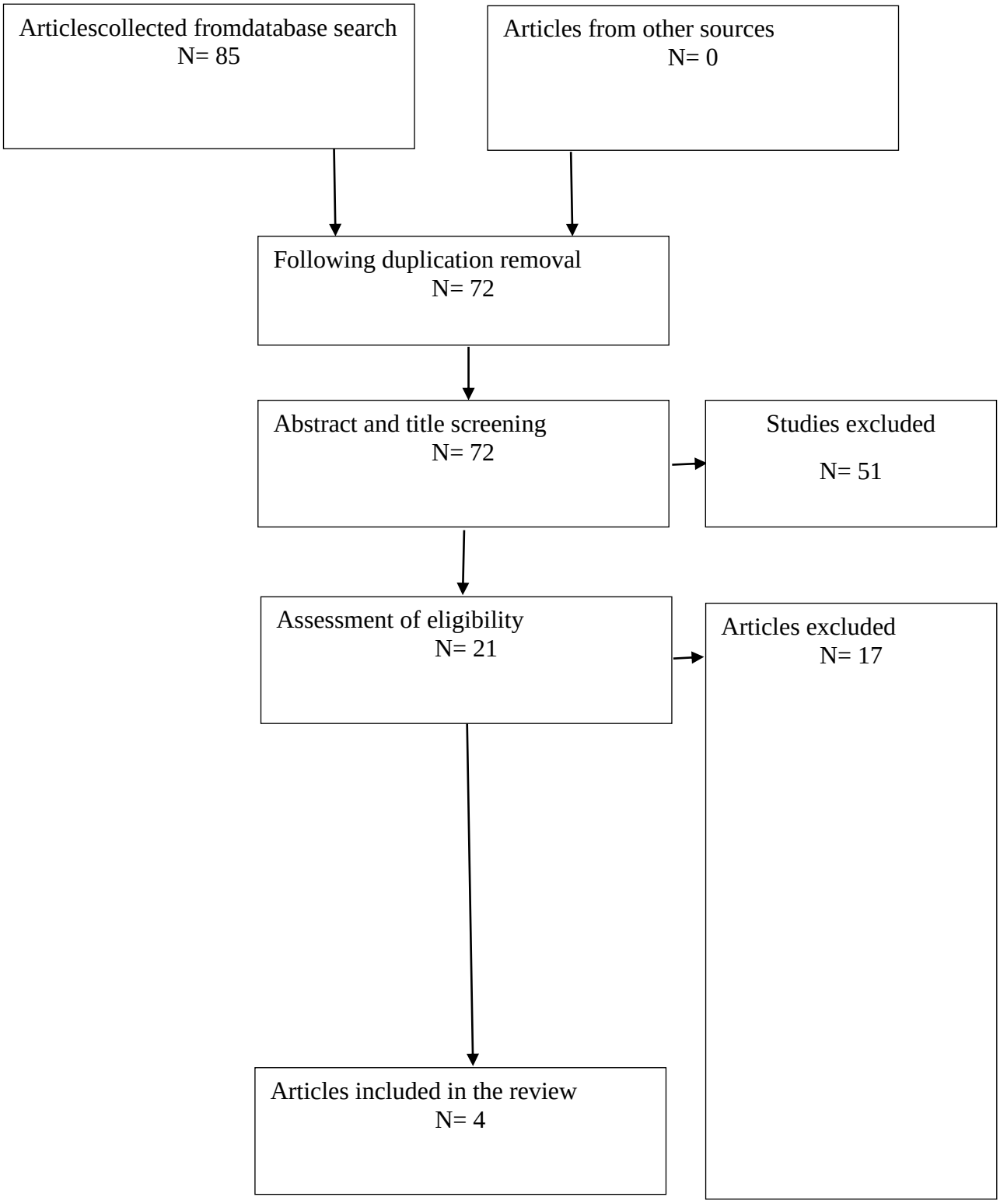
Method

In this study we adhered to thePreferred reporting items for systematic reviews and meta-analyses (PRISMA) statement.We focused on studies including individuals with CF, regardless of age, who were identified based on clinical criteria, or genetic analysis with any kind of respiratory failure. We included original studies.Interventions of any kind, including the volume preset or pressure preset NIV methods, will be taken into account and contrasted with alternative approaches to managing acute and chronic respiratory failure.

We searched the literature for publications published up until 2015 using PubMed, Cochrane, MEDLINE, and Embase.Using a pre designed formula to record the primary inclusion criteria mentioned above, three writers independently chose the studies to be included in the review. There was no disagreement on a trial's eligibility for review.

