The importance of education and training for noninvasive ventilation: suggestions from the literature

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Noninvasive ventilation (NIV) is a commonly used respiratory support. The use of the NIV is expanding over time and, but its knowledge and skills are very important for the proper use of this life-saving support. This study aims to evaluate the available evidences for the education and training of NIV. There are no clinical trials examining the impact of education and training of the NIV as the primary objective. However, few studies with indirect evidences, and evidence from a simulation-based training, and some reviews were found. Organized training to increase NIV skills is also limited mostly within few developed countries. Education and training in NIV have the potential to increase knowledge and skills of the staff. The development of organized education and training program in NIV appears to be the need in several types of disciplines and care environments.

Keywords:
education, noninvasive ventilation, programs, staff, training

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Introduction

The growing interest in the quality of patient care at the level of healthcare professionals is a clear evidence. The growing population requiring good quality health has been increasing over time. Healthcare professionals have always been concerned with the quality they can provide to their patients with the best available treatment options. These aspects are of interest to those in the internal and respiratory care field and are working on more critical patients. An example is noninvasive ventilation (NIV), as an alternative to intubation which has led often to lower mortality and intubation rates compared with standard medical treatment. An NIV program should be a multidisciplinary and quality-improvement initiative. In this regard, an educational program is paramount [1].

The education and training of medical personnel in NIV is essential in improving the outcomes, reducing failures, and avoiding complications associated with the use of ventilation [1]. Proper training allows the use of NIV in several acute exacerbations and disorders such as acute respiratory distress syndrome or acute decompensated chronic obstructive pulmonary disease (COPD) to gain time and to avoid early acute invasive mechanical ventilation (IMV) [1]. Furthermore, adequate training of staff is cost efficient for patient care. In this regard, a proper training period should be part of the training of respiratory healthcare professionals, being part of the multidisciplinary respiratory team dealing the NIV. Based on the hospital organization, respiratory, emergency medicine, and ICU physicians are key components of this multidisciplinary team. They should be familiar with different diseases underlying the respiratory failure, treatments, and knowledge on how and when to initiate and to control NIV. Furthermore, they need to be well grounded in intensive care medicine. Nurses are also key actors in the management of patients under NIV. They are responsible for 24-h patient care within the hospital setting and their contribution is essential for the multidisciplinary respiratory team. As key professionals in the coordination of patient care, nurses may contribute to the collaborative cost-effective approach for patients under NIV [1,2]. Specialized nurses as well as respiratory therapists, who exclusively deal with ventilator settings, patient adaptation, respiratory equipment, and monitoring of the NIV can help to keep the focus on NIV and can prevent desynchronization on NIV and therapeutic failure. Respiratory physiotherapists need to work closely with other members of the multidisciplinary respiratory team [2]. This is achieved through a combination of education and intervention for the specialized physiotherapists dealing with NIV. Physiotherapy supports for patients on NIV aims to

aid expectoration, and also reduce his/her fear and anxiety, dyspnea, and work of breathing [2].

Importance and influence of staff training on outcome with noninvasive ventilation

It is well known that a proportion of patients undergoing NIV support will fail, requiring intubation and IMV. The failure depends on several factors, including particularly the skill levels of physicians, nurses, and therapists in this technique and at last but not least patient's clinical situation. In this regard, it is important that the personnel and the facility for intubation are rapidly available if needed. This is essential for every kind of clinical settings to avoid an increased mortality trend with the NIV. Since it is known the advantages with respect to invasive ventilation, NIV is frequently implemented also in advanced disorders, in search of new evidence for its effectiveness, and trying to leave the option of tracheal intubation as the last measure of respiratory support [1].

Several variables recorded at starting NIV and after a short period of ventilation have been described to be able to predict the likelihood of success or failure with a reasonable degree of precision. One of the most important parameters is the level of pH after a few hours of ventilation [3]. A decrease in $PaCO_2$ also reflects the efficiency of the NIV and gives reason to continue. In hypercapnic acute respiratory failure (ARF) patients, improvement in respiratory rate, heart rate, $PaCO_2$, and pH, 1 h after starting NIV predicts the success of NIV [4]. Simple clinical monitoring of respiratory rate and chest and abdomen movement along with an analysis of arterial blood gases can indicate the patients at risk of acute respiratory acidosis and failure [5]. This reflects the importance of well-adapted ventilation from the beginning. Accordingly, there are several prognostic factors that depend on staff training like leak minimizing, coordination with the ventilation, and compliance. However, even at the highest risk of failure, NIV can succeed and if so the outcome can be superior to IMV.

