
Noninvasive Mechanical Ventilation in Patients with Acute Respiratory Failure Due to Pandemic Influenza A(H1N1) Virus

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Keywords

Respiratory Failure • Pandemic H1N1 influenza • Non-invasive ventilation

16.1 Introduction

Pandemic influenza A (PA-H1N1) is a new strain of influenza virus that was first identified in Mexico and United States during the early part of 2009. The PA-H1N1 virus originated from the swine influenza (H1) virus circulating in North American pigs.

Animal studies have shown that the novel influenza virus caused increased morbidity and replicated to high titers in lung tissue, explaining its pathogenicity and capacity to invade the lower respiratory tract in humans and resulting in rapid and fulminant respiratory failure.

About 30–40 % of severe cases globally have occurred in previously healthy children and adults, usually under the age of 50 years. Patients with severe disease present with fever, cough, dyspnea, respiratory distress, increased serum lactate dehydrogenase levels, and bilateral patchy pneumonia and infiltrates [1]. Respiratory presentations of H1N1 virus infection include viral pneumonitis, exacerbations of asthma or chronic obstructive pulmonary disease (COPD), exacerbations of other underlying disease, secondary bacterial pneumonia, and croup/bronchiolitis in the pediatric population [2].

Clinical deterioration is characterized by sudden, rapidly progressive respiratory failure with persistent, refractory hypoxia, bilateral diffuse pulmonary infiltrates, and low PaO₂/FiO₂ meeting the criteria for acute respiratory distress syndrome (ARDS). Severe respiratory failure is common during the first week, with the

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incidence decreasing as the week progresses. Refractory hypoxia was the major cause of death, followed by multi-organ failure and shock. Shock was more significant during the latter part of the disease course. Other organ failures are seen in the kidneys, liver, and bone marrow.

During the epidemic about 10–30 % of hospitalized patients needed intensive care unit (ICU) admission. Co-morbidities were noted in 32–84 % of patients admitted to the ICU. They include obesity, COPD, diabetes mellitus, asthma, immunosuppression, chronic kidney disease, and heart failure.

The overall ICU mortality rate for critically ill patients with PA-H1N1 was close to 17 % [1]. Factors independently associated with mortality included the requirement for invasive mechanical ventilation (IMV) and a low $\text{PaO}_2/\text{FiO}_2$ at ICU admission, the presence of co-morbidities, and older age. Autopsy findings showed three distinct pulmonary pathologies: diffuse alveolar damage (DAD), necrotizing bronchiolitis, and DAD with alveolar hemorrhage.

16.2 Ventilatory Management

Invasive mechanical ventilation with a lung-protective ventilatory strategy and fluid restriction is recommended as the initial approach for managing patients with pandemic A(H1N1) infection complicated by ARDS.

Noninvasive mechanical ventilation (NIMV) has been used as first-line therapy in a small number of patients. Most of them deteriorated and subsequently needed IMV. The guidelines endorsed by the European Respiratory Society (ERS) and European Society of Intensive Care Medicine (ESICM) state that NIMV should not be considered an alternative to IMV in patients with acute hypoxemic respiratory failure secondary to PA-H1N1 infection that is likely to progress to ARDS [3]. The reasons against NIMV being used as first-line therapy in PA-H1N1-associated respiratory failure are as follows:

- Poor clinical efficacy in severe respiratory failure that rapidly progresses to refractory hypoxemia and ARDS
 - Patients with PA-H1N1 present almost uniformly with hypoxemic respiratory failure, not hypercapnic respiratory failure
 - Great concern about aerosol droplet particle dispersion and spread of infection
- Indications for NIMV in patients with PA-H1N1 infection are the following:
- During the early stages with mild respiratory failure characterized by minimal pulmonary infiltrates and $\text{PaO}_2/\text{FiO}_2 > 250$
 - Mild to moderate hypercapnic respiratory failure such as exacerbation of COPD related to PA-H1N1 infection
 - Postextubation respiratory failure due to resolving ARDS
 - Weaning from prolonged mechanical ventilation
 - Patients with cardiogenic edema in the absence of pneumonia, multi-organ failure, and refractory hypoxemia

There are some additional requirements for NIMV.