Each trial's data was separately extracted by two review writers using well-established data extraction methodologies; discrepancies were resolved by consensus. If further information was needed, the relevant author was contacted. The data collection form include; citation, study purpose, population, research strategy, key findings, and conclusion.

Fig 1: PRISMA consort chart of studies selection



Result and discussion

In this study we included 4 articles. NIV was tested as a nighttime breathing technique in three studies including a total of 27 individuals (6–8). The results of the final experiment, which lasted six weeks (8), and two single-night trials (6,7) are provided individually. One of these investigations employed a full face mask (8), while two others used a nasal mask (6,7). On the first trial night, participants in a single-night study were given room air (6). The outcomes were compared to one overnight session of NIV plus oxygen and to one overnight session of oxygen if they showed signs of severe hypoxemia, hypercapnia, or both on the room air night (6).The second trial examined an overnight session of NIV, a low level CPAP and oxygen session, and a low level CPAP and room air session(7). Participants with CF who had daytime hypercapnia were given room air, oxygen, or NIV for six weeks as part of a domiciliary six-week experiment (7).

NIV was assessed as an airway clearing technique in one experiment (9). During a two-week course of therapy for an acute exacerbation, the study employed a nasal mask or mouthpiece and compared NIV with or without an additional airway clearing strategy to no NIV, i.e., another sort of airway clearance(9).

Participants in the experimental group reported noticeably less fatigue upon hospital release than those in the control group, per a 2015 research by Dwyer et al. When NIV-assistance was introduced to a single chest physiotherapy session, additional trials of CF patients similarly observed a decrease in tiredness (10,11). The maintenance of respiratory muscle strength after NIV-assisted chest physiotherapy, which has been shown in earlier research (11,12) and the Dwyer et al. study(9), may be linked to the decreased levels of tiredness. In Dwyer et al. study, the increase in respiratory muscle strength after NIV-assisted chest physiotherapy was only noticeable when tested on the second day of admission.

The first randomized, placebo-controlled study of CF patients with hypercapnia was conducted by Young et al. (8)Their study's findings show that, in comparison to a placebo, nocturnal NIV for 6 weeks improves exertional dyspnea, chest discomfort, and nocturnal hypoventilation.

The ventilator-measured compliance in the Young et al. research was 4.3 hours per night. In CF, single overnight sessions have shown deterioration of PaCO2 with O2 treatment and attenuation of the increase in PtcCO2 with NIV (6,7).

Using nocturnal NIV, Young et al.'s study shows that CF patients' exercise performance improves. NIV significantly improved exercise performance by increasing shuttle distancemean by 83 m as compared to placebo, above the 40 m cut-off (13). Notably, six out of seven individuals increased their shuttle distance by more than fifty meters, which is notable considering that the test is incremental. It is noteworthy that a decrease in exercise capacity while on placebo contributed to a portion of the 25-meter absolute increase in mean shuttle distance from baseline with NIV. It's possible that NIV prevented the exercise capacity reduction that happened when a placebo was administered. However, further study is required on this idea before any firm conclusions can be drawn(8).

In prior research, exercise performance using NIV has seldom ever been objectively evaluated. The use of , daytime,nocturnal and exercise NIV has been shown to improve dyspnea and exercise performance in COPD patients (14–16). In CF patients, inspiratory pressure support has been used to chest physical therapy to increase muscle strength and oxygenation (11). Because breathing requires less effort, the process

probably has to do with better gas exchange. NIV increases alveolar ventilation while asleep (7) and decreases diaphragmatic effort when awake in CF patients with severe lung illness (17,18).

