

A Survey of the Use of Noninvasive Ventilation in Academic Emergency Departments in the United States

Dean R Hess PhD RRT, Jessica M Pang, and Carlos A Camargo Jr MD DrPH

OBJECTIVE: To determine the frequency of, and barriers to, use of noninvasive ventilation (NIV) for adult patients with acute asthma, chronic obstructive pulmonary disease (COPD), and congestive heart failure (CHF) in academic emergency departments (EDs). **METHODS:** A survey instrument was developed by the authors, pilot tested, and distributed to one physician (MD) and one respiratory therapist (RT) at the 132 hospitals with emergency medicine residencies. **RESULTS:** The response rate was 90%. Ninety-nine percent of RTs and 64% of MDs are very familiar with NIV ($P < .001$). The reported time needed to initiate NIV was < 10 min for 41% of sites (< 20 min for 89%). Compared to the time requirement in other clinical areas, 60% of RTs reported that NIV “takes no additional time” in the ED. An RT is always present in 38% the EDs, and equipment for NIV is readily available in 76% of the EDs. The majority reported that NIV use is about right for acute COPD, CHF, and asthma. NIV is used infrequently for asthma (89% reported use in $< 20\%$ of these patients), while 66% reported use in $> 20\%$ of COPD patients and 67% reported use in $> 20\%$ of CHF patients ($P < .001$, as compared to asthma). The perceived utility of NIV was significantly different between the 3 diagnoses ($P < .001$); there was more uncertainty about the utility of NIV for asthma. Bilevel ventilators and oronasal masks are most commonly used for NIV. Nearly all of the centers administer bronchodilators in-line with NIV. **CONCLUSIONS:** Consistent with available evidence, NIV use is more common in the ED for acute COPD and CHF than for acute asthma. Barriers to greater use of NIV in the ED include physician familiarity, availability of RT and equipment in the ED, and time required for NIV. For acute asthma, uncertainty about therapeutic benefits remains a challenge. *Key words:* asthma, chronic obstructive pulmonary disease, congestive heart failure, emergency medicine, noninvasive ventilation, respiratory care, survey. [Respir Care 2009;54(10):1306–1312. © 2009 Daedalus Enterprises]

Introduction

Use of noninvasive ventilation (NIV) is standard practice for patients presenting with severe exacerbation of chronic obstructive pulmonary disease (COPD) and acute congestive heart failure (CHF), where it has been shown to decrease intubation rate and improve survival.^{1,2} The benefit of NIV in other conditions such as severe acute asthma

SEE THE RELATED EDITORIAL ON PAGE 1302

is unclear,³ primarily because it has not been adequately studied. Because many patients with acute respiratory failure present first to the emergency department (ED), it seems reasonable that this should be a setting where NIV is commonly used.⁴ The participants in an international consensus

Dean R Hess PhD RRT FAARC is affiliated with Respiratory Care Services Massachusetts General Hospital and Harvard Medical School, Boston, Massachusetts. Jessica M Pang and Carlos A Camargo Jr MD DrPH are affiliated with the Department of Emergency Medicine; Dr Camargo is also affiliated with the Division of Rheumatology, Allergy, and Immunology, and the Department of Medicine, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts.

Dr Hess has disclosed relationships with Respironics, Pari, and Impact. Dr Camargo has disclosed relationships with Alza, AstraZeneca, Bayer, Critical Therapeutics, Dey, Genentech, GlaxoSmithKline, Jerini, MedImmune, Merck, Novartis, NovoNordisk, Respironics, Schering-Plough, and Teva. Ms Pang has disclosed no conflicts of interest.

Dr Hess presented a version of this paper at the 2008 American Thoracic Society International Conference, May 16-21, 2008, in Toronto, Ontario, Canada.



Fig. 1. Map of the United States, indicating sites that participated and did not participate in the study.

conference recommended that NIV can be initiated in the ED.⁵ The practice guideline by Sinuff et al included the ED as a site for use of NIV.⁶ However, the extent and appropriateness of NIV use in academic EDs is unknown. Surveys of the use of NIV have been conducted,⁷⁻¹² but only two^{7,12} have been specific to the ED setting, and none has been specific to academic EDs in the United States. We conducted this study to determine the frequency of, and barriers to, NIV use in academic EDs in the United States.