In a recent study, a group of consecutive patients requiring NIV due to acute hypercapnic respiratory failure were included in a prospective, observational cohort study performed on general medical wards aiming to analyze the variables related to NIV outcomes [6]. Although the number of patients was small, the authors were able to identify an inadequate use of NIV due to lack of personnel training in all patients in which NIV failed. Some of the errors detected were that there was poor mask fitting with excessive air leaks; the personnel did not know how to deal with ventilator alarms, or did not know how to control oxygen therapy using high flow, or simply the ventilator was not used during that shift because the staff was not familiar with how to operate it. The authors concluded that staff training was a key factor impacting the NIV outcome [6]. Centers attending patients with an ARF should have an area in which this requirement is fulfilled. The application of NIV by a trained and experienced team, with careful patient selection, should optimize patient's outcomes. The providers should be able to pick up the NIV failure early, and for this knowledge detecting timing and the cause of failures are important. arterial blood gases within an hour and short timings of vital checks can make a difference [7]. Another study found that the time taken by a respiratory physiotherapist for initiation of NIV changed significantly with training [8]. Inadequate knowledge and skills are shown as the reasons for low utilization of NIV [9]. Evidence also indicates that the medical and nursing team members feel ill-prepared and unsafe to deliver NIV in accordance with the guidelines due to lack of skills [10]. Utilization of the NIV has remained low despite the fact that the technology has evolved and is being easily available also in the emergency department [9,11]. Overall, data from worldwide literature indicate that the levels of knowledge and skills for NIV implementation need often to be enhanced among the entire healthcare professionals except for the respiratory physiotherapists [12–20].

Staff to initiate noninvasive ventilation: who and when?

NIV has been reported to be a time-consuming procedure, especially at the beginning of the training period. A number of studies on ICUs have shown that a significant amount of time is required in the initial stages to establish the patient on the NIV [8,21]. However, there is a learning curve and with time and experience, the required time improves [22], with no difference in workload between skilled nurses and physicians applying NIV. As new equipment and technologies for NIV implementations (e.g. interfaces, ventilators, and breathing circuits) become available in the settings of care, the professionals are challenged to acquire adequate knowledge and skills to manage them. In fact, often different ventilators and NIV equipment can be found inside a single ward. However, even in this case, this

temporary difficulty will be compensated with time and the plateau of the learning curve [13]. Therefore, though a considerable amount of time is needed for training and education when a unit first starts to provide NIV, as long as a critical mass of nurses and therapists remain, new staff will gain the necessary skills from their colleagues. Respiratory physiotherapists are the most often responsible for applying NIV in North America while in India it is mostly done by physicians [1,13]. According to the recent literature, the experience and skill of the personnel who manage NIV are the key components of NIV success. Over an 8-year span in an Italian Respiratory ICU, Carlucci *et al.* [23] found that their overall NIV success rate remained steady despite an increasing severity of illness of patients treated with NIV and concluded that increasing experience with NIV over time allowed caring for sicker patients while maintaining the same success rate. Over a 7-year period in a French ICU, Girou *et al.* [24] found that the utilization rate of NIV among almost 500 patients who presented with ARF due to either COPD or congestive heart failure rose from ~20% to more than 80% from the beginning of NIV use. During that same period, the rate of ventilator-associated pneumonia dropped from 20 to 8%, with a corresponding drop in mortality. The authors attributed the improved outcomes to routine use of NIV and a 'learning effect' [24]. Although difficult to be proved, both the studies [23,24] attributed outcome improvements to increasing experience and skill of the staff. Nicolini *et al.* [4] found similar results in their study on factors related to NIV failure. Protocols are used as a strategy to lower the occurrence of medical errors, omissions, and delays. They may reduce conflicts between team members, improve outcomes, decrease costs, and increase educational efforts. The development of protocols and guidelines for NIV management is recommended in order to clarify the roles of each professional and to increase the efficiency during NIV application [13]. Regular ward rounds with documented outcomes and review of defined treatment goals between nursing and medical staff have been shown to reduce the length of ICU stay. The gold standard teaching tool is individual feedback on videos of real meetings [25]. Competency in communication is a core clinical skill, which must be taught, tested, and practiced. An understanding of the evidence and theory of communication coupled with a commitment to cultivate and improve skills not only benefit patients and their families, but it can also invigorate professional practice and provide an ongoing clinical challenge [25,26].

