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Original Research

CRITICAL CARE

Use and Outcomes of Noninvasive Positive Pressure Ventilation in Acute Care Hospitals in Massachusetts

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Background: **This study determined actual utilization rates and outcomes of noninvasive positive pressure ventilation (NIV) at selected hospitals that had participated in a prior survey on NIV use.**

Methods: **This observational cohort study, based at eight acute care hospitals in Massachusetts, focused on all adult patients requiring ventilatory support for acute respiratory failure during predetermined time intervals.**

Results: **Of 548 ventilator starts, 337 (61.5%) were for invasive mechanical ventilation and 211 (38.5%) were for NIV, with an overall NIV success rate of 73.9% (ie, avoidance of intubation or death while on NIV or within 48 h of discontinuation). Causal diagnoses for respiratory failure were classified as (I) acute-on-chronic lung disease (23.5%), (II) acute de novo respiratory failure (17.9%), (III) neurologic disorders (19%), (IV) cardiogenic pulmonary edema (16.8%), (V) cardiopulmonary arrest (12.2%), and (VI) others (10.6%). NIV use and success rates for each of the causal diagnoses were, respectively, (I) 76.7% and 75.8%, (II) 37.8% and 62.2%, (III) 1.9% and 100%, (IV) 68.5% and 79.4%, (V) none, and (VI) 17.2% and 60%. Hospital mortality rate was higher in patients with invasive mechanical ventilation than in patients with NIV (30.3% vs 16.6%, $P < .001$).**

Conclusions: **NIV occupies an important role in the management of acute respiratory failure in acute care hospitals in selected US hospitals and is being used for a large majority of patients with acute-on-chronic respiratory failure and acute cardiogenic pulmonary edema. NIV use appears to have increased substantially in selected US hospitals over the past decade.**

Trial registry: **ClinicalTrials.gov; No.: NCT00458926; URL: www.clinicaltrials.gov**

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Abbreviations: ARF = acute respiratory failure; CHF = congestive heart failure; CPE = cardiogenic pulmonary edema; DNI = do not intubate; DNR = do not resuscitate; ETI = endotracheal intubation; INV = invasive mechanical ventilation; NIV = noninvasive positive pressure ventilation; PNA = pneumonia; SAPS = Simplified Acute Physiology Score

Use of noninvasive positive pressure ventilation (NIV) as a first-line therapy for acute respiratory failure (ARF), especially that associated with exacerbations of COPD, acute cardiogenic pulmonary edema (CPE), and immunocompromised states, is increasing worldwide.[1-10] Due to the lack of information on NIV use in the United States, we performed a survey in 2002 and 2003 of utilization patterns in acute care hospitals in Massachusetts and Rhode Island.[11] The overall average estimated utilization rate was 20%, but it varied considerably between hospitals from none to > 50%. A substantial number of hospitals (42%) were considered as low NIV utilizers (< 15% of ventilator starts).

In the present study, we sought to establish more accurate rates for utilization, success, and mortality for NIV in the United States, based not on practitioners' estimates of use in response to questionnaires, but rather via on-site data collection at selected hospitals that participated in our previous survey. We hypothesized that overall use has increased because of the accumulating evidence for the efficacy of NIV. We

prospectively identified patients started on ventilators at selected Massachusetts hospitals that were low utilizers of NIV in our previous study.

Materials and Methods

Study Centers

Eight of 76 medical centers from our prior survey[11] were selected based on their willingness to participate, distance < 90 miles from Boston, and ability to provide a mix of teaching and nonteaching hospitals. The institutional review boards of participating institutions approved the study (Tufts ID #7642) and waived the need for patient consent because it was observational only. Characteristics of the eight acute care hospitals are presented in Table 1. Participating hospitals were estimated to have NIV utilization rates < 15% at the time of the prior survey.

Patients

Patients were enrolled prospectively at each institution during sequential 3-month data collection periods between January 1, 2004, and August 3, 2007. All adult patients receiving ventilator assistance in the form of NIV (CPAP or pressure support ventilation and positive end expiratory pressure) or invasive mechanical ventilation (INV) at any time throughout their hospitalization were screened.

Screened patients were included if they required ventilator support for ARF. Exclusions were as follows: long-term use of NIV without an acute deterioration, initiation of endotracheal intubation (ETI) or NIV prior to admission, use of INV for surgery or procedures only, or presence of a tracheotomy. In each hospital, a respiratory therapist prospectively enrolled each patient and completed a standardized data form. Patients were then followed for up to 30 days after enrollment or until they died, whichever occurred first.

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Table 1—*Characteristics of Participating Hospitals*

Hospital	Type	No. of ICU Beds	No. of Hospital Beds	ED Annual Visits in Thousands
T1	T	62	496	129
T2	T	46	382	47
C1	NT	26	220	58
C2	NT	12	155	55
C3	NT	14	210	45
C4	NT	12	182	55
C5	NT	10	157	35
C6	T	10	200	45
Total	…	192	2,002	469

C = community; NT = nonteaching; T = teaching.

Data Collection

Respiratory therapists recorded the following pertinent information at the time of enrollment: time of initiation, equipment applied, and patient demographics and characteristics. Investigators filled in any missing information post hoc by reviewing medical records on-site and recording duration of use, diagnoses, complications, and clinical outcomes. Investigators also reviewed respiratory therapy department billing records to ascertain that no qualifying ventilator starts were missed.

The main indications for ventilatory support were classified into six groups according to etiology of ARF using a system modified from Demoule et al[9]: group I, acute-on-chronic lung disease (ie, COPD, asthma, OSA syndrome); group II, de novo ARF (ie, pneumonia [PNA] and acute lung injury/ARDS); group III, CPE; group IV, ARF associated with neurologic diseases; group V, cardiopulmonary arrest; and group VI, others (ie, postoperative, massive trauma, burns, sepsis, and other cardiac).

Outcome Variables

The primary outcome was the utilization rate of NIV as a percentage of all ventilator starts to treat ARF. The success rate of NIV and in-hospital mortality rates were secondary outcomes. Success was defined as avoidance of ETI or death during use of NIV or the subsequent 48 h, including patients discontinued because of improvement or intolerance, and patients discharged on NIV or still using NIV on day 30. Failure was defined as ETI or death during NIV application or within 48 h of discontinuation.

Statistical Analysis

Statistical analysis was performed using SPSS statistical analysis software, version 12.0 (IBM). Utilization, success, and 30-day hospital mortality rates were calculated based on all patients placed on ventilators for acute respiratory problems, but most patients in categories IV (neurologic) and V (cardiac arrest) and some in VI (others) were intubated primarily for airway protection (n = 189). Although these were included for calculation of NIV utilization rates to render our data comparable with that of Demoule et al,[9] they were also analyzed separately to compare characteristics of subgroups. Two-tailed standard statistical analyses were used when appropriate. Median or Kruskal-Wallis tests were carried out to compare baseline characteristics between the NIV and INV groups (Table 2). The χ^2 test was used for categorical data when appropriate. Data are ± interquartile range unless otherwise specified. A P value of $< .05$ was considered significant.