Methods

Questionnaire Development and Pilot Testing

This study was conducted by the Emergency Medicine Network (EMNet, <http://www.emnet-usa.org>). The survey

Dr Hess as editor in chief was blinded to the identity of the peer reviewers of this paper.

Correspondence: Dean R Hess PhD RRT FAARC, Respiratory Care, Ellison 401, Massachusetts General Hospital, 55 Fruit Street, Boston MA 02114. E-mail: dhess@partners.org.

instrument was developed by two of the authors (DRH and CAC), who have considerable academic and clinical experience in the use of NIV and survey research involving the ED. Content validity was augmented by pilot tests including emergency physicians (4 members of the EM-Net Steering Committee) and 14 respiratory therapists (RTs). These individuals were chosen because they practice in an academic hospital and they have expertise related to the subject matter of the survey. These individuals were asked to comment on the following aspects of the survey:

1. Time. How many minutes were required for you to complete the survey?
2. Clarity. Are any questions ambiguous? If so, which ones? Suggestions to make those questions more clear?
3. Face validity. Are there any questions that are unimportant and can be deleted?
4. Content validity. Any additional questions that absolutely must be included, remembering that this will lengthen the survey and take more time to complete?
5. Utility. Do you think respiratory directors will be willing to complete this survey?

The survey questionnaire was revised according to the feedback we received. The survey instrument is available from the authors upon request. The study protocol was approved by the institutional review board of the Massachusetts General Hospital.

Data Collection

The survey population was the 132 general EDs in the United States with accredited emergency medicine residency training programs in calendar year 2007. The physician director of the emergency residency program and the director of respiratory care were identified at each site and invited to complete the survey. These individuals were asked to complete the questionnaire themselves or to solicit input from others at the site. The survey questionnaire was Internet-based and self-administered, although a hard copy of the survey was made available to those who requested it. To improve the response rate, e-mail and telephone follow-up was conducted for non-respondents.

Data Analysis

Data were aggregated according to response categories. Percentages were calculated and differences between groups were determined via chi-square analysis. Two-tailed $P \leq .05$ was considered statistically significant.

Results

Response Rate

We received a response from 119 of the 132 hospitals with an emergency medicine residency program (90%). A map of the participating and nonparticipating sites is provided as Figure 1.

Familiarity and Time Requirement

Sixty-four percent of physicians (MDs) and 99% of RTs reported that they are very familiar with NIV ($P < .001$). Compared to the time requirement in other clinical areas, 60% of RTs reported that NIV "takes no additional time" in the ED; 11% reported that it "usually" or "always" takes a lot of time; the remainder reported that NIV takes "a little more time." The RTs reported that NIV is used $\geq 1/\text{wk}$ in 92% of EDs, 98% of intensive care units (ICUs), 89% of step-down units, and 70% of general care units ($P < .001$). RTs reported that use of NIV in the ED is similar to use elsewhere in the hospital ($P = .30$, Fig. 2).

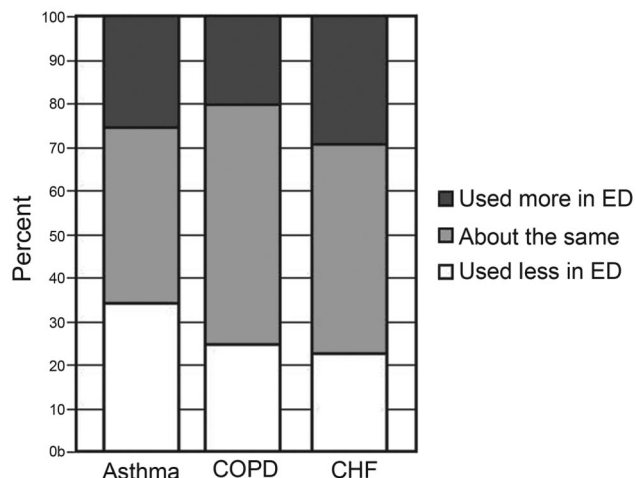


Fig. 2. Use of noninvasive ventilation in the emergency department (ED), compared to elsewhere in the hospital. COPD = chronic obstructive pulmonary disease. CHF = congestive heart failure.