Starting noninvasive ventilation use

The best location for NIV treatment depends on several factors, including particularly the skill levels of physicians, nurses, and physiotherapists in this technique. With relatively small number of patients per month, the NIV is best performed in a single location within every center, in order to facilitate staff training and to maximize the results. Interestingly, when deciding where to start NIV, staff training and experience are more important than the location itself [23,25]. Skills and early recognition of failure cannot be replaced by high levels of technologies for patient monitoring. An adequate NIV-skilled personnel should be available 24 h/day. Ideally, the NIV should be usually best carried out in a single location with one nurse responsible for no more than 3–4 patients in total in every shift [13,27]. The NIV is also increasingly used in pulmonary rehabilitation programs in addition to aerobic exercise training, allowing moderate and even more severe COPD patients to train at higher intensities. The overall benefits are improving in exercise capacity, dyspnea, and health-related quality of life. Assisted ventilation leads to better leg muscle oxygenation during exercise and prevents exercise-induced diaphragmatic fatigue. Another application is the addition of nighttime NIV to daytime exercise training in severe stable COPD patients, with significant improvement in exercise capacity and health-related quality of life compared with the patients only physically trained [13]. Noninvasive ventilatory support is seen now as the treatment of choice in the management of patients with RF during sleep, with consequences on sleep quality and gas exchange [28]. The choice of interface plays an important role in patients' outcomes. Willson *et al.* [27] have reported that nasal masks were associated with the patients with an increased comfort and decreased oral leak compared with oronasal masks. In COPD patients under long-term home respiratory support, NIV was administered during walking, resulting in improved oxygenation, decreased dyspnea, and increased walking distance [29]. There are selected patients with limitations in life support and treatments [e.g. do-not-intubate (DNI)] or near the end of life, that will receive comfort measures only (CMO). If the patients are informed on risks and potential benefits of NIV and consent with the method, NIV can be appropriate to DNI and CMO patients to reverse an ARF episode, or to improve patient comfort, or to delay death [30]. The patients should be educated that NIV is a form of noninvasive life support that can be discontinued at any

time; if the patients fully understand the risks and benefits, and is comfortable with NIV, the treatment should be administered, even for a short period. It seems that NIV at the end of life is more likely for DNI and CMO patients with COPD and congestive heart failure than in end-stage cancer patients [15]. In DNI patients, NIV may reverse the acute hypercapnic respiratory failure and allows patient's discharging from the acute-care facility. Increasing patient comfort by decreasing shortness of breath and avoiding opiates to reduce dyspnea may be of interest in CMO patients [28].

The use of NIV in general wards is also gradually increasing [1]. It was reported as effective in achieving the goals [16]. The authors emphasized that improvement in staff training and introduction of protocols could help to make this technique safer and more common. However, one recent study found that, although protocol-based management is feasible, it was not significantly superior to nonprotocolized management [30]. On the other hand, finding from a national survey suggested that protocol-based management or initiation of NIV may have a good impact [12].

Educational programs and efficacy of the noninvasive ventilation

A PubMed/Medline advanced search for a time duration of 1990 to 2019 with index word 'noninvasive ventilation,' 'training,' 'education,' 'training/assessment,' and 'education/assessment' showed no relevant clinical trial except few review articles. This indicates that the field is yet to be explored and the opinions of the experts too indicate so. One study examining the simulation-based training of staffs in NIV has shown to be effective in skill development and is likely to play an important role for proper utilization [31]. Another study indirectly indicates that the training was effective in reducing the initiation time of the NIV by respiratory physiotherapists [8].

Training programs

Training program in the NIV is prevalent in European as well as other developed countries. The European Respiratory Society conducts both basic and advanced training in NIV [32,33]. The project, Harmonized Education in Respiratory Medicine for European Specialists, is a notable initiative of European Respiratory Society [34,35]. The use of NIV in clinical practice in India is not uncommon [36], but such organized education programs are lacking in developing countries like India. Although, the majority of the clinicians in India uses it, a marked variation in the patterns relating to actual deployment of NIV, site of initiation, protocols for initiation, and monitoring of patients were noted [36].

So far, there are extensive and detailed reviews and recommendations on NIV summarizing indication and practical application [5,13]. These publications are treated as the theoretical fundament for the use of NIV physicians who should be familiar with. However, these manuscripts give only few suggestions on how to train physicians, nurses, or physiotherapists. The British Thoracic Society guidelines [37] include some recommendation on training programs. It is recommended that all staff involved in the NIV service should receive training appropriate to their individual knowledge. This should include a combination of knowledge-based learning supported by clinical experience in the workplace. Training in India is mostly through workshop during different zonal and national conferences and is mostly limited to the physicians. This type of training has limited impact in changing practice [38]. The Tact Academy of Clinical Training is also running a 2-day program for training in Mechanical Ventilation with a target audience of physicians. Unlike European Respiratory Society, which runs training module for the NIV, the Indian Society of Critical Care Medicine is yet to take that step, although the Indian Society of Critical Care Medicine came out with the guideline for NIV in ARF more than a decade ago [39]. Training programs should build knowledge in a progressive manner to ensure the knowledge about various topics regarding NIV. This training should be compulsory to all healthcare professionals dealing with NIV at any time, including not only physicians, but also nurses and physiotherapists. Training time needed for adequate training of health personnel involved in the NIV is very variable between studies and there are currently no agreed standards. Some authors have suggested that an initial session of 2 h three times a month may give an initial basis to start using the NIV safely [1]. These sessions can distance themselves in time with increasing experience of staff. Although the contents may vary slightly depending on the target audience (physicians, nurses, respiratory physiotherapists), generally speaking, they should include all these figures. Optimal management of NIV requires that all members of the team be experienced and skillful. Physicians and respiratory physiotherapists need to be adept at selecting patients who are likely to succeed with NIV and

