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Non-invasive positive pressure ventilation (nppv) its uses, complications, & implications within nursing practice in acute care settings

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NON-INVASIVE POSITIVE PRESSURE VENTILATION (NPPV): ITS USES, COMPLICATIONS, & IMPLICATIONS WITHIN NURSING PRACTICE IN ACUTE CARE SETTINGS

by

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Abstract

The use of noninvasive positive pressure ventilation (NPPV) in acute care settings has drastically increased within the past 20 years. Research has indicated that NPPV is equally as effective as traditional mechanical ventilation (MV) in treating acute exacerbations of chronic pulmonary obstructive disease (COPD) and cardiogenic pulmonary edema. Furthermore, the risk of complication from NPPV is much lower than MV, in terms of ventilator-associated pneumonia and sepsis.

It is imperative for the nurse to understand the various indications, interfaces, and potential complications associated with NPPV use. In addition to treating acute exacerbations of COPD and cardiogenic pulmonary edema, NPPV has been used for prevention of reintubation, palliative care, and status asthmaticus. Furthermore, NPPV could be delivered through various interfaces, such as nasal, facial, and helmet. Each of these interfaces could eventually cause complications for the patient, such as skin ulceration and sepsis.

However, there is limited amount of research available discussing the role of the nurse in caring for the patient with NPPV. There are no standardized guidelines established to assist the nurse in this care, in terms of interface selection, prevention of complications, and staffing patterns.

Several recommendations are presented at the end of this thesis to guide future nursing research, education, and clinical practice, such as exploring the role of oral care and education for NPPV patients.

Dedication

To Becky and Christian, you have always inspired me to go after my dreams, no matter how impossible they may seem.

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I am forever indebted to my thesis chair, Dr. Mary Lou Sole. She believed in me as a nurse before I did, challenged me, and has shown me the art of perseverance. I am grateful to have such a brilliant nurse and wonderful person as my mentor.

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List of Abbreviations

BiPAP: bilevel positive airway pressure ventilation, *a form of NPPV*

COPD: chronic obstructive pulmonary disease

CPAP: continuous positive airway pressure ventilation, *a form of NPPV*

ED: Emergency Department

ICU: Intensive Care Unit

MV: invasive mechanical ventilation

NPPV: Non-invasive (or also referred as *noninvasive*) positive airway pressure

VAP: ventilator-associated pneumonia

Introduction

Acute respiratory failure refers to the body's inability to meet ventilatory demands, often seen in severe exacerbations of asthma and pneumonia. Difficulties in gas exchange may result in numerous complications, such as damage to vital organs (e.g. heart) and respiratory arrest, within a matter of minutes to hours. Often seen in combination, respiratory failure could be either hypoxemic or hypercapnic. Hypoxemic respiratory failure refers to difficulties in oxygen exchange (defined as PaO_2< 60 mm Hg on 60% O_2), while hypercapnic respiratory failure refers to inadequate carbon dioxide removal (defined as $PaCO_2$> 45 mm Hg and pH <7.35) (Arbour, 2011).

Treatment for acute respiratory failure often involves the application of supplemental oxygen, mobilization of secretions, and pharmacological therapy. Oxygen is delivered through a nasal cannula to provide immediate oxygen to the patient. Additionally, it is imperative to mobilize secretions that may contribute to respiratory distress through chest physiotherapy and airway suctioning (Arbour, 2011). Reduction of airway inflammation and congestion could be provided through pharmacological therapies, such as bronchodilators and diuretics (Arbour, 2011). If not successfully treated, mechanical ventilation is often the next course of action.

The use of mechanical ventilation is often warranted for patients with acute respiratory failure in acute care settings, such as the intensive care unit (ICU) (Pierce & Sole, 2009). Historically, invasive mechanical ventilation (MV) had been used to maintain adequate respiratory levels. However, numerous complications have been reported through the use of MV, such as barotrauma, ventilator-associated pneumonia (VAP), and aspiration of gastric contents (Pierce & Sole, 2009). These complications, especially VAP, often result in prolonged hospital

stays, while requiring extensive care by health care personnel (Restrepo et al., 2010).

With the various complications associated with MV, many physicians and respiratory therapists have successfully used non-invasive positive pressure ventilation (NPPV) in place of MV to assist certain patient populations with certain forms of respiratory distress, such as COPD. NPPV involves the simultaneous application of positive airway pressure and noninvasive continuous airway pressure without intubation (Ho & Boyle, 2000). Although its modern origins stem back to 1938, for treatment of acute pulmonary edema and asthma, its popularity in use in acute care settings did not begin until the 1980s with the success of treating sleep apnea (Burns, 2010).

During the past 20 years, much research has been completed in comparing the effectiveness of NPPV to MV. NPPV appears to improve pH levels and stabilize respiratory rates just as effective as MV without the complications often seen in the latter (Honrubia et al., 2005). Although it has been used successfully for the treatment of sleep apnea, its use has drastically increased in the acute care setting to treat acute exacerbations of chronic obstructive pulmonary disease (COPD), acute pulmonary edema related to heart failure, and acute respiratory failure (Pierce & Sole, 2009).

Problem

From 1998 to 2008, the initial use of NPPV for COPD in acute care settings increased by 462% throughout the United States (Chandra et al., 2012). Although extensive research has focused on the use and complications of mechanical ventilation, there is a limited amount of accessible research regarding the use of NPPV in the acute care setting. Much of the current

research has primarily focused comparing the effectiveness of NPPV over MV, as opposed to focusing on its use in acute care settings (Honrubia et al., 2005).

With such a drastic increase in the use of NPPV to treat COPD, it is crucial for the nurses in the acute setting to be able to understand, utilize, and identify any potential complications, such as pulmonary barotrauma and skin breakdown associated with this treatment (Burns, 2010).

Purpose

The purpose of this thesis is to provide a comprehensive literature review of research findings about the various types of NPPV and its uses in acute care. Furthermore, findings regarding complications, as well as potential causes of failure of this treatment, will be analyzed to establish the role of the nurse in caring for these patients. Clinical recommendations for nurses will be provided at the end of this thesis.

Method

An integrated literature review was conducted to analyze the indications, complications, and role of the nurse in caring for patients receiving NPPV. Databases, such as Cumulative Index to Nursing and Allied Health Literature (CINAHL), EBSCOhost Medline, and Cochrane Systematic Reviews, were consulted. Search terms, such as *noninvasive positive airway pressure* or *NPPV, continuous positive airway pressure (CPAP), bilevel positive airway pressure (BiPap), complications*, and *nursing care,* were utilized.

Inclusion factors for the literature review include adult patients, ICU/ED, acute exacerbations of COPD, pulmonary edema related to heart failure, and ARF. Exclusion factors include pediatric patients (under age 18), chronic respiratory failure, and sleep apnea.