Respiratory Therapist and Equipment Availability

An RT is primarily responsible for initiation of NIV in 96% of the EDs. In 38% of the hospitals an RT is always available in the ED. Equipment for NIV is stored in the ED in 76% of the reporting hospitals. NIV is initiated in < 10 min in 41% of the hospitals, and in < 20 min in 89% of the hospitals.

Use by Diagnosis and Perception of Utility

The reported use of NIV for asthma was less than that for COPD and CHF (Fig. 3). NIV use in $\geq 20\%$ of cases was reported by 14% of respondents for asthma, 66% of respondents for COPD, and 67% of respondents for CHF ($P < .001$). NIV use in $< 10\%$ of cases was reported by 70% of respondents for asthma, 17% of respondents for COPD, and 19% of respondents for CHF. The majority of respondents reported the perception that the use of NIV is about right for each of the diagnoses ($P = .16$, Fig. 4). About a third of physicians and RTs reported that NIV does not help, or they are uncertain of its utility, for acute asthma (Fig. 5). The majority of MDs and RTs reported the perception that NIV often helps for acute COPD or acute CHF. The perceptions of the utility of NIV were significantly different between the diagnoses of asthma, COPD, and CHF ($P < .001$).

Equipment Used for Noninvasive Ventilation

In 51% of the centers only bi-level ventilators are used for NIV; 82% of the centers reported that they use bi-level ventilators in $\geq 50\%$ of cases. A ventilator with an oxygen

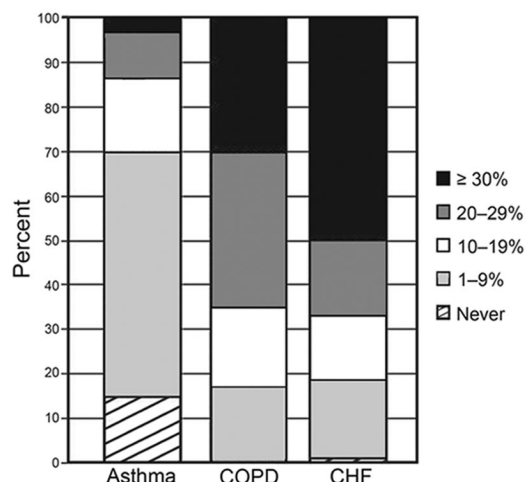


Fig. 3. Percentage of cases in which noninvasive ventilation is used in the emergency department. COPD = chronic obstructive pulmonary disease. CHF = congestive heart failure.

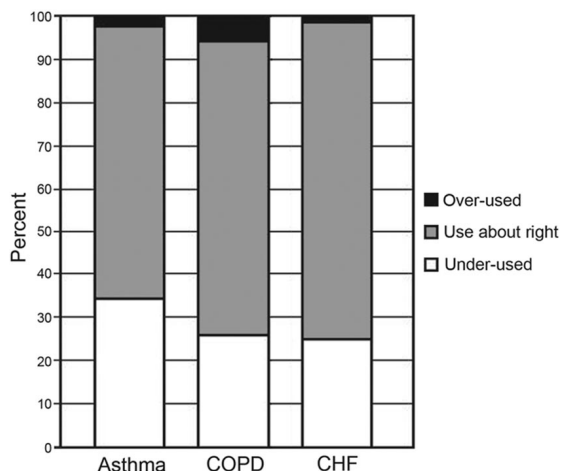


Fig. 4. Perceptions of the appropriateness of the use of noninvasive ventilation in the emergency department. COPD = chronic obstructive pulmonary disease. CHF = congestive heart failure.

blender is used by 71%, and 41% reported using a fraction of inspired oxygen (F_{IO_2}) > 0.6 for NIV. In 17% of the centers only oronasal masks are used for NIV; 76% reported use of oronasal masks in $\geq 50\%$ of cases. In addition, 15% never use oronasal masks, 28% never use nasal masks, and 72% never use total face masks. Nearly all (90%) of centers administer bronchodilators in-line with NIV; 86% use nebulizers, and 14% use pressurized metered-dose inhalers. Most (85%) of the centers reported that this therapy is effective, and 88% reported that this therapy is technically easy.