Table 1: method and aim of the included articles

Citation	Study method	Study aim
Dwyer et al., 2015 (9)	Intention-to-treat analysis, and randomized controlled experiment. Adults with moderate to severe cystic fibrosis lung disease who were hospitalized due to an acute exacerbation were research participants. Complete inpatient care from Day 2 of admission till release, compared to the same care plus non-invasive breathing during airway clearing procedures.	Authors postulated the potential benefits of non-invasive ventilation as a supplement to the airway clearing regimen during an acute exacerbation of cystic fibrosis.
Gozal. 1997 (6)	Comparative study. The research included six CF participants with a mean age of 22.3 years. Every patient showed radiological abnormalities, lung symptoms, and indications typical with cystic fibrosis. At the time of the trial, all CF individuals were taking vitamin supplements and pancreatic enzymes, and some were also getting intravenous or inhaled antibiotics. When CF patients were clinically stable, they were examined.	To evaluate how using NIPPV or nighttime low-flow oxygen improves respiratory and sleep outcomes in CF patients with moderate to severe lung illness and notable problems in gas exchange while they sleep.
Milrosset al., 2001 (7)	The authors of this clinical research examined 13 adult CF patients who were in stable clinical condition and had moderate to severe lung disease. Throughout the trial period, eight more CF patients had diagnostic sleep tests performed. Although all eight of these extra patients showed 90% nocturnal oxyhemoglobin desaturation, they declined to take part in the current trial.	To ascertain if oxygen or bilevel treatment may help these individuals' sleep-related hypoventilation.
Young et al., 2008 (8)	Eight participants were enrolled in a crossover research that was randomized and placebo-controlled. The main outcome measures were exertional dyspnea, daytime drowsiness, and QoL specific to CF. Lung function, peak exercise capacity,sleep architecture, and gas exchange while awake and sleeping were secondary end measures.	The authors examined how nocturnal NIV affected the functional, physiological, and quality of life outcomes of CF patients experiencing awake hypercapnia.

Table 2: main findings and conclusion of the studies included

Citation	Main findings	Conclusion
Dwyer et al., 2015 (9)	Forced expiratory volume in one second (FEV1) improved more quickly in the experimental group than in the control group, however this difference was not statistically significant when examined as the main outcome. At discharge, however, the experimental group's FEV1 was noticeably greater than the control group's. At discharge, the experimental group's Schwartz fatigue scores were noticeably lower than those of the control group. There was no significant difference between the experimental and control groups in subjective symptom intensity, quality of life, exercise ability, length of hospital hospitalization or time to next hospital admission.	When used in conjunction with the airway clearing regimen, non-invasive ventilation dramatically improves tiredness and FEV1 in patients hospitalized for an acute exacerbation of cystic fibrosis.
Gozal. 1997 (6)	Overall nighttime oxygen saturation throughout both REM and non-REM sleep periods was markedly enhanced by NIPPV and oxygen treatment in comparison to the control night. NIPPV significantly enhanced alveolar ventilation in all sleep stages, however during oxygen treatment, there were notable increases in transcutaneous CO2 tension. Arousals and sleep architecture did not alter over the nights of oxygen therapy and NIPPV treatment.	In individuals with severe cystic fibrosis, noninvasive positive pressure breathing improves sleep-related hypoxaemia and hypercapnia without interfering with sleep. Uncertainty surrounds the long-term advantages and compliance of noninvasive positive pressure breathing.
Milross et al., 2001 (7)	REM and non-REM sleep did not significantly differ in I on the bilevelventilatory support night. Low-flow oxygen and bilevelventilatory assistance both increased nocturnal SpO2, particularly during REM sleep. Bilevelventilatory assistance reduced the increase in transcutaneous carbon dioxide that was observed during REM sleep when using both room air and low-flow oxygen.	In this patient population, bilevelventilatory assistance improves alveolar ventilation while they sleep.
Young et al., 2008 (8)	NIV enhanced the transitional dyspnea index score and the chest symptom score on the CF QoL Questionnaire as compared to air. It improved exercise performance on the Modified Shuttle Test and decreased the maximal nocturnal pressure of transcutaneous CO2. NIV had no effect on awake	In adult patients with stable CF who have awake hypercapnia, six weeks of nocturnal NIV improves exertional dyspnea, nocturnal hypoventilation, peak exercise capacity, and chest

	PaCO2, lung function, or sleep architecture.	symptoms.

Conclusion

Non-invasive ventilation significantly increases fatigue and FEV1 in individuals hospitalized for an acute exacerbation of cystic fibrosis when administered in combination with the airway clearing regimen. Noninvasive positive pressure breathing reduces sleep-related hypoxemia and hypercapnia in people with severe cystic fibrosis without disrupting their sleep. The long-term benefits and compliance of noninvasive positive pressure breathing are unclear.

List of abbreviations

CF, cystic fibrosis

CPAP, level continuous positive airway pressure

FEV1, Forced expiratory volume in the first second

NIPPV, Noninvasive positive pressure ventilation

NIV, Non-invasive ventilation

PtcCO2, skin-surface partial pressure of carbon dioxide

REM, rapid eye movement

SPO2, Saturation of peripheral oxygen

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