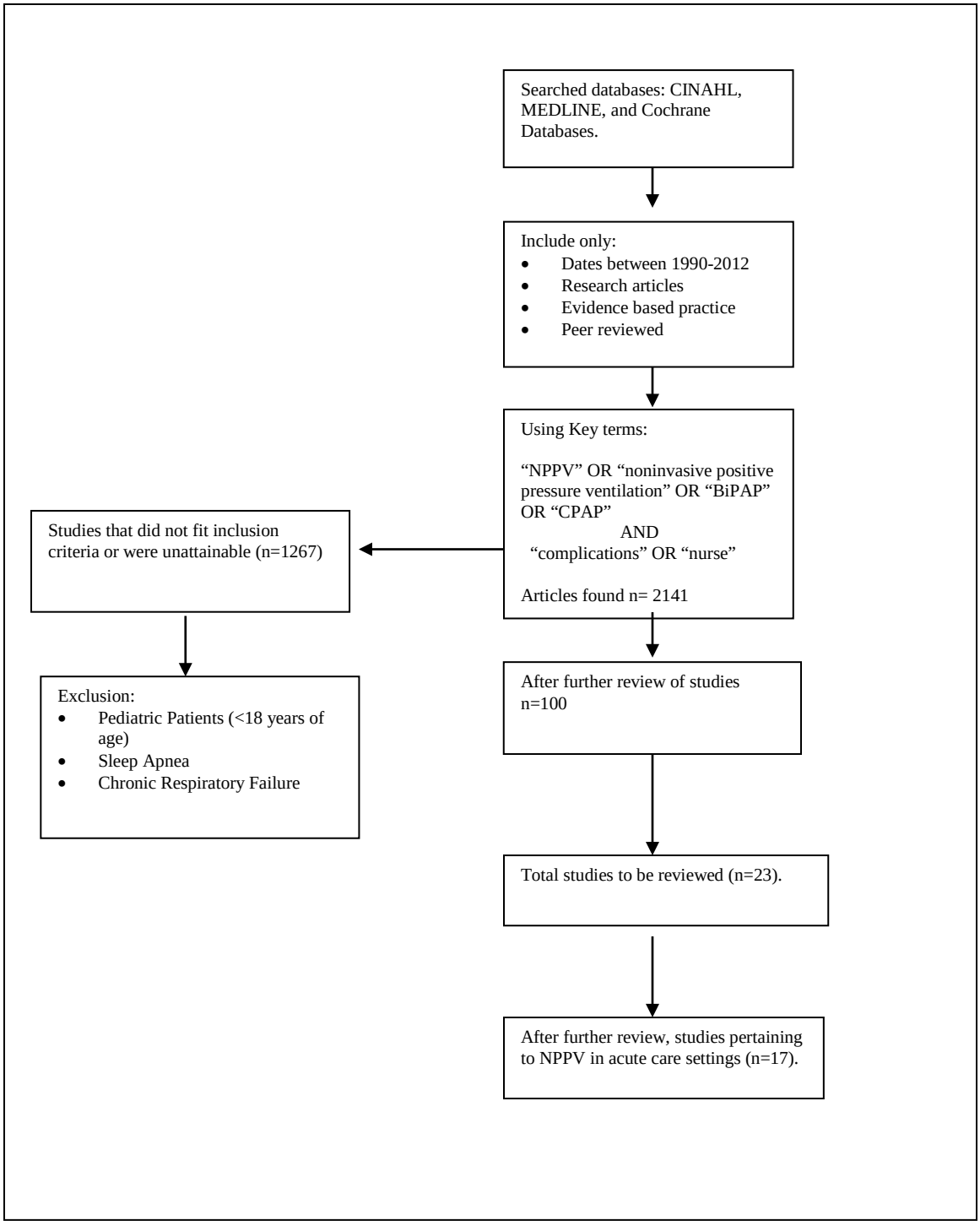

Figure 1. Consort diagram displaying selection of literature.

Background

Although its modern origins stem back to the 1980s, noninvasive ventilation (e.g. NPPV) has been used with varying degrees of success since the early twentieth century. Some early examples of noninvasive ventilation include the pneumobelt, rocking bed, and negative pressure ventilation.

In the 1930s, the pneumobelt consisted of a rubber band placed on the abdomen, which would inflate to help stimulate respiration (Kacmarek, 2009). A key component to its success involved positioning the head of bed (HOB) above 30 degrees. However, after time, it appeared that this device only worked on patients without existing pulmonary conditions, such as COPD.

Another innovative device used to provide noninvasive ventilation was the rocking bed. The patient would alternate from in Trendelenburg position to reverse Trendelenburg (Kacmarek, 2009). It was believed that such change in position would assist with respiration. Similar to the pneumobelt, these beds would work best for patients without any preexisting respiratory conditions.

Of the three forms of noninvasive ventilation, the most popular was negative pressure ventilation. Known as the "iron lung", negative pressure would be administered through chambers to assist chest walls to rise and initiate inspiration (Kacmarek, 2009). Complications related to air leaks and upper airway obstruction decreased its use, prompting future research into its counterpart, NPPV.

The remaining portion of this thesis will discuss the progression of NPPV research, with particular emphasis on the indications for NPPV in acute care setting, its different interfaces, possible complications, and the role of the nurse in caring for these patients.

Results

Non-invasive positive airway pressure ventilation (NPPV) involves the application of positive pressure to help maintain ventilation in patients with compromised respiratory function (Wilkins, Stoller, & Kacmarek, 2009). The mechanism of NPPV is similar to invasive positive pressure mechanical ventilation (MV). According to Mehta and Hill (2001), positive pressure is delivered to the lungs to increase transpulmonary pressure on inhalation, while exhalation is controlled by elastic recoil of the alveoli and expiratory muscles. The major difference between NPPV and MV is the use of interfaces. While MV involves intubation or tracheostomy, NPPV delivers positive pressure through a mask (e.g. oronasal and facial).

Some of the fundamental goals of NPPV treatment include avoidance of intubation, decreased mortality rates, decreased incidences of ventilator-associated pneumonia (VAP), improved gas exchange, decreased ventilation time, and increased patient comfort (Kacmarek, 2009).

Modes of Delivery

NPPV is delivered via multiple modes, with the two most common being continuous positive airway pressure (CPAP) and bilevel positive airway pressure (BiPAP).

CPAP. This method involves the application of simultaneous inspiratory and expiratory pressure during spontaneous breathing (Bucher & Seckel, 2011). It can be administered through endotracheal intubation or noninvasively via a facial mask. It became increasingly popular in the 1980s when its success in treating obstructive sleep apnea and other chronic respiratory conditions was discovered (Burns, 2011). The overall goal of CPAP is to decrease the work of breathing.

BiPAP. Unlike CPAP, BiPAP involves the application of two different levels of pressure: higher inspiratory pressure and lower expiratory pressure with oxygen (Bucher & Seckel, 2011). It is administered non-invasively through a facial or nasal mask. Similar to CPAP, the patient receiving BiPAP must be able to spontaneously breathe to receive ventilation.

Types of Interfaces

Unlike traditional MV, NPPV is administered non-invasively through different facial interfaces. Some of these interfaces include, but are not limited to, nasal, full facial, mouthpiece, and helmet.

Nasal. As one of the initial masks used for NPPV, nasal masks continue to be one of the common masks used for this treatment (Figure 2c). Consisting of plastic, the nasal interface surrounds the entire nose, resting on top of the bridge of the nose (Kacmarek, 2009). It is often triangular or conical in shape.

However, over time, it is reported that several complications (such as mask intolerance and air leakage) resulted from the use of this interface. Similar alternative, such as nasal pillows, helps to alleviate the discomfort often associated with the traditional nasal mask (figure 2e). Nasal pillows are soft cushions inserted into the nasal nares during treatment (Mehta & Hill, 2000).

Full Facial. Another option instead of the nasal interface is the full facial (Figure 2a). Also known as the oronasal mask, it covers from the bridge of the nose to around the mouth, while headgear and straps help to hold the mask in place. This interface is common in acute care settings to treat ARF (Mehta & Hill, 2000).

Mouthpiece. Infrequently used, mouthpieces are used during the day for ventilation (figure 2d). This interface fits into the mouth, without any irritation to the face. However, due to its placement, it is only recommended for use during the patient's waking hours. Another interface must be used while the patient is asleep to prevent aspiration (Kacmarek, 2009)

Helmet. Although not approved in the United States, the helmet interface is another option (figure 2f. It encloses the patient's head into NPPV therapy, resulting in less skin breakdown compared to the other interfaces. The helmet is held in place by straps attached to the axillary region (Kacmarek, 2009).