Discussion

The major findings of this national survey are: (1) NIV use is more common in the ED for COPD and CHF ex-

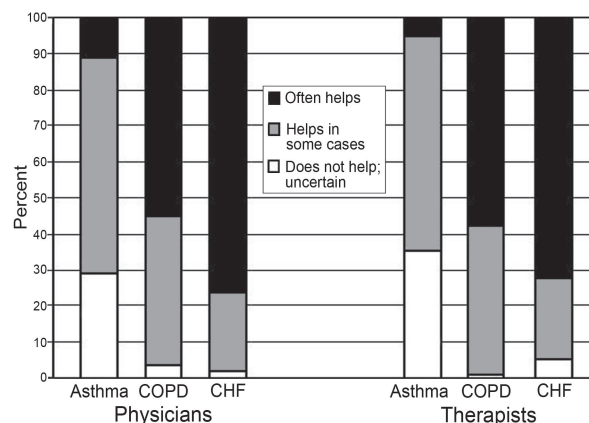


Fig. 5. Perceptions of physicians and respiratory therapists of the utility of noninvasive ventilation. COPD = chronic obstructive pulmonary disease. CHF = congestive heart failure.

acerbations than for acute asthma, (2) NIV use could be higher for COPD and CHF, (3) barriers to greater NIV use in the ED include physician familiarity and availability of an RT and equipment in the ED, and (4) there is uncertainty about the therapeutic benefits of NIV for acute asthma.

A robust evidence base supports the use of NIV for acute COPD or CHF. Picot et al¹ conducted a systematic review of 14 randomized controlled trials (RCTs) reporting the use of NIV for acute COPD. There was an approximately 60% reduction in the risk of intubation in the NIV group, when compared to usual medical care, with a number-needed-to-treat of 4 (95% confidence interval 4-5). There was also nearly a 50% reduction in mortality, with a number-needed-to-treat of 10 (95% confidence interval 7-20).

Vital et al² conducted a systematic review of 9 RCTs comparing CPAP to usual patient care; 5 RCTs that compared NIV to usual standard care; 3 RCTs that compared CPAP, NIV, and usual medical care; and 4 RCTs comparing CPAP plus usual medical care to NIV plus usual medical care. With CPAP, a constant pressure greater than atmospheric is applied to the mask throughout the respiratory cycle. With NIV, the pressure in the mask increases during the inspiratory phase (for example, pressure-support ventilation). In other words, inspiratory assistance is provided with NIV, but not for CPAP. When studies of CPAP and NIV are combined, there was a significantly lower endotracheal intubation rate for patients treated with CPAP or NIV, compared with standard medical care alone, with a number-needed-to-treat of 8. There was also a significant reduction in hospital mortality for patients treated with CPAP or NIV, compared with standard medical care alone, with a number-needed-to-treat of 14. However, there was no significant difference between NIV and CPAP for

the outcomes of endotracheal intubation or mortality. In our survey we asked only about NIV; we did not include separate questions about NIV and CPAP.

In contrast to the strong evidence supporting the use of NIV for acute COPD and CHF, evidence is lacking for the use of NIV for acute asthma. For example, a Cochrane review by Rowe et al³ concluded that, despite some interesting and very promising preliminary results, the use of NIV for acute asthma remains controversial. The results of our survey are consistent with this evidence. NIV was used more commonly for acute COPD and CHF than for acute asthma, and the survey participants were uncertain of the therapeutic benefits of NIV for acute asthma.

Although consensus groups have recommended NIV as first-line standard therapy for patients with acute COPD and CHF,^{5,13} the appropriate utilization rate in these patients is not clearly established. Several reports from France suggested that the utilization rate should be high. Girou et al,¹⁴ in an 8-year retrospective evaluation of NIV in a single center, reported an increased NIV utilization over the study period that was associated with a decrease in mortality and nosocomial infections. In the final year of that study (2001), ICU-use of NIV was 78% of patients with acute COPD and 22% of patients with acute CHF. In a survey of NIV use in 70 French ICUs, Demoule et al¹⁰ reported that first-line NIV use in patients not intubated before ICU admission was 64% in patients with acute-on-chronic respiratory failure (most with COPD) and 40% in patients with acute CHF.

