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# Oxygen saturation/fraction of inspired oxygen ratio is a simple predictor of noninvasive positive pressure ventilation failure in critically ill patients☆

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**Abstract**

**Purpose:** Noninvasive positive pressure ventilation (NPPV) can improve outcomes of critically ill patients. Early and simple predictors of NPPV outcome could improve clinical management of patients with respiratory failure.

**Materials and methods:** A prospective observational study was conducted in a medical intensive care unit of a tertiary medical center. Patients requiring NPPV were included and followed. Clinical data including respiratory mechanics at the time of NPPV initiation, and clinical outcomes were recorded. Data were analyzed to identify variables that distinguished NPPV success or failure.

**Results:** A total of 133 patients were included in the study. Noninvasive positive pressure ventilation success rate was 41%. Patients diagnosed with malignancy had only 29% NPPV success rate. Among patients without malignancy, higher oxygen saturation, oxygen saturation/fraction of inspired oxygen (SF) ratios, and SF/minute ventilation ratios were associated with NPPV success. Receiver operating characteristic curve analyses identify SF ratio less than 98.5 to be a specific (89% specificity, $P = .013$) predictor of NPPV failure. Furthermore, for patients requiring at least 24 hours of NPPV support, tidal volume/predicted body weight ratio negatively correlated with respiratory improvement.

**Conclusions:** For patients without malignancy, SF ratios at the time of NPPV initiation discriminated NPPV success and failure, and could be used to help guide the management of critically ill patients who require ventilatory support.



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## 1. Introduction

Mechanical ventilation is an essential component of critical care for patients with acute respiratory failure. However, several aspects of invasive mechanical ventilation can detrimentally impact clinical outcomes. Complications of invasive mechanical ventilation include ventilator-associated pneumonia, increased sedation use, and mechanical trauma of the upper airway [1-3]. Noninvasive positive pressure ventilation (NPPV) has received increasing consideration in the intensive care unit (ICU) because of the potential benefits over invasive ventilatory support. Randomized controlled studies have offered support for the use of NPPV in patients with chronic obstructive pulmonary disease (COPD) [4] and in the immunocompromised hosts [5]; however, the use of NPPV in a more general population of patients with acute respiratory failure is less certain with several reports having suggested that patients with hypoxemic respiratory failure are less likely to benefit from NPPV [1,6,7]. Therefore, predictors of NPPV success would be valuable in selecting patients who would more likely benefit from NPPV. Other investigators have identified $Pa_{O_2}$/fraction of inspired oxygen ($F_{IO_2}$) ratio, various injury severity scores, acidemia, and temporal changes of physiologic variables as predictors of NPPV outcomes [8-10]; however, these parameters require invasive and/or extended periods of monitoring and observations. We conducted a prospective observational study to identify noninvasive parameters at the time of NPPV institution that can serve as predictors of NPPV outcomes in the intensive care setting.

## 2. Methods

### 2.1. Study design

All patients with respiratory failure receiving NPPV support in the medical ICUs at the Brigham & Women's Hospital between May 2007 and March 2009 were included in the study. Routine practice in our ICU is that the respiratory therapists select the mask type or interface, and the initial NPPV settings aiming to provide adequate support. Subsequently, the therapist records respiratory mechanics, including exhaled tidal volumes, and ventilator settings from the ventilator (Vision BiPAP, Respironics, Murrysville, Pa) every 4 hours. The ventilator system was humidified by Fisher & Paykel 850 humidifier (Fisher & Paykel Healthcare, Irvine, Calif) with heated wire. Initial data after NPPV initiation and stabilization (typical lasting several minutes) were used for this study. Patient demographics, vital signs, clinical data, and outcomes were extracted from medical records. Clinical management of the patient was entirely made by the caring physicians without any influence by this observational study; therefore, the decisions to initiate NPPV or to intubate patients were entirely based on clinical judgments of the caring physicians. The study was approved by the Brigham & Women's Hospital Institutional Review Board, Partners Human Research Committee with waived informed consents because the study was strictly observational without any impact to clinical care and in compliance with the Helsinki Declaration.

### 2.2. Classification

Diagnosis of COPD and malignancy was determined from medical records. Immunocompromised states were defined as active immunosuppressant therapy (eg, prednisone at >5 mg/d), diagnosis of malignancy, or positive HIV test.

NPPV success was defined as surviving ICU discharge without invasive mechanical ventilatory support. Cases not meeting these criteria were classified as NPPV failure.

### 2.3. Statistics

Preselected parameters for analysis were oxygen saturation % ($O_2$ Sat), tidal volume in milliliters without and with predicted body weight in kilograms (PBW) correction (TV and TV/PBW), respiratory rate (RR) per minute, minute ventilation in liters (MV), and inspiratory and expiratory positive airway pressures in centimeters of water (IPAP and EPAP). Preselected combination variables for analysis were $O_2$ Sat /$F_{IO_2}$ (SF) ratio, SF/MV ratio, RR/TV (L) ratio, and SF/EPAP ratio. For patients with multiple ICU admissions and NPPV initiations, only the initial admission was considered.

Summary data are presented as mean ± SD where appropriate. Differences between groups were compared with the $\chi^2$ test for dichotomous variables and the Student $t$ test for continuous variables. Logistic regression was performed to identify factors correlating NPPV outcomes in univariate and multivariate analyses (SAS version 8.0, SAS Institute, Cary, NC). Receiver operating characteristic curve analyses were performed using Prism 4 (GraphPad Software, La Jolla, Calif). $P < .05$ was considered significant.

## 3. Results

### 3.1. Patient characteristics

A total of 133 patients were included in the study. The general characteristics of these patients are summarized in Table 1.

Our study population spent almost half of the initial 24-hour period on NPPV (average, 13 hours) and only 41% of our patients improved on NPPV compared to the 70% NPPV success rate reported by a large multicenter ICU study [9]. The high failure rate in our study was likely reflecting