Selection of Interface. Regardless of interface selection, special consideration is taken in account to ensure the adequate fit for each patient through the use of a sizing gauge provided by the manufacturer (Kacmarek, 2009)**.** This is done to prevent any complications (to be further discussed) from NPPV treatment.

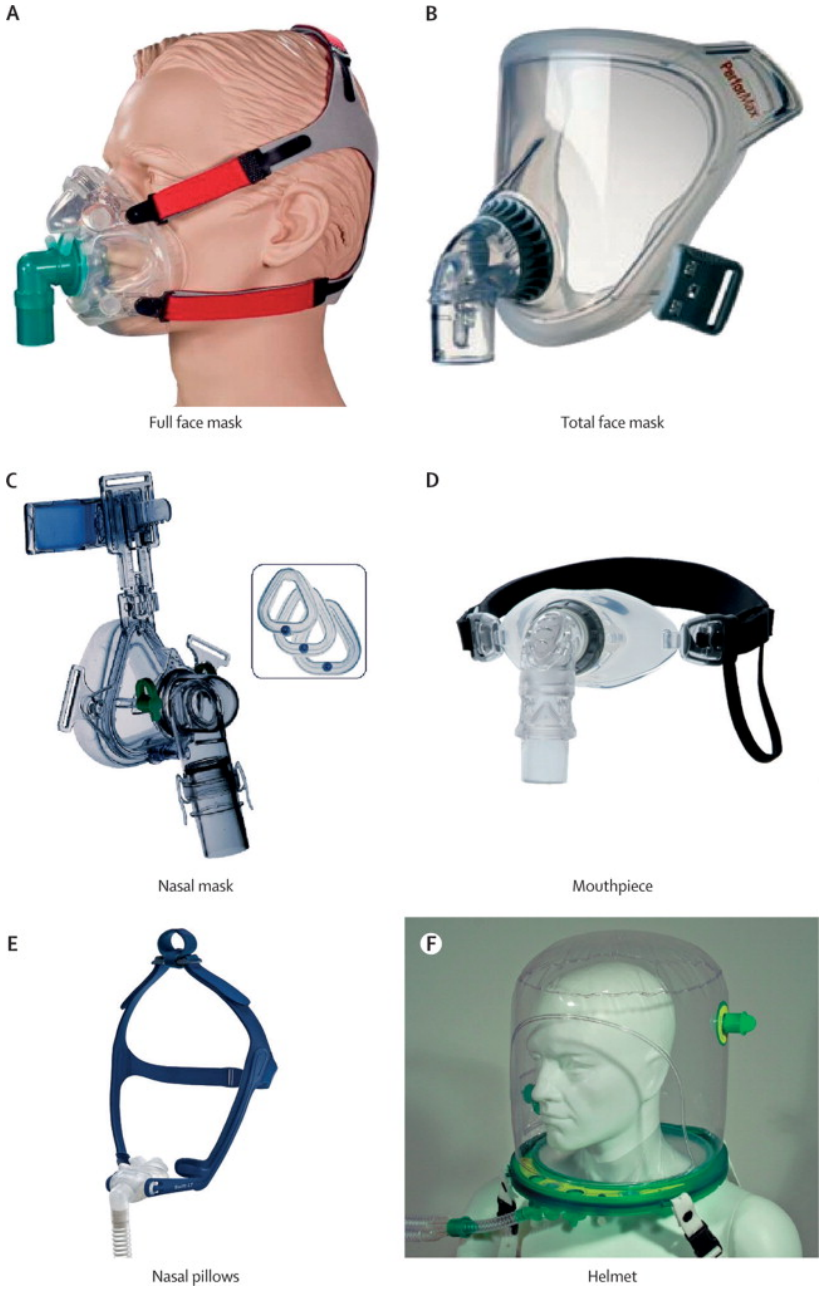

Figure 2. Interfaces used during NPPV treatment. Reprinted from The Lancet, 374, Stefano Nava & Nicholas Hill, Non-invasive ventilation in acute respiratory failure, 250-259, 2009, with permission from Elsevier.

Indications in Acute Care

Potential uses of NPPV in acute care settings include, but are not limited to, acute respiratory failure, cardiogenic pulmonary edema related to heart failure, prevention of re-intubation after extubation, and palliative care (Burns, 2011). Due to their chronic nature, obstructive sleep apnea or chronic respiratory failure will not be discussed in this thesis.

Recommendations set forth by the American Association of Critical Care Nurses (Burns, 2011), Aboussouan and Ricaurte (2010), and the Canadian Medical Association (Keenan et al., 2011) will be included for each indication. The guidelines sent by Keenan et. al (2011) uses a grading system to rate the effectiveness of NPPV in selected indications (1-2-no grade for strength of recommendation, A-D for level of quality). This grading system was created upon a meta-analysis of 146 randomized clinical trials. Similarly, the recommendations set by Aboussouan and Ricaurte (2010) are rated according to the strength of evidence for each indication from minimal to highly successful (option – guideline – recommended).

Acute Respiratory Failure due to COPD . Another common indication for NPPV in acute care settings is for ARF. It is reported that 30% of all patients admitted to the ICU receive MV due to ARF (Honrubia et al., 2005). Although there are various etiologies, the primary focus will be on ARF due to acute exacerbations of COPD.

Lightowler, Wedzicha, Elliott, and Ram (2003) conducted a meta-analysis of eight studies. These studies analyzed the effectiveness of NPPV (as an adjunct to conventional treatment) over conventional treatment (medications and controlled oxygen) to treat an acute exacerbation of COPD. Of the 529 total participants, approximately half received NPPV (n=268)

and the other usual medical care (n=261). Upon analysis, NPPV reduced the risk of intubation (p=.42, risk reduction of 58%) and complications (p=.32, risk reduction of 68%).

The guidelines set forth by Keenan et al (2011) strongly recommend (grade of 1A) the use of NPPV for ARF due to severe exacerbation of COPD as evidenced by a pH <7.35 and relative hypercarbia. This is further supported by the American Association of Critical Care Nurses (Burns, 2011) and Aboussouan & Ricaurte (2010).

Cardiogenic Pulmonary Edema. Often seen in patients with heart failure, cardiogenic pulmonary edema refers to a collection of fluid in the alveoli and interstitial spaces of the lungs as a result of left ventricular failure (Malone, 2011).

A study conducted by Nava et al. (2003) compared the outcomes of patients (n=130) receiving standard care (n=65) and NPPV via a facial mask (n=65). Although mortality and complication rates were insignificant between the two groups, when subdivided into hypercapnic patients ($PaCO_2$> 45 mmHg), standard care patients were more likely to be intubated than NPPV patients. Furthermore, the respiratory status of patients receiving NPPV improved faster than that of the standard care.

According to Keenan et al (2011), NPPV is strongly recommended for cardiogenic pulmonary edema (1A). This is further supported by the American Association of Critical Care Nurses (Burns, 2011) and Aboussouan & Ricaurte (2010).

Other Indications. Some of the other potential uses of NPPV in the acute care setting include, but are not limited to, prevention of reintubation, palliative care, status asthmaticus, and failure to wean. There has been mixed reviews about the safety and efficacy of NPPV use in

these situations due to the limited amount of research available (Burns, 2011; Keenan et. al, 2011; Aboussouan & Ricaurte, 2010).

Table 1 displays the recommendations for several indications for NPPV set forth by three sources.