In our survey NIV use in $\geq 20\%$ of cases was reported by 66% of respondents for COPD, and by 67% of respondents for CPE. Put another way, NIV is used in $< 20\%$ of cases of acute COPD and CHF in about a third of the EDs in our survey. It is interesting to note that NIV was used in $< 10\%$ of cases by 17% of respondents for COPD and 19% of respondents for CHF. This suggests that the utilization of NIV in academic EDs in the United States could be increased for patients presenting with acute COPD or CHF. Although we did not ask about the frequency of contraindications for use of NIV in the ED, it is unlikely that usual criteria for initiation of NIV would prevent its use in more than 90% of patients in nearly 20% of EDs.

In our survey bi-level ventilators were most commonly used for NIV. This differs from the survey by Demoule et al,¹⁰ in which an ICU ventilator was used in 79% of cases and a bi-level ventilator was used in 12% of cases. It would thus appear that bi-level ventilators may be used more commonly in the United States than in France. In the survey by Vanpee et al in Belgium,¹² bi-level ventilators were used for the majority of NIV cases. It is interesting to note that, increasingly, ICU ventilators are designed with both invasive and noninvasive ventilation modes.^{15,16} We also found that oronasal masks are most commonly used

for NIV. This is similar to the surveys of Demoule et al¹⁰ and Vanpee et al¹² and it is consistent with available evidence suggesting better patient tolerance of an oronasal mask in patients with acute respiratory failure.^{17,18} In our survey, aerosolized bronchodilators were commonly administered with NIV, consistent with the literature reporting effectiveness of this therapy.¹⁹

There have been 6 other surveys of NIV use published (Table 1)⁷⁻¹² and 2 of these focused on use in the ED.^{7,12} Our study is unique in that, to our knowledge, ours is the only survey of NIV use that focused on academic EDs in the United States and ours is the only one to survey RTs as well as MDs. Vanpee et al¹² surveyed head physicians in Belgium. Unlike our study, only 13% of the EDs in this study were in academic hospitals (the remainder were community hospitals). Unlike in the United States, the responsibility for initiation of NIV in Belgium is assumed by a physician and nurse working together. At the time of this survey (2001), NIV was used in 49% of the EDs in Belgium, which is less than the reported use in our survey. Reasons given for not using NIV in the Vanpee et al¹² study were no available equipment in 71%, lack of experience with NIV in 33%, and more time-consuming for physicians and nursing staff in 23%. This is consistent with our survey results, in which only 64% of MDs reported that they are very familiar with NIV, only 76% of sites reported that equipment for NIV is stored in the ED, and only 60% of RTs reported that NIV takes no additional time in the ED. The initiation of NIV may be more time-consuming in the first hour of therapy, and this should be appreciated by those responsible for providing this therapy.²⁰ Browning et al,⁷ in a survey of NIV use in EDs in the United Kingdom in 2006, reported that although NIV is commonly used in EDs in the United Kingdom, practices vary significantly. They suggested the development of guidelines on when and how to use NIV in ED practice. In a survey by Burns et al⁸ of NIV use in Ontario, 80% of responding sites had guidelines, protocols, or policies related to the initiation of NIV. There have been several reports of the development and implementation of NIV guidelines.^{6,21}

The results of our survey suggest that important barriers to greater use of NIV in the ED include physician familiarity, availability of an RT and equipment in the ED, and the time delay in initiation of NIV. Our results are consistent with other surveys. Of example, in the survey by Maheshwari et al¹¹ the top 2 reasons given for lower NIV utilization rates were a lack of physician knowledge and inadequate equipment. In the survey by Burns et al⁸ ED physicians utilized NIV less frequently than physicians specialized in critical care and respiratory; they also reported that a greater number of noninvasive ventilators were associated with greater use.