- Negative-pressure or well-ventilated rooms
- Bacterial and viral filters in the expiratory circuit

Table 16.1 Published data on NIMV during PA-H1N1 epidemic

Country of study [first author]	Date published	Patients on NIMV	NIMV failure needing IMV	Reference
Australia [Kaufman, MA]	July 2009	$n=4$, 66 %	100 %	<i>MJA</i> 2009;191:154–156
Spain [Rello, J]	September 2009	$n=8$, 33 %	75 %	<i>Critical Care</i> 2009;13:R148
France [Djibre, M]	October 2009	$n=1$, case report	None	<i>Intensive Care Med</i> 2010;36:373–374
Canada [Kumar, A]	November 2009	$n=55$, 33 %	85 %	<i>JAMA</i> 2009;302:1872–1879
Utah, USA [Miller, RR]	November 2009	$n=13$, 33 %	85 %	<i>Chest</i> 2010;137:752–758
South African [Koegelenberg, CFN]	March 2010	$n=6$, 66 %	66 %	<i>Q J Med</i> 2010;103:319–325
Portugal [Winck, JC]	March 2010	$n=1$, case report	None	<i>Crit Care</i> 2010;14:408
Brazil [Hajjar, LA]	April 2010	$n=8$, 50 %	25 %	<i>Ann Oncol</i> 2010;21(12):2333–2341
Chilean-Uruguay [Nin, N]	April 2011	$n=43$, 45 %	77 %	<i>J Crit Care</i> 2011;26(2):186–192

- Strict personal protection equipment for health care workers (HCWs)
- Minimal number of individuals caring for the patient
- Strict monitoring of HCWs for signs and symptoms of infection

16.3 NIMV as a Risk for Aerosol Droplet Infection

Recommendations regarding NIMV as a risk for aerosol droplet infection are mainly based on studies published and experiences following the severe acute respiratory syndrome (SARS) epidemic in 2003 (Table 16.1). The pivotal study arguing that NIMV poses high risk of infection spread is based on the assessment of particle dispersion using an experimental model [4]. Smoke was introduced into the lungs of a mannequin while noninvasive ventilation (NIV) was being used. Plumes of smoke emerging from the vented mask were photographed for particle dispersion. So far no study has been conducted to evaluate particle dispersion on humans. Whether a mannequin simulates a live patient using NIMV has been greatly debated, and many argue that the NIMV mask may in fact offer protection from secretions that would have otherwise been dispersed from the infected patient during coughing, sneezing, and speaking. Also, there are no comparative data on particle dispersion between individuals undergoing NIMV and those who do not.

During the SARS outbreak, a study in Hong Kong looked at the efficacy of NIMV in early ARDS patients. It also evaluated the infection risk among HCWs who had direct contact with patients on NIMV [5]. In all, 22 patients (25 %) needed NIMV and 155 HCWs (including doctors, nurses, and health-care assistants)

exposed to patients on NIMV therapy were regularly screened for signs of infection. Coronavirus serology was obtained for 97 % of HCWs. NIMV equipped with expiratory bacterial and viral filters was provided in isolated cubicles in the ward or in the ICU, which were centrally air-conditioned and fitted with exhaust ventilation fans to achieve negative-pressure flow. The study concluded that NIMV was not only effective in preventing IMV in 70 % of patients with acute respiratory failure due to SARS but it effectively reduced the ICU length of stay or avoided ICU admission altogether. Moreover, no infection was noted in any of the 155 HCWs, and their serology tests for coronavirus were negative.

Based on the guidelines from ERS/ESICM, the World Health Organization, the United Kingdom's National Health Services Agency, The Hong Kong Lung Foundation, and the American Association of Respiratory Care, NIMV is currently considered a high-risk procedure during respiratory pandemics. This has led to ICU overuse, strain on available resources, and an increase in IMV-related complications. Further validation of the association between NIMV and infection spread by particle dispersion is needed for planning for future pandemics [2, 6, 7].

Conclusion

Noninvasive mechanical ventilation has a role in the management of early respiratory failure due to PA-H1N1 infection in a strictly controlled environment with close monitoring of HCWs. NIMV has no role in patients with severe respiratory failure and ARDS related to severe PA-H1N1 infection. These patients must be intubated and placed on IMV. However much it is still debated, the potential risk of particle dispersion and spread of infection due to NIMV is present.

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