Table 1. Indications for NPPV

Indication	American Association of Critical Care Nurses	Canadian Medical Association	Aboussouan & Ricaurte (2011)
ARF due to COPD	Yes	Yes (Grade 1A)	Recommended: use in ICU, RCU[1], & general ward.
Cardiogenic Pulmonary Edema	Yes	Yes (Grade 1A)	Recommended: ICU & RCU[1]
Prevention of Reintubation	Yes	No (Grade 2C),unless patient is receiving care on a specialized unit.	Option: ICU
Palliative Care	Yes	Not mentioned	Guideline: general ward & RCU[1]
Failure to Wean	Yes	No (Grade 2C)	Guideline: ICU & RCU[1]
Status Asthmaticus	No	No recommendations due to limited research	Option: ICU & RCU[1]

Footnote: 1. *RCU*, Respiratory Care Unit

Contraindications. Several studies have indicated that NPPV is not appropriate for patients with severe hypoxemia (PaO_2/FiO_2 <75), respiratory arrest, upper airway obstruction, severe acidemia, multi organ failure, recent airway surgery, or cardiac arrest (Aboussouan & Riccaurte, 2010).

Complications

Although many of the serious complications associated with MV are significantly reduced in NPPV, serious complications still occur with NPPV use, such as pulmonary barotrauma, aspiration pneumonia, and hemodynamic changes (Mehta & Hill, 2000). However, mask intolerance is the one of the most common complications of this treatment. Factors that contribute to intolerance include excessive air leakage through the mask, discomfort, and feelings of claustrophobia (Burns, 2011).

Nasal. Although nasal masks are one of the oldest interfaces used, they often lead to several complications. It is reported that 30-50% of patients using this interface experience mask discomfort with a smaller percentage experiencing a skin rash, nasal-bridge sores, and nasal obstruction (Gay, 2009).

Facial. Some of the complications reported for this interface are mask discomfort (30-50%), claustrophobia (10-20%), skin rash/nasal bridge sores (10-20%), and seldom, aspiration of vomit (Gay, 2009).

Physical. Ferrer, Esquinas, Leon, Gonzalez, Alarcon, and Torres (2003) analyzed the effectiveness of NPPV via a facial mask (n=51) over oxygen therapy (n=54) in patients admitted for severe hypoxemic respiratory failure. Some of the complications reported reported, due to use of a facial mask, were moderate nasal bridge ulceration (25%), conjunctivitis (6%), and gastric distention (2%).

Psychological. Torheim and Gjengedal (2009) analyzed the patient's experience with mask treatment. These patients (n=5) were admitted to critical care units due to acute exacerbations of COPD and received NPPV via mask interfaces. Upon analysis, some common themes shared among the patients included experiences of "anxiety, panic, and loss of control", "regaining control and trust due to skilled help", and the "experience of mobilizing willpower". These themes appear to have presented in a sequential matter, from the start of treatment ("loss of control" and "anxiety") to feeling comfortable with treatment ("regaining control") to terminating treatment ("mobilizing willpower").

Helmet. Although not approved for use in the United States, the helmet interface is used throughout Europe. One of the biggest complications reported is claustrophobia.

Dimech (2012) provides one of the few qualitative studies analyzing the experiences of patients (n=6) who underwent helmet NPPV in acute care settings for more than 12 hours at a time, had acute respiratory failure, and were able to survive their illness. The major themes found were “entrapment,” “confusion,” “helping me breathe,” “liberation,” and “trust”. The extent of each theme varied per patient due to their level of comfort with the helmet.

Between Interfaces. Several studies have been conducted to determine whether interface selection made a difference in treatment and further complications.

Oronasal vs. Nasal Mask. Kwok, McCormack, Cece, Houtchens, and Hill (2003) conducted a randomized controlled trial to determine whether oronasal or nasal masks made a difference in treatment. Patients with ARF (n=70) were divided equally into two groups: nasal or oronasal mask. Between the two groups, there were no significant differences in vital signs and improved gas exchange. However, patients in the nasal mask group were more likely to have mask intolerance than the facial mask group (p=.023).

Facial Mask vs. Helmet. Antonaglia et al. (2011) equally divided recently admitted patients with acute exacerbations of COPD (n=40) into two groups: mask and helmet. Patients in the mask group (n=20) received NPPV via a facial mask on admission. Patients selected for the helmet group (n=20) initially received NPPV via a facial mask on admission, but were later transitioned to the helmet interface after four hours. At the end of the study, it was determined that mask patients were more likely to be intubated than the helmet patients (45% to 10%, $p < 0.01$). However, helmet patients required longer ventilator assistance (89 hours to 62 hours, $p<0.01$) and longer lengths of stays (10 days to 7 days, $p<0.01$) than the mask patients. Rates of

sepsis, pneumonia, and metabolic complications were not significant between these two interfaces.

Role of the Nurse

Traditionally, the care for a patient receiving NPPV has mainly been the responsibility of the nurse and respiratory therapist. Although initiated by a physician, the nurse is responsible for the daily care of the patient, in terms of patient assessment, treatment of any complications, and patient education. A controversial topic, which should be noted later in this section, is the amount of time and effort the nurses are required to provide for the patients receiving NPPV.

Patient Assessment. A crucial component of caring for a patient receiving NPPV treatment is patient assessment. Patient comfort, level of conscious, work of breathing, gas exchange parameters, hemodynamic status, and ventilator parameters should be high priority when caring for these patients (Rose & Gerdtz, 2009). A thorough respiratory assessment should be completed by the nurse every shift to serve as a baseline to detect any respiratory distress (e.g. pneumothorax) (Burns, 2011).

Respiratory Distress. It is imperative for the nurse to watch for signs and symptoms of respiratory distress, such as increased respiratory rate, dyspnea, and the use of accessory muscles (Ho & Boyle, 2000). Treatment should be stopped immediately and a physician should be notified if this occurs.

Skin Breakdown. Skin underneath the edges of the mask should be assessed every 1 to 2 hours to detect any evidence of skin breakdown. If any breakdown should occur, a dressing should be placed on top of the affected skin or the straps should be loosened (Mehta & Hill, 2000).

Air Leakage. Occurring in 80-100% patients receiving NPPV, air leaks are a sign of an incorrectly sized mask (Mehta & Hill, 2000). The nurse should encourage the patient to close their mouth, use chinstraps, or change the interface.

Air Pressure Complications. The patient receiving NPPV might complain of nasal congestion, sinus pain, nasal/oral dryness, and eye irritation (Mehta & Hill, 2000). In an effort to prevent these complications, the best fitting interface should be initially selected. Nasal saline sprays further assists with nasal dryness, while humidification might assist with ensuring a tight-fit to prevent oral dryness (Parsons, Sole, & Byers, 2000).

Patient Education. In any situation, a fundamental nursing role is patient education. It is imperative to explain any procedure or medication given, such as NPPV, to the patient and their family. Unlike intubation where the patient is often unconscious, patients receiving NPPV are alert and oriented. With this, patient education becomes even more paramount to reduce anxiety for the patient. Education should be focused on discussing the reason for treatment, explaining the length of treatment, and signs of possible complications (Burns, 2011).

Timing. The extent of the nursing care (in terms of time spent) of a patient receiving NPPV has been a heavily debated topic. Several studies have debated whether the extended time necessary for patient care on NPPV is worth the benefit of the treatment.

A 1991 study published by Chevrolet, Jolliet, Abajo, Toussi, and Louis reported that patients receiving NPPV via a nasal mask (n=6) required more care and time from the nurse. Patients with no air flow obstruction (n=3) required less nursing care (41±9%) than patients with such obstruction (n=3, 91±9%), in terms of total length of treatment.