Table 1. Summaries of Surveys of the Use of Noninvasive Ventilation

First Author	Year	Survey Population	Primary Findings
Carlucci ⁹	2001	42 ICUs in France: 16 non-university hospitals and 26 university hospitals	The use of NIV for patients admitted without intubation was 35%. The percent of patients receiving NIV ranged from 0% (in 8 ICUs) to 67% (in 1 ICU).
Vanpee ¹²	2002	Head physicians in 145 EDs in Belgium	NIV used in 49% of the EDs. Most important reasons for not using NIV were no available equipment (71%), lack of experience (32.7%), and more time-consuming for physicians and nursing staff (22.8%). Only 3.8% of the physicians doubted the benefit of NIV.
Burns ⁸	2005	808 attending physicians and residents in 4 specialties at 15 teaching hospitals in Ontario, Canada	Variation in NIV utilization among specialties but not hospitals. Specialty (critical care and respiratory vs internal and emergency medicine), fewer years of experience, and a greater number of NIV ventilators were predictors of more frequent NIV use.
Maheshwari ¹¹	2006	Directors of respiratory care at 71 acute-care hospitals in Massachusetts and Rhode Island	The utilization of NIV varied enormously among acute care hospitals within the same region. Lower utilization rates due to lack of physician knowledge, respiratory therapist training, and inadequate equipment.
Demoule ¹⁰	2006	70 French ICUs	NIV use significantly increased over past 5 years. In patients not previously intubated, NIV was the leading first-line ventilation modality.
Browning ⁷	2006	233 EDs in the United Kingdom	NIV is commonly used in United Kingdom emergency departments, but practices vary significantly.

ICU = intensive care unit
NIV = noninvasive ventilation
ED = emergency department

We suggest that several strategies might be used to increase NIV utilization in the ED.²² A knowledgeable and enthusiastic clinical champion is important when initiating an NIV program. Ideally the use of NIV should be multidisciplinary and include RT, MD, and nurse champions. Knowledge and training are also important. Knowledge of the evidence for NIV can be presented at formal educational venues such as grand rounds and journal clubs. Technical training should ideally be one-on-one and hands-on. The hospital and departmental administration must appreciate that adequate personnel and equipment resources are necessary when implementing an NIV program. Guidelines and protocols may be useful as educational resources, to avoid clinical conflict, and to consolidate authority.^{6,21} When initiating an NIV program, it is important to recognize that NIV does not avoid intubation in all cases and that success often improves with experience. The available evidence suggests that NIV is cost-effective.²³

Limitations

There are several potential limitations of our study. We sent the survey to only 1 MD and 1 RT at each site, and thus assumed that their responses were reflective of the NIV utilization at the site. We did ask these individuals to solicit input from others if they were unsure of the appro-

priate response. We did not ask for the criteria to initiate NIV in the 132 EDs, although we speculate that it probably varied greatly from one ED to another. Another potential limitation is that we surveyed the use of NIV for only 3 diagnoses (asthma, COPD, CHF). However, it is unlikely that NIV is used commonly in the ED for other applications such as hypoxemic respiratory failure or post-extubation.^{24,25} In our survey we did not ask for the number of patients requiring NIV, because that information is very difficult to correctly determine using a survey. Finally, we surveyed NIV use in academic EDs only and therefore cannot generalize to the use of NIV in other clinical settings.

Conclusions

Consistent with available evidence, NIV use is more common in the ED for acute COPD and CHF than for acute asthma. Barriers to greater use of NIV in the ED include physician familiarity, availability of an RT and equipment in the ED, and time required for NIV. For acute asthma, uncertainty about therapeutic benefits remains a challenge. Knowledge of these barriers should facilitate programs to increase the utilization of NIV in the ED for patients presenting with asthma, COPD, and CHF.

