# The Where-to-Do-It of Noninvasive Ventilation Revisited

Noninvasive ventilation (NIV) represents the standard of care in acute respiratory failure.[1] In acute hypercapnic ventilatory failure due to COPD exacerbations and acute cardiogenic pulmonary edema, NIV is without doubt highly effective in terms of reduced intubation rates and mortality.[2,3] As a consequence of the growing amount of evidence for these benefits, NIV use has been ever increasing during the past decade.[4,5] The rising number of patients treated with NIV applies not only to the aforementioned, well-proven indications but also to other conditions leading to acute respiratory failure: NIV use extended into the prehospital setting,[6] postextubation respiratory failure,[7] acute hypoxemic failure due to pneumonia or ARDS,[8] and support during bronchoscopy in acute hypoxemic respiratory failure.[9]

Besides the question of which conditions can be effectively treated with NIV, the question of where to perform NIV is nearly as old as the technique itself.[10,11] Before the advent of NIV, nearly all patients in need of mechanical ventilation had to be transferred to an ICU. In this setting, optimal monitoring equipment is present, and the 24/7 presence of respiratory therapists, nurses, and physicians ensures competent and uninterrupted care of these vulnerable patients. The German national guidelines recommend that NIV be initiated in the setting of intermediate care units or ICUs.[12] This high level of care is desirable to achieve optimal results regarding patient safety. However, as significant shortages of ICU beds are a constant problem in many countries around the world, such recommendations appear to be impractical for many situations. Furthermore, the chance for reduced ICU resource utilization is one of the many benefits of NIV in the management of acute respiratory failure. Hence, most national and international guidelines on NIV do not specify exactly where to initiate NIV for acute respiratory failure.[13-16] Instead, they describe a range of different scenarios: from high-level ICUs, emergency departments, and respiratory intermediate care units to general wards, all settings may be appropriate under certain conditions. The recommendation is to analyze the available resources at an institutional level and match them with the group of patients who need care. The importance of formal and continuous training is emphasized.

A randomized multi-center study investigated whether initiating NIV in COPD subjects with acute hypercapnic ventilatory failure (average pH 7.32, range of 7.25–7.35) in the general ward is safe and effective.[17] Intubation rates and mortality were reduced in comparison with standard therapy by 44% and 50%, respectively. It should be emphasized that in this study, NIV was initiated by nurses and physiotherapists. Success was felt to be dependent on the quality of the medical staff's formal training, protocol-based procedures, and focusing on specialized NIV wards. Regarding the difference in work load, the authors found an average increase of only 26 min used for the NIV group during the first 8 h following admission, whereas no difference between the NIV and standard-care groups was observed after 8 h. Because this study had the largest number of subjects investigated in this context, it provides the main evidence that NIV may be safely used in the general ward. Other reports presented similar reassuring data that providing NIV is feasible and safe outside of the ICU if adequate monitoring and medical staff are provided.[18]

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In this issue of RESPIRATORY CARE, Olivieri et al[19] describe their experience using NIV in the management of subjects with acute hypercapnic failure due to COPD exacerbations.[19] In their prospective, uncontrolled, interventional study, they were able to stabilize subjects who showed considerable respiratory acidosis at initial presentation in the emergency department using only 2 h of NIV in an ICU-like setting. All subjects with improved blood gas results following 2 h of NIV treatment were transferred to general wards with a low nurse/patient ratio. ICU physicians assisted the general ward team in NIV management.

The most important observation presented by Olivieri et al[19] is the high quality of NIV in terms of mask leakage and NIV interruptions that was achieved in their study using only limited supervision by the ICU team and ward staff. Earlier studies showed significant percentages of relevant mask leakage that may constitute the crucial step

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toward late NIV failure.[20] The authors speculated that improvements in NIV interface technology (ie, masks) and the high level of staff training explain their excellent results. This high-quality NIV application translated into an acceptable low failure rate (eg, endotracheal intubation rate of 20%), which falls into the reported range.[21]

The presented results have to be interpreted in the context of the uncontrolled study design, the limited number of subjects included, and the absence of observations regarding nurse and physician work load. The study should be interpreted as a feasibility study of high-quality NIV in a setting of limited resources.

If the presented results are to be reproduced, one has to keep in mind that Olivieri et al[19] used strict exclusion criteria, including the complete absence of impaired consciousness. Proper patient selection can be considered as fundamental for successful NIV treatment. As is repeatedly stressed in all guidelines on NIV therapy, only patients without contraindications should be treated with NIV in general or in less intensive care settings.[12-16] However, Olivieri et al[19] showed that local variations are possible if the staff is experienced in NIV therapy.