Hilbert et al. (2000) countered the claim presented by Chevrolet et al. (1991). After the first 24 hours of treatment, the time required to care for these patients was minimal (25% for acute exacerbation of COPD, 15% for patients with postextubation). Additionally, Honrubia et al. (2005) further supports this claim, stating that the nurse's workload is only increased during the initial 24 hours of treatment.

Discussion

Although extensively studied for its effectiveness over MV, there is much to be studied and analyzed to further understand the role of NPPV in the acute care setting, especially in terms of its indications, complications, and the role of the nurse.

Indications

Several studies have determined that patients with acute exacerbations of COPD or cardiogenic pulmonary edema due to heart failure are ideal candidates for NPPV treatment. The effectiveness for these two indications has been studied extensively. Furthermore, there is an abundance of studies comparing effectiveness of different NPPV modes (CPAP and BiPAP).

Throughout the years, several other indications for NPPV have been suggested for use, such as palliative care, post-extubation, or post-operative situations. For example, this treatment has often been utilized as palliative care to avoid sedation and unnecessary intubation. Minimal research has focused solely on this use. Questions of patient quality of life and risk of complications are paramount in determining its benefit.

A controversial indication for NPPV is status asthmaticus. Several sources indicate that NPPV is absolutely contraindicated for this condition. However, some do argue that the benefits of this treatment outweigh the potential complications. More research, in particular clinical trials, is necessary to determine the effectiveness of this treatment for this life-threatening condition.

Complications

Several of the complications associated with NPPV use have been identified, such as skin ulceration and gastric distention. These complications are often seen as minimal compared to the ones more often seen in MV, such as ventilator-associated pneumonia (VAP) and death.

However, some of the studies analyzed indicate that VAP, septic shock, and even death were potential complications of NPPV. In these studies, it is difficult to conclude whether NPPV alone triggered these complications or a confounding variable, such as inadequate patient selection, was involved.

The recommendations provided to treat these complications have been a result of clinical practice. There are no randomized clinical trials, in particular, that deal with which course of treatment is ideal to treat or prevent such complications. Is oral care necessary for these patients as with those on MV? Which interface should be initially chosen to minimize complications?

Oral Care. Several studies have concluded that an oral care bundle use (e.g. frequent mouth washing with chlorhexidine and endotracheal suctioning) minimizes the risk of ventilator-associated pneumonia for a patient on MV (Parsons & Sole, 2009). However, no studies analyzed, within the scope of this thesis, have associated the use of an oral care bundle to NPPV.

Interface Selection. A crucial component of NPPV treatment that should be further analyzed is the choice in interface. Several studies have reported that nasal masks are often the most troublesome, in terms of complications. When such complications do occur, it is suggested that the nurse change the interface to another one. However, the selection process of initially choosing an interface is not clearly defined. It is imperative to understand what factors contribute to the success of an interface, such as patient diagnosis, comorbidities, and laboratory values.

Role of the Nurse

The nurse plays a tremendous role in care of the patient receiving NPPV through patient education and assessment. However, a majority of studies analyzed within this thesis did not address these major nursing roles.

Nursing Research. Several studies have indicated that nursing practice for this treatment is based on the clinical experiences of previous healthcare professionals. These articles are often anecdotal and provide limited evidence-based practice. Furthermore, a majority of the clinical trials relating to NPPV are led by physicians, not including multi-disciplinary efforts.

Clinical Practice Guidelines. There is no standardized, systematic method to address the needs of these patients. Often presenting in the emergency department (ED), healthcare professionals, especially the nurse, must be able to identify the presenting clinical signs and symptoms to correctly identify a patient as a candidate for NPPV. Although the physician is responsible for initiating the course of treatment for the patient, it is important for the nurse to understand such conclusions.

Clinical practice guidelines, presented as algorithms, should be created for any healthcare professional to ultimately assist in deciding the best course of treatment for a patient presenting to the ED with respiratory distress. Sinuff, Cook, Randall, and Allen (2003) created such an algorithm to help guide healthcare professionals to determine the course of treatment for patients with ARF (as presented in figure 3, page 22). Another potential application for these algorithms might be to guide nursing practice for caring for patients with NPPV – from choosing the correct interface to addressing complications and its treatment.

Connection to Patients. The nurse-patient relationship is a crucial aspect of the success of NPPV treatment. Education is a major component to this care. However, no studies analyzed focused on the critical aspects of this education, such as identifying potential complications, treatment plan, and mechanism of NPPV.

Another aspect of this relationship that has been questioned is the increased nursing workload. The article written by Chevrolet et al. (1991) stated that NPPV should not be used because of its increased demand on nursing time. Further studies have stated the initial 24 hours of treatment are the most time consuming. If such an increase in nursing workload exists, should guidelines exist to guide staffing practice?

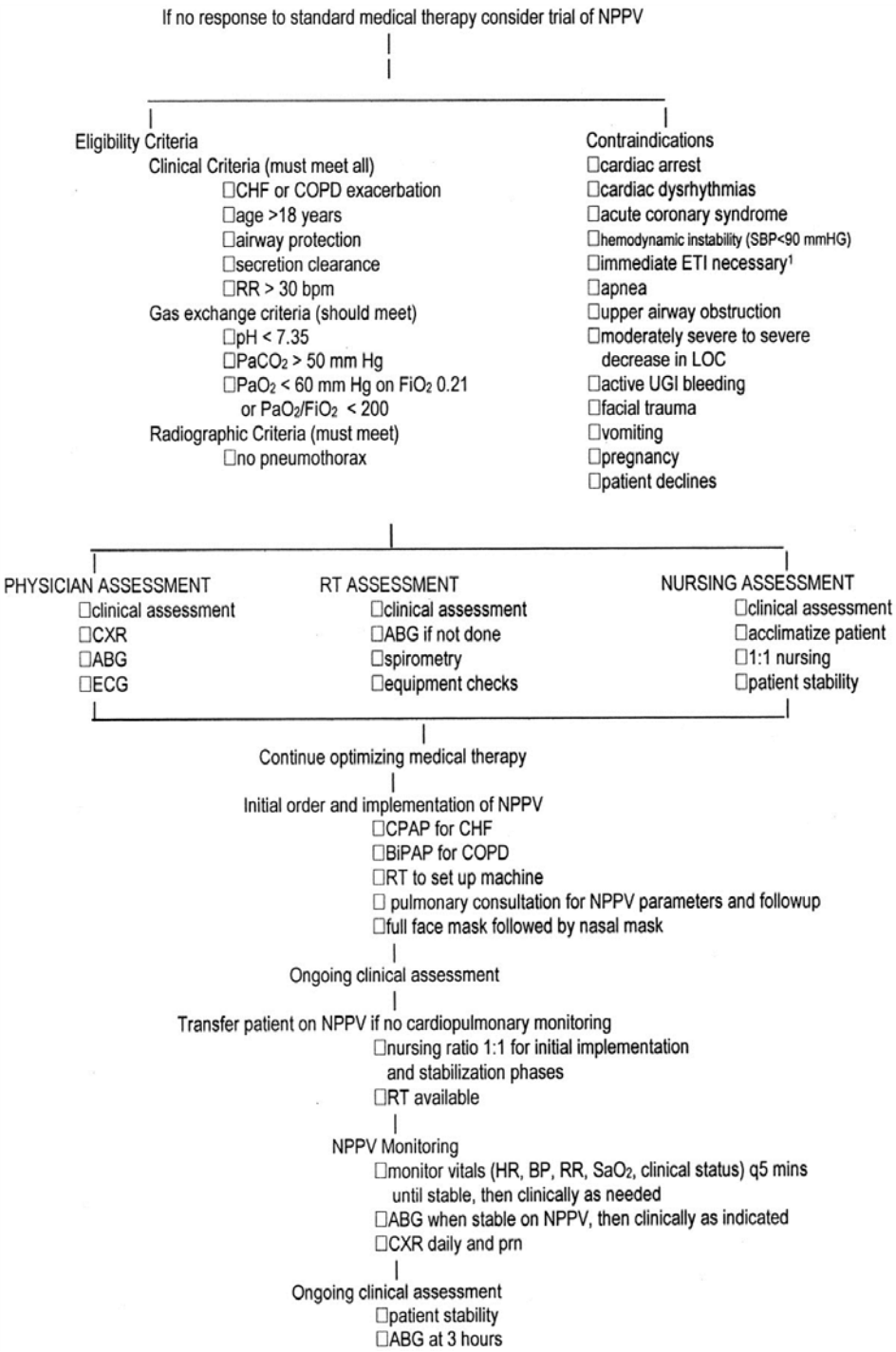

Figure 3. Example of Clinical Practice Guideline for COPD. Reprinted from CHEST, 123, Tasnim Sinuff, Deborah J. Cook, Jill Randall, & Christopher J. Allen, Evaluation of a practice guideline for noninvasive positive-pressure ventilation for acute respiratory failure, 2062-2073, 2003, with permission from American College of Chest Physicians.

Limitations

There was a limitation in the amount of articles available discussing the care of the patient receiving NPPV. A majority of articles found only discussed the effectiveness of NPPV over MV. These articles were published over fifteen years ago.

Interfaces

Few studies conducted analyzed the differences between the various interfaces used for this treatment. It is necessary to understand the complications associated with each interface to assist in the initial selection.

An aspect of NPPV treatment that has not been extensively studied is that of the patient experience often associated with the use of the mask and helmet interfaces. Limited literature exists to describe the patient's perception of this lengthy treatment and if any commonalities existed from one patient to another. Used for acute and chronic problems, it is imperative to understand any psychological complications that might arise from the extensive use of NPPV.

Role of the Nurse

Only three articles exclusively discussed the role of the nurse in NPPV treatment, such as patient education and assessment. These articles were often anecdotal in nature and provided clinical advice on the role of the nurse. Another limitation was the minimal amount of literature available written by nurses, especially in clinical trials. Nurses play a tremendous role in the care of a patient receiving NPPV.

Implications for Nursing Practice

Upon analysis of seventeen articles, this literature review provides several recommendations to advance future nursing research, education, and clinical practice. These recommendations only serve as a guide for future development into understanding the role of the nurse in caring for the NPPV patient.

Research

There is a minimal amount of research available discussing the role of the nurse in NPPV care. Further research is necessary to understand this role and the importance of patient care, in terms of staffing practices and prevention of complications.

There are no standardized guidelines available to assist nurses in this treatment process. Research should focus on analyzing different hospital NPPV protocols, if any exist. Rates of complications between these hospitals should be compared to create a standardized protocol for all hospitals. Through the creation of such protocols, patient outcomes will potentially be similar throughout the country.

Furthermore, the articles analyzed for this literature did not discuss patient care, such as if patients were allowed to take off the interfaces to eat or the necessity of oral care. Additional research will enable nurses to further understand the best evidence-based practice for care of these patients.

Finally, nurses and registered therapists, who serve as the main caregivers of these patients, should complete additional research on this topic or focus of their care should be included in physician-led studies. It is imperative to understand these healthcare personnel's perspective, in terms of patient care and outcomes.

Education

With these advances in research, there is a need to introduce these findings into nursing education, especially at the undergraduate level. With NPPV extending to the ED and general medical-surgical units, many of the healthcare personnel are novice nurses or have minimal experience with this treatment. It is necessary for all personnel, especially nurses and respiratory therapists, to have a basic understanding of how NPPV works and how to care for the patient with this treatment. Textbooks and educational materials should be available for all personnel to keep up on the advances in research in this field and any clinical recommendations.

Clinical Practice

With the advances of NPPV research, it is imperative to connect these findings to clinical practice. Focus groups and surveys should be utilized to understand the practices that best work within each hospital. With the standardized clinical guidelines created previously, hospitals will be able to gain feedback about the efficacy of these guidelines in clinical practice. Furthermore, there should be creation of patient education materials (pamphlets, videos, and posters) for these patients and their families. It is important to include the patient in this teaching, considering that they are conscious during the treatment.

Summary

NPPV is a safe alternative to MV for patients with respiratory distress. Indicated for several reasons, patients with acute exacerbations of COPD and cardiogenic pulmonary edema related to heart failure are more likely to have improvements in their respiratory status with less complications. Although noted for its decreased rates of complications, several complications still exist with NPPV use, such as skin ulceration and feelings of claustrophobia. It is imperative for the nurse to thoroughly assess the patient receiving NPPV, noting any potential complications, and educating the patient and their family about the course of treatment.

Appendix: Tables of Evidence

Table 2. Clinical Practice Guidelines

Article	Participants & Study Design	Intervention Details	Outcome Measures	Results/Key Findings	Relevance/Implications
Keenan, S.P., Sinuff, T., Burns, K.E., Muscedere, J., Kustsogiannis, J., Cook, D.J., ... Dodek, P. (2011). Clinical practice guidelines for the use of noninvasive positive-pressure ventilation and noninvasive continuous positive pressure in the acute care setting. *CMAJ, 183(3), 195-213.*	Meta-analysis of articles discussing NPPV in acute care settings to create clinical practice guidelines by a group of 15 physicians and 3 respiratory therapists.	None specified, meta-analysis	Determination of GRADE methodology (with one numeric grade: 1=strong, 2=weak, no grade = no recommendation; and one letter grade: A=high quality, B=moderate, C=low, D=very low) to rank the efficacy of each form of NPPV and its indications in acute setting.	Situations that are ideal for the use of NPPV (receiving GRADE of 1A) are during severe exacerbations of COPD and cardiogenic pulmonary edema (when compared to standard therapy). However, insufficient evidence exists for the use of NPPV in asthma exacerbations, chest trauma, and post-operative settings.	The use of NPPV in severe exacerbations of COPD and cardiogenic pulmonary edema are clearly recommended. Much more research, in particular randomized clinical trials, is needed to further explore other uses of NPPV in the acute care setting.
Sinuff, T., Cook, D.J., Randall, J., & Allen, C.J. (2003). Evaluation of a practice guideline for noninvasive positive-pressure ventilation for acute respiratory failure. *CHEST*, 123, 2062-2073.	Retrospective/ prospective study analyzing the effectiveness of a NPPV practice guideline, in which a total of 189 patients were enrolled and divided into two groups: pre-guideline (n=91) and post-guideline (n=98).	Pre-guideline group (n=91) received standard care prior to the creation of practice guideline and post-guideline group (n=98) receive care in adherence to newly created practice	Determining intubation rates and mortality rates between the two groups.	Between the two groups, there were no differences in the intubation rates. However, the mortality rates of patients in the pre-guideline group were higher than the post-guideline (p= 0.037). Furthermore, more patients in the post-guideline group were transferred to the ICU for improved monitoring (65% to 35% in the pre-guideline group).	Creating a practice guideline for NPPV improves patient monitoring (ICU) and healthcare professional adherence. However, further research is necessary to see if the benefits of transferring such patients to the ICU is greater than the risks.