REFERENCES

1. Picot J, Lightowler J, Wedzicha JA. Non-invasive positive pressure ventilation for treatment of respiratory failure due to exacerbations of chronic obstructive pulmonary disease. *Cochrane Database Syst Rev* 2004;(3):CD004104.
2. Vital FM, Saconato H, Ladeira MT, Sen A, Hawkes CA, Soares B, et al. Non-invasive positive pressure ventilation (CPAP or bilevel NPPV) for cardiogenic pulmonary edema. *Cochrane Database Syst Rev* 2008;(3):CD005351.
3. Rowe BH, Wedzicha JA. Non-invasive positive pressure ventilation for treatment of respiratory failure due to severe acute exacerbations of asthma. *Cochrane Database Syst Rev* 2005;(3):CD004360.
4. Hill NS. Where should noninvasive ventilation be delivered? *Respir Care* 2009;54(1):62-70.
5. International Consensus Conferences in Intensive Care Medicine: noninvasive positive pressure ventilation in acute respiratory failure. *Am J Respir Crit Care Med* 2001;163(1):283-291.
6. Sinuff T, Cook DJ, Randall J, Allen CJ. Evaluation of a practice guideline for noninvasive positive-pressure ventilation for acute respiratory failure. *Chest* 2003;123(6):2062-2073.
7. Browning J, Atwood B, Gray A. Use of non-invasive ventilation in UK emergency departments. *Emerg Med J* 2006;23(12):920-921.
8. Burns KE, Sinuff T, Adhikari NK, Meade MO, Heels-Ansdell D, Martin CM, Cook DJ. Bilevel noninvasive positive pressure ventilation for acute respiratory failure: survey of Ontario practice. *Crit Care Med* 2005;33(7):1477-1483.
9. Carlucci A, Richard JC, Wysocki M, Lepage E, Brochard L. Non-invasive versus conventional mechanical ventilation: an epidemiologic survey. *Am J Respir Crit Care Med* 2001;163(4):874-880.
10. Demoule A, Girou E, Richard JC, Taille S, Brochard L. Increased use of noninvasive ventilation in French intensive care units. *Intensive Care Med* 2006;32(11):1747-1755.
11. Maheshwari V, Paioli D, Rothaar R, Hill NS. Utilization of noninvasive ventilation in acute care hospitals: a regional survey. *Chest* 2006;129(5):1226-1233.
12. Vanpee D, Delaunois L, Lheureux P, Thys F, Sabbe M, Meulemans A, et al. Survey of non-invasive ventilation for acute exacerbation of chronic obstructive pulmonary disease patients in emergency departments in Belgium. *Eur J Emerg Med* 2002;9(3):217-224.
13. British Thoracic Society Standards of Care Committee. Non-invasive ventilation in acute respiratory failure. *Thorax* 2002;57(3):192-211.
14. Girou E, Brun-Buisson C, Taille S, Lemaire F, Brochard L. Secular trends in nosocomial infections and mortality associated with non-invasive ventilation in patients with exacerbation of COPD and pulmonary edema. *JAMA* 2003;290(22):2985-2991.
15. Chatburn RL. Which ventilators and modes can be used to deliver noninvasive ventilation? *Respir Care* 2009;54(1):85-101.
16. Scala R, Naldi M. Ventilators for noninvasive ventilation to treat acute respiratory failure. *Respir Care* 2008;53(8):1054-1080.
17. Kwok H, McCormack J, Cece R, Houtchens J, Hill NS. Controlled trial of oronasal versus nasal mask ventilation in the treatment of acute respiratory failure. *Crit Care Med* 2003;31(2):468-473.
18. Nava S, Navalesi P, Gregoretti C. Interfaces and humidification for noninvasive mechanical ventilation. *Respir Care* 2009;54(1):71-84.
19. Hess DR. The mask for noninvasive ventilation: principles of design and effects on aerosol delivery. *J Aerosol Med* 2007;20(Suppl 1):S85-S98.
20. Kramer N, Meyer TJ, Meharg J, Cece RD, Hill NS. Randomized, prospective trial of noninvasive positive pressure ventilation in acute respiratory failure. *Am J Respir Crit Care Med* 1995;151(6):1799-1806.
21. Sinuff T, Kahn moui K, Cook DJ, Giacomini M. Practice guidelines as multipurpose tools: a qualitative study of noninvasive ventilation. *Crit Care Med* 2007;35(3):776-782.
22. Hess DR. How to initiate a noninvasive ventilation program: bringing the evidence to the bedside. *Respir Care* 2009;54(2):232-243.
23. Keenan SP, Gregor J, Sibbald WJ, Cook D, Gafni A. Noninvasive positive pressure ventilation in the setting of severe, acute exacerbations of chronic obstructive pulmonary disease: more effective and less expensive. *Crit Care Med* 2000;28(6):2094-2102.
24. Epstein SK. Noninvasive ventilation to shorten the duration of mechanical ventilation. *Respir Care* 2009;54(2):198-208.
25. Keenan SP, Mehta S. Noninvasive ventilation for patients presenting with acute respiratory failure: the randomized controlled trials. *Respir Care* 2009;54(1):116-126.