promptly intubating patients likely to fail NIV [2]. They must be skilled at selecting an appropriate mask, fitting it to optimize comfort, and adjusting the ventilator to alleviate respiratory distress efficiently. Nurses need to be knowledgeable about monitoring, to help avoid and detect problems [1,2]. Quantifying the experience and skill of a unit's staff is challenging because individuals differ considerably and personnel changes can have important effects. However, as units use more NIV, outcomes appear to improve. Periodic in-services and updates probably help personnel maintain their skills and stay abreast of new developments [4,40]. Simulation has been defined as 'a technique, not a technology, to replace or amplify real experiences with guided experience, often immersive in nature, that evokes or replicates substantial aspects of the real world in a fully interactive fashion' [41]. Simulation-based medical education can therefore be defined as any educational activity which uses simulated components to replicate clinical practice [42]. Several systematic reviews have investigated the effectiveness of simulation-based medical education in terms of knowledge and skills outcomes and there is now a large body of good quality research evidence which demonstrates that simulation-based education is not only effective in terms of skill acquisition but also that clinical skills acquired during simulation-based training translate directly into improved patient care and better clinical outcomes [2]. Currently, there are few NIV simulator models which can be used to assess the user's competence in establishing ventilator settings and understanding and correctly responding to the effect of the ventilator on patient's pathophysiology and tolerance. Evidence suggests simulation-based education is effective in terms of clinical skills acquisition and that these skills translate into improved patient care and clinical outcomes. A study by Spadaro *et al.* [43] compared computer-based approaches to mannequin-based approaches for training residents on MV. This prospective randomized single-blind trial involved 50 residents. All participants attended the same didactic lecture on respiratory pathophysiology and were subsequently randomized into two groups: the mannequin group (n=25) and the computer screen-based simulator group (n=25). One week later, each underwent a training assessment using five different scenarios of ARF. Later, both groups underwent further testing of patient management, using in-situ high-fidelity simulation of a patient with ARF. In the final assessment, the scores of only the mannequin group significantly improved between the training and final session in terms of either global rating score or percentage of key score [43]. An ideal NIV education course should be constituted of 30% lectures, 20% interaction and question time dedicated to learners, and 50% hands-on training. The total duration time of the course and the rate of time to be spent for theory and practice sessions should be decided taking into account the characteristics of trainees (roles and number of participants), the typologies of equipment, and the level of NIV to be explained (e.g. high flow CPAP, Helmet/Mask PSV) [44]. The use of high-fidelity simulation training could be useful for acquiring NIV skills. However, published literature about this method of learning the NIV know-how is still scant [2,12,17,25,31,44]. The hands-on training sessions should offer to the learners the opportunity to play the role of 'patient'. The fitting of a mask, a helmet, and feeling on their own positive expiratory pressure and pressure support ventilation aid the trainees to understand how NIV works and its collateral effects on patients. These experiences provide the trainees with a unique awareness that can help them to manage real NIV situations at the patients' bedside [44]. Like any other educational program, the education and training module should be audited and updated as per feedback and requirement and the cycle of implementation, evaluation, modification, and reimplementation should go on [2,44].

Conclusion

Education and training in the NIV have the potential to increase knowledge and skills of the staff. The development of organized education and training program in NIV appears to be the need of the hour, especially in developing countries. Some key messages should be reported at the end of this review. The format of training and education of medical personnel is essential in improving the outcomes, reducing failures, and avoid complications associated with the use of NIV.

(1) When deciding to start NIV, staff training and experience are more important than the location.
(2) The application of NIV by a trained and experienced team associated with critical care, enabling them to start with NIV in any patient at risk, can optimize patient outcomes.
(3) Centers attending acute respiratory patients should have a dedicated area in which staff training and education (simulation area) is a key element.
(4) Significant time is needed for adequate training and education of health personnel involved in the use of NIV; the time requirement is highly variable, but should include repetitive sessions

depending on the degree of expertise, and later on annual refresher courses/updates

(5) Every care hospital, medical institutes/universities should have an NIV training setup, team, and timing throughout the year for training and retraining.

(6) Participants should be retained as and when necessary for newer technologies as well.

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