Table 3. Clinical Trial

Article	Participants and Study Design	Intervention Details	Outcome Measures	Results/Key Findings	Relevance And Implications
Antonaglia, V., Ferluga, M., Molino, R., Lucangelo, U., Peratoner, A., Roman-Pognuz, E., …Zin, W.A. (2011). Comparison of noninvasive ventilation by sequential use of mask and helmet versus mask in acute exacerbation of chronic obstructive pulmonary disease: A preliminary study. *Respiration, 82, 148-154.*	Patients admitted with severe exacerbation of COPD (n=40) were randomized after 2h of NPPV by mask into 2 groups: mask (n=20) and helmet (n=20).	Mask group (n=20) continued to receive NPPV via initial mask used at admission, while helmet group (n=20) transitioned from mask to helmet use.	Determining intubation rates and its causes (impaired gas exchange or intolerance), length of stay, and any complications associated with either intervention.	Mask (n=20) patients were more likely to be intubated than the helmet group (45% to 10%, $p<0.01$). However, helmet (n=20) patients required longer ventilator assistance (89h to 62h, $p<0.01$) and averaged longer length of stays (10 to 7, $p<0.01$). Rates of sepsis, pneumonia, and metabolic complications were not significant for these interventions.	Complications between mask and helmet use are not determining factor in choosing a NPPV interface. Research is necessary to determine the factors that cause mask intolerance and interventions that could be done to prevent incidence of such intolerance.
Chevrolet, J.C., Jolliet, P., Abajo, B., Toussi, A., & Louis, M. (1991). Nasal positive pressure ventilation in patients with acute respiratory failure. Difficult and time-consuming procedure for nurses. *Chest,100, 775-782.* doi:10.1378/chest.100.3.775.	Prospective study of patients (n=6) who were not eligible for MV, instead received NPPV.	All patients received NPPV via nasal mask on a positive-pressure ventilation designed for long-term home ventilation (PEEP, 0 cm H_2O; assist-control mode; I/E ratio 1:3).	Determining the indications for success in NPPV use as well as the time spent caring for these patients on healthcare professionals, in particular, the nurse.	Patients with no air flow obstruction (n=3) required less nursing care, in terms of percent of total time (41 ± 9%). Patients with air flow obstruction (n=3) required more nursing care (91±9%).	Patients receiving NPPV with obstructive respiratory conditions require more nursing time than those without such obstruction.

Article	Participants and Study Design	Intervention Details	Outcome Measures	Results/Key Findings	Relevance And Implications
Hilbert, G., Gruson, D., Vargas, F., Valentino, R., Portel, L., Gbikpi-Benissan, G., & Cardinaud, J.P. (2000). Noninvasive ventilation for acute respiratory failure. Quite low time consumption for nurses. *European Respiratory Journal, 16, 710-716.*	Prospective study of COPD patients (n=100) divided into 2 groups based on diagnosis: acute exacerbation of COPD (pH <7.35) (n=58) and postextubation hypercapnic respiratory insufficiency after weaning from MV (n=42).	All patients received NPPV via full face mask. Acute exacerbation patients (n=58) used BiPap ventilator, while hypercapnic patients (n=42) used same ventilator used for weaning from MV. Nurses were asked to record time spent caring for each patient on a grid.	Determining the time spent caring for these patients on nurses.	Patients receiving NPPV in either group required minimal amounts of time spent by the nurse during the first 24h of initiating NIMV treatment (acute exacerbation = 25%; postextubation hypercapnic = 15%).	The time spent caring for patients with NPPV is not as high as once reported in Chevrolet, Jolliet, Abajo, Toussi, & Louis (1991).
Hilbert, G., Gruson, D., Vargas, F., Valentino, R., Portel, L., Gbikpi-Benissan, G., & Cardinaud, J.P. (2000). Noninvasive ventilation for acute respiratory failure. Quite low time consumption for nurses. *European Respiratory Journal, 16, 710-716.*	Prospective study of COPD patients (n=100) divided into 2 groups based on diagnosis: acute exacerbation of COPD (pH <7.35) (n=58) and postextubation hypercapnic respiratory insufficiency after weaning from MV (n=42).	All patients received NPPV via full face mask. Acute exacerbation patients (n=58) used BiPap ventilator, while hypercapnic patients (n=42) used same ventilator used for weaning from MV. Nurses were asked to record time spent caring for each patient on a grid.	Determining the time spent caring for these patients on nurses.	Patients receiving NPPV in either group required minimal amounts of time spent by the nurse during the first 24h of initiating NIMV treatment (acute exacerbation = 25%; postextubation hypercapnic = 15%).	The time spent caring for patients with NPPV is not as high as once reported in Chevrolet, Jolliet, Abajo, Toussi, & Louis (1991).

Article	Participants and Study Design	Intervention Details	Outcome Measures	Results/Key Findings	Relevance And Implications
Honrubia, T., Garcia Lopez, F.J., Franco, N., Mas, M., Guevara, M., Daguerre, M., Alia, I., Algora, A., & Galdos, P. (2005). Noninvasive vs. conventional mechanical ventilation in acute respiratory failure: A multicenter, randomized controlled trial. *Chest*, 128, 3916-3294. doi:10.1378/chest.128.6.3916	A randomized, multicenter, controlled trial, patients (n=64) in 7 ICUs with ARF and met 3 of the following criteria ($FiO_2 \leq 170$; RR ≥ 35; blood pH < 7.30, 3-5 score on Kelly scale of neurologic dysfunction, and score >3 on modified scale of accessory respiratory muscle use) were randomized into 2 groups: NPPV (n=31) or endotracheal intubation and MV (n=33)	NPPV (n=31) was applied via face mask (mode: PS plus PEEP). PEEP was administered between 5 and 10 cm H_2O, continuously for 1st 6h. MV (n=33) was administered following hospital protocol (sedation: n=32)	Determining intubation avoidance in the NPPV group compared to the MV group. Furthermore, determining the relevance of clinical complications, length of nursing workload, and factors that determine failure of NPPV in ICUs were analyzed.	Approximately 58% of the patients in the NPPV group required subsequent MV. In terms of complications, 52% of NPPV patients experienced at least one, while 70% of MV. No differences were found comparing the nursing workload for caring for a patient in either group. Pneumonia and RR >35 were crucial indicators of NPPV failure.	The use of NPPV reduces the need of intubation and its possible complications in the ICU. Pneumonia continues to be a major factor in determining the success of NPPV.
Kwok, H., McCormack, J., Cece, R., Houtchens, J., & Hill, N.S. (2003). Controlled trial of oronasal versus nasal mask ventilation in the treatment of acute respiratory failure. *Critical Care Medicine*, 31(2), 468-478.	A randomized, controlled trial, acute respiratory failure patients (n=70) who met study criteria (clinical: worsened dyspnea, RR>24 breaths per minute, & use of accessory muscles for breathing or blood gas values of pH<7.35, >45 mmHg, or PaO_2/FiO_2 ratio <200) were equally divided into two groups: nasal or facial mask	Patients were given a nasal or facial mask at time of admission. For all patients, the ventilator mode was CPAP 10 cm H_2O or BiPAP 11-12 cm H_2O inspiratory pressure and 4 cm H_2O expiratory pressure .	Determining mask intolerance, H, RR, respiratory rates, and intubation rates for patients in each group.	Mask intolerance was higher in the nasal than the facial group (12 vs. 4, p=0.32). There were no significant differences in success rates (65.7% to 48.6%), intubation rates, or mortality between the two groups (facial to nasal).	Mask intolerance is one of the major differences between nasal and facial masks. More research is necessary to determine mask intolerance between other interfaces and what factors contribute to the high rates of nasal mask intolerance.