Several surveys from the United States showed that use of NIV in real life is subject to a significant amount of variation regarding type and percentage of treated patients, medical staff involved (physicians, nurses, physiotherapists, respiratory therapists), quality of staff training, protocols used, and finally locations of NIV application.[22,23] The results revealed a high degree of variation in NIV use even in situations in which it is strongly recommended. Reasons for this finding were lack of physician knowledge, insufficient respiratory therapist training, and inadequate technical equipment.[23] These reports, which can be expected to be representative for many other countries worldwide, emphasize that one has to be very cautious in transferring a well-established NIV program from one institution to another unless all relevant circumstances are comparable. A recent retrospective multicenter study in French ICUs revealed a strong correlation between case volume and use of NIV.[24] Experienced centers used NIV more frequently and obtained lower mortality rates for patients with a comparable severity of illness. To cut it short, training saves lives.

As confirmed in the mentioned surveys, underuse of NIV therapy is likely to exert a negative impact on patient outcomes. In contrast, there are concerns regarding possible harm of early NIV use. Since the early years of NIV, it has been well known that, under certain circumstances, a failed NIV trial may delay intubation and lead to increased mortality for COPD patients with acute respiratory failure.[25] Retrospective data show a disturbing increase in the proportion of COPD patients with acute hypercapnic insufficiency who fail an initial NIV trial.[5] Even more disturbing is the increasing mortality rate of this subgroup at an even faster pace.[5] In addition, NIV failure in cases of acute respiratory failure with underlying conditions other than COPD is associated with a higher mortality rate in comparison with patients receiving mechanical ventilation without a preceding NIV trial.[4] These observations underscore that the decision to initiate NIV therapy must not be an automatism in the presence of acute respiratory failure.

Evaluation of the success or failure of NIV in the first hour appears to be crucial.[12-16] If the patient does not improve during this period, endotracheal intubation is usually mandatory unless strong arguments allow continued NIV (eg, a do-not-intubate order). Keeping this in mind, it is clearly necessary to use adequate monitoring in terms of personal and technical resources to identify those patients in need of endotracheal intubation following a failed NIV trial. However, it is important to remember that NIV failure can occur even after the first few hours. Of note, Olivieri et al[19] covered only a period of 48 h in their study. In a recent review, a late failure rate (ie, occurring $>$ 48 h after NIV initiation) of 17% was calculated from published randomized controlled trials.[26] To minimize risks while using NIV in the general ward, measures need to be taken to precisely and quickly identify those patients at risk. With reduced technical monitoring devices, a high level of staff vigilance is necessary, which again can be secured only by adequate, intensive, and continuous training.

Although NIV use in the general ward instead of an ICU is generally rated as somehow dangerous for the patient due to the reduced monitoring resources, another aspect that is highlighted by the results of Olivieri et al[19] should not be forgotten. Their observation that NIV use was longer during the night than during the day points to the relationship between impaired sleep quality and outcome in NIV therapy. This important relationship has been addressed by Roche Campo et al.[27] They observed that those subjects who developed late NIV failure had severely impaired sleep. In this context, avoidance of the ICU setting with its inherent noise and light may be beneficial for the patient who is not critically dependent on ICU resources other than a ventilator. Prevalence of delirium in ICU patients appears to be related to ICU-related noise and light.[28] Delirium again is a predictor of mortality in ventilated ICU patients.[29] Sometimes in life and also in medicine, less can be more.

The study by Olivieri et al[19] highlights the need for awareness regarding the appropriate setting for NIV initiation, continuation, and termination. Their results are good news: they represent the promise that NIV therapy can be of good quality even with limited resources if the necessary homework has been done. However, it cannot be overemphasized that the adequate training of all involved staff (nurses, ICU and ward physicians, respiratory therapists) is of the utmost importance to obtain good results. The task to tailor an appropriate NIV management pro-

gram, based on general guidelines, to the local conditions will always remain at the local level.

