REVIEW ARTICLE

Noninvasive Ventilation

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Introduction

Mechanical ventilation encompasses all procedures that use a mechanical device to assist or replace a patient's respiratory function. If the ventilatory support does not require inserting an endotracheal tube (by oro- or nasotracheal intubation or tracheostomy), it is called noninvasive ventilation (NIV).[1,2] The early development of this therapeutic modality focused on patients with neuromuscular diseases, sequelae of tuberculosis, thoracic cage deformities, and hypoventilation-obesity syndrome.[3] Negative pressure techniques were the most utilized during epidemics of poliomyelitis in the 1950s but were used less often after the development of mechanical ventilation through an endotracheal tube.[4] At the beginning of the 1980s, when the efficacy of continuous positive airway pressure (CPAP) applied through a nasal mask was described for patients with obstructive sleep apnea syndrome,[5] the number of patients receiving NIV was not great. However, the demonstrated ability of NIV to give effective, comfortable, and well-tolerated mechanical ventilation through a nasal mask[6] encouraged exponential growth in the number of patients using that modality for long periods at home in Spain. Likewise, the application of positive pressure NIV devices in most respiratory medicine wards in Spain also increased.[7-20] Negative pressure techniques were cast aside almost entirely and their use today is exceptional.[21] The 1990s can be considered the decade of NIV and home ventilation thanks to the important invention of the nasal mask.

NIV in Chronic Respiratory Insufficiency

No doubt remains about the efficacy of NIV in patients with chronic respiratory insufficiency (CRI) arising from thoracic restriction. Research has shown that NIV improves quality of life, prolongs survival, and improves gas exchange, and sleep quality in restrictive CRI patients.[3,9,12] Debate continues, however, on the usefulness of long-term ventilation of patients whose CRI is due to chronic obstructive pulmonary disease (COPD).[22-24] Initial experiences reported after noncontrolled trials were generally positive and promising. Evidence available now, however, does not allow us to establish clear criteria for prescribing NIV in COPD-associated CRI. Wijkstra et al[25] recently published a systematic review of controlled trials that analyzed the results of standard NIV treatment in stable COPD patients with hypercapnic respiratory insufficiency. No evidence for improvement in gas exchange, lung function, exercise tolerance, or muscle force was found after 3 months of nocturnal NIV. Given how small the samples were in the trials identified, however, and the short periods of NIV, the authors concluded that further study would be needed to clarify the role for NIV in such patients. Preliminary results from 2 European multicenter studies have found no differences between patients treated with NIV and those treated with oxygen therapy.[26,27] Given these results, in spite of the lack of precise indications, the British Thoracic Society (BTS)[28] recommended that home NIV be considered for COPD patients requiring more than 7 days of treatment during an exacerbation, for patients with severe hypercapnia even after adequate oxygenation, or for those who have been hospitalized 3 or more times in 1 year with hypercapnic respiratory failure. The 1999 Consensus Conference,[24] on the other hand, suggested that nocturnal ventilation be prescribed when $PaCO_2$ is greater than 55 mm Hg in the presence of hypoventilation symptoms. If $PaCO_2$ falls to between 50 and 55 mm Hg, the consensus was to recommend starting NIV if the patient had nocturnal desaturation defined as a pulse oximeter reading of less than 88% for longer than 5 consecutive minutes in spite of receiving oxygen at 2 L/min. Finally, along the lines of the BTS recommendations,[28] nighttime ventilatory support was considered appropriate for COPD patients with $PaCO_2$ between 50 and 55 mm Hg who had been hospitalized with hypercapnic respiratory insufficiency at least twice in 1 year. From a clinical perspective, the absence of clearly defined indications means that the use of NIV in stable COPD patients with hypercapnia tends to differ considerably from one group prescribing these techniques to another.[8]

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NIV in Acute Respiratory Insufficiency

As has happened for patients with CRI, the application of NIV has gradually become accepted for patients with acute respiratory insufficiency (ARI) of varied etiologies, the exacerbation of COPD being the condition with the greatest amount of evidence supporting its efficacy.[29-33] After meta-analysis of randomized controlled trials in patients with COPD exacerbation and $PaCO_2$ greater than 45 mm Hg or a pH less than 7.35, Fernández-Guerra et al[34] reported that NIV reduced mortality and the need for orotracheal intubation (OTI) both in intensive care units (ICUs) and on respiratory medicine wards. The findings after meta-analysis by Lightowler et al[35] were similar, leading those authors to propose NIV as the first line of action in cases of exacerbated COPD with ARI and $PaCO_2$ greater than 45 mm Hg. The early application of NIV, before severe acidosis is established, would reduce mortality and render OTI unnecessary. Those findings led Elliot[36] to suggest that NIV be considered the new gold standard for treating acute COPD exacerbation and in fact that proposal is reflected in the workshop summary of the Global Initiative for Chronic Obstructive Lung Disease,[37] in which the efficacy of NIV in such patients is recognized as being supported by the highest level of scientific evidence.

Recent studies have hypothesized the usefulness of NIV in ARI from a variety of causes, with or without hypercapnia. A range of other obstructive diseases has been considered: asthma and cystic fibrosis[38-41]; diseases of the pulmonary parenchyma such as community-acquired pneumonia or adult respiratory distress syndrome[42,43]; acute pulmonary edema[44]; respiratory complications related to human immunodeficiency virus infection, other forms of immunodeficiency, or immunosuppression in transplant recipients[45-47]; or hypercapnia due to obesity.[20] Likewise NIV is useful in the elderly,[48] cancer patients,[49,50] burn patients,[51] and generally all those who are not