Article	Participants and Study Design	Intervention Details	Outcome Measures	Results/Key Findings	Relevance And Implications
Nava, S., Carbone, G., DiBattista, N., Bellone, A., Baiardi…& Groff, P. (2003). Noninvasive ventilation in cardiogenic pulmonary edema: A multicenter randomized trial. *American Journal of Respiratory Critical Care Medicine*, 168, 1432-1437.	A randomized, multicenter trial, patients with cardiogenic pulmonary edema (n=130) who met study criteria (severe ARF, dyspnea of sudden onset, RR > 30 breaths/minute) were divided into two groups: control (n=65) and NPPV (n=65).	The control group (n=65) received standard medical care (e.g. medications) plus oxygen. The NPPV group (n=65) used a full face mask (PEEP set at 5 cm H_2O initially, while inspiratory pressure was at 10 cm H_2O).	Determining the rates of intubation, in-hospital mortality, and changes in physiological variables between the two groups.	No significant differences existed between the two groups in terms of intubation, in-hospital mortality, and changes in physiological variables. However, when the groups were subdivided, control group patients who had a $PaCO_2$ >45mmg were more likely to be intubated than the NPPV group (p=0.015)	Hypercapnic patients receiving standard care were more likely to be intubated. NPPV helps to improve respiratory rate, dyspnea, and improvement in $PaCO_2$.

Table 4. Descriptive Studies

Article	Participants and Study Design	Intervention Details	Outcome Measures	Results/Key Findings	Relevance And Implications
Dimech, A. (2012). Critical care patients' experience of the helmet continuous positive airway pressure. *Nursing in Critical Care*, 17(1), 36-43.	Qualitative design based on descriptive phenomenological methodology. Interviews were given to patients (n=6), who required helmet CPAP >12h daily, survived their critical illness, and had acute RF.	Interviews were conducted away from the critical care setting, in a relative's house and lasted no more than one hour.	Determining characteristics descriptive of patient's experience using helmet CPAP.	Some of the common themes found among the patients (n=6) about their experience were *entrapment, confusion, helping me breathe, trust,* and *liberation.*	It is imperative to further understand the psychological implications of helmet CPAP and the other interfaces used for NPPV.
Torheim, H. & Gjengedal, E. (2009). How to cope with the mask? Experiences of mask treatment in patients with acute chronic obstructive pulmonary disease-exacerbations. *Scandinavian Journal of Caring Sciences*, 24, 499-506.	Qualitative design based on descriptive phenomenological methodology. Patients (n=5) were admitted to hospital to receive NPPV due to an acute exacerbation of COPD. Nurses (n=8) were experienced with this treatment.	Interviews were given to patients a few days after treatment ended and group of 8 nurses were interviewed during a focused session	Determining characteristics descriptive of patient's experience using mask interface and the factors that nurses believe are essential for treatment success.	Three themes common between all five patients' experiences were: *anxiety, panic and loss of control; regaining control and trust through skilled help*; and *a mobilization of willpower.* Some of the issues mentioned within the nurses (n=8) are individualizing needs, time is vital during this treatment, and experience equates to competence.	There are psychological issues that arise after extended NPPV use. It is necessary for nurses to be aware of these issues.

Table 5. Literature Review

Article	Participants and Study Design	Intervention Details	Outcome Measures	Results/Key Findings	Relevance And Implications
Amboussouan, L.S. & Ricaurte, B. (2010). Noninvasive positive pressure ventilation: Increasing use in acute care. *Cleveland Clinical Journal of Medicine, 77(5), 307-314.*	Literature Review.	None specified. Literature review.	Over the past 20 years, NPPV has increased in use in acute care settings.	Based on analysis of this article, NPPV is indicated for several reasons in the acute care settings (e.g. acute respiratory failure, acute exacerbations of COPD, and cardiogenic pulmonary edema).	With its increase in use, it is crucial to understand the several indications for NPPV and their success rates.
Bambi, S. (2009). Noninvasive positive pressure ventilation: An abc approach for advanced nursing in emergency departments and acute care settings. *Dimensions of Critical Care Nursing, 28(6), 253-263.*	Literature Review.	None specified. Literature review.	Determining factors of NPPV success to create a standardized nursing checklist.	Critical determinants for success of NPPV treatment checklist include airway, breathing, circulation, disability, drainages, exposure, examinations, emotional and education, extensive clinical documentation, family, and guiding the patient until the end of ED path.	Through creating a standardized nursing checklist, it will provide a protocol for nurses to follow when initiating NPPV to identify any possible complications early on.
Ho, R.P. & Boyle, M. (2000). Non-invasive positive pressure ventilation in acute respiratory failure: Providing competent care. *Australian Critical Care, 13(4), 135-143.*	Literature Review.	None specified. Literature review.	Determining the rate in use of NPPV in acute care settings and its complications to apply to nursing care considerations.	Based on analysis of this article, the use of NPPV in acute care has increased. Several of the articles reported lower mortality rates and endotracheal intubation for NPPV patients. Indicators of failure of NPPV were discussed, such as inability to clear secretion and increasing hypercarbia.	Nurses should be attune to completing a thorough patient assessment, being aware of treatment complications,

Article	Participants and Study Design	Intervention Details	Outcome Measures	Results/Key Findings	Relevance and Implications
Parsons, C.L., Sole, M.L., & Byers, J.F. (2000). Noninvasive positive-pressure ventilation: Averting intubation of the heart failure patient. *Dimensions of Critical Care Nursing, 19(6), 18-24.*	Literature Review.	None specified. Literature review.	Limited research exists discussing the use of NPPV in managing heart failure.	Based on analysis of this article, NPPV provides an option in treating acute respiratory distress in heart failure patients. It is stated that much research must be done to test the effectiveness of NPPV over pharmacological therapies, individually and collectively. Furthermore, the different forms of NPPV and its indications must be studied further.	NPPV provides an option to avoid intubation in acute distress of heart failure patients presenting to the emergency department.
Rose, L. & Gerdtz, M.F. (2009). Review of non-invasive ventilation in the emergency department: Clinical considerations and management priorities. *Journal of Clinical Nursing, 18, 3216-3224.*	Literature Review.	None specified. Literature review.	Determine the indications for use of NPPV, creation of strategies to prevent its complications, and determine the role of the nurse in caring for a patient with NPPV.	Upon analysis of 37 articles, terminology used to describe NPPV was unclear. However, there are various modes available to deliver such ventilation. In terms of nursing practice, NPPV must be used with caution due to the increased workload. There is little evidence to guide staffing decisions.	The role of NPPV in the ED must be explored further. The balance of increased workload and benefits must be analyzed.

Table 6. Meta-Analysis

Article	Participants and Study Design	Intervention Details	Outcome Measures	Results/Key Findings	Relevance and Implications
Lightowler, J.V., Wedzicha, J.A., Elliott, M.W., & Ram, F.S. (2003). Non-invasive positive pressure ventilation to treat respiratory failure resulting from exacerbations of chronic obstructive pulmonary disease: Cochrane systematic review and meta-analysis. *BMJ, 326 (185), 1-5.*	Meta-analysis of 8 different controlled clinical trials studies (n=529) in which participants (diagnosis of acute exacerbation of COPD) were divided into 2 groups: NPPV (n=268) and control (usual medical care, n=261).	NPPV group (n=268) received NPPV through nasal or facial mask in additional to conventional medical care, while the control group (n=261) received solely conventional care (e.g. pharmacotherapy, tracheal intubation)	Determine whether NPPV should be the first line of care for patients with acute exacerbations of COPD in the acute care setting, in terms of failure, mortality, improvement within 1 hour of treatment, and need for intubation.	When comparing NPPV to conventional medical care, the relative risk for treatment failure was 0.51, mortality 0.41, intubation 0.42, and complications 0.32 (95% confidence interval).	Using NPPV in addition to usual medical care provides fewer complications and greater improvement in patient respiration within the first hour than compared to conventional medical care.

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