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## REFERENCES

1. Hess DR. Noninvasive ventilation for acute respiratory failure. Respir Care 2013;58(6):950-972.
2. Ram FS, 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(1):CD004104.
3. Weng CL, Zhao YT, Liu QH, Fu CJ, Sun F, Ma YL, et al. Meta-analysis: noninvasive ventilation in acute cardiogenic pulmonary edema. Ann Intern Med 2010;152(9):590-600.
4. Walkey AJ, Wiener RS. Use of noninvasive ventilation in patients with acute respiratory failure, 2000-2009: a population-based study. Ann Am Thorac Soc 2013;10(1):10-17.
5. Chandra D, Stamm JA, Taylor B, Ramos RM, Satterwhite L, Krishnan JA, et al. Outcomes of noninvasive ventilation for acute exacerbations of chronic obstructive pulmonary disease in the United States, 1998–2008. Am J Respir Crit Care Med 2012;185(2): 152-159.
6. Goodacre S, Stevens JW, Pandor A, Poku E, Ren S, Cantrell A, et al. Prehospital noninvasive ventilation for acute respiratory failure: systematic review, network meta-analysis, and individual patient data meta-analysis. Acad Emerg Med 2014;21(9):960-970.
7. Ferrer M, Valencia M, Nicolas JM, Bernadich O, Badia JR, Torres A. Early noninvasive ventilation averts extubation failure in patients at risk: a randomized trial. Am J Respir Crit Care Med 2006;173(2): 164-170.
8. Antonelli M, Conti G, Esquinas A, Montini L, Maggiore SM, Bello G, et al. A multiple-center survey on the use in clinical practice of noninvasive ventilation as a first-line intervention for acute respiratory distress syndrome. Crit Care Med 2007;35(1):18-25.
9. Baumann HJ, Klose H, Simon M, Ghadban T, Braune SA, Hennigs JK, Kluge S. Fiber optic bronchoscopy in patients with acute hypoxemic respiratory failure requiring noninvasive ventilation—a feasibility study. Critical Care 2011;15(4):R179.
10. Elliott MW, Confalonieri M, Nava S. Where to perform noninvasive ventilation? Eur Respir J 2002;19(6):1159-1166.
11. Vitacca M. Where and how must we perform noninvasive mechanical ventilation? Monaldi Arch Chest Dis 1997;52(1):80-82.
12. Schönhofer B, Kuhlen R, Neumann P, Westhoff M, Berndt C, Sitter H. Clinical practice guideline: non-invasive mechanical ventilation as treatment of acute respiratory failure. Dtsch Arztebl Int 2008; 105(24):424-433.
13. Mechanical Ventilation Committee of the Brazilian Intensive Care Medicine Association, Commission of Intensive Therapy of the Brazilian Thoracic Society. Brazilian recommendations of mechanical ventilation 2013. Part I. J Bras Pneumol 40(4):327-363, 2014.
14. Keenan SP, Sinuff T, Burns KE, Muscedere J, Kutsogiannis J, Mehta S, et al. Clinical practice guidelines for the use of noninvasive positive-pressure ventilation and noninvasive continuous positive airway pressure in the acute care setting. CMAJ 2011;183(3):E195-E214.
15. Chawla R, Khilnani GC, Suri JC, Ramakrishnan N, Mani RK, Prayag S, et al. Guidelines for noninvasive ventilation in acute respiratory failure. Indian J Crit Care Med 2006;10(2):117-147.
16. American Thoracic Society, European Respiratory Society, European Society of Intensive Care Medicine, and Société de Réanimation de Langue Française. 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.
17. Plant PK, Owen JL, Elliott MW. Early use of non-invasive ventilation for acute exacerbations of chronic obstructive pulmonary disease on general respiratory wards: a multicentre randomised controlled trial. Lancet 2000;355(9219):1931-1935.
18. Cabrini L, Idone C, Colombo S, Monti G, Bergonzi PC, Landoni G, et al. Medical emergency team and non-invasive ventilation outside ICU for acute respiratory failure. Intensive Care Med 2009;35(2): 339-343.
19. Olivieri C, Carenzo L, Vignazia GL, Campanini M, Pirisi M, Della Corte F, Navalesi P. Does noninvasive ventilation delivery in the ward provide early effective ventilation? Respir Care 2015;60(1): 6646.
20. Carlucci A, Richard JC, Wysocki M, Lepage E, Brochard L. Noninvasive versus conventional mechanical ventilation. An epidemiologic survey. Am J Respir Crit Care Med 2001;163(4):874-880.
21. Carron M, Freo U, BaHammam AS, Dellweg D, Guarracino F, Cosentini R, et al. Complications of non-invasive ventilation techniques: a comprehensive qualitative review of randomized trials. Br J Anaesth 2013;110(6):896-914.
22. Bierer GB, Soo Hoo GW. Noninvasive ventilation for acute respiratory failure: a national survey of Veterans Affairs hospitals. Respir Care 2009;54(10):1313-1320.
23. 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.
24. Dres M, Tran TC, Aegerter P, Rabbat A, Guidet B, Huchon G, et al. Influence of ICU case-volume on the management and hospital outcomes of acute exacerbations of chronic obstructive pulmonary disease. Crit Care Med 2013;41(8):1884-1892.
25. Wood KA, Lewis L, Von Harz B, Kollef MH. The use of noninvasive positive pressure ventilation in the emergency department: results of a randomized clinical trial. Chest 1998;113(5):1339-1346.
26. Ozyilmaz E, Ugurlu AO, Nava S. Timing of noninvasive ventilation failure: causes, risk factors, and potential remedies. BMC Pulm Med 2014;14:19.
27. Roche Campo F, Drouot X, Thille AW, Galia F, Cabello B, d'Ortho MP, Brochard L). Poor sleep quality is associated with late noninvasive ventilation failure in patients with acute hypercapnic respiratory failure. Crit Care Med 2010;38(2):477-485.
28. Caruso P, Guardian L, Tiengo T, Dos Santos LS, Junior PM. ICU architectural design affects the delirium prevalence: a comparison between single-bed and multibed rooms. Crit Care Med 2014;42(10): 2204-2210.
29. Ely EW, Shintani A, Truman B, Speroff T, Gordon SM, Harrell FE Jr, et al. Delirium as a predictor of mortality in mechanically ventilated patients in the intensive care unit. JAMA 2004;291(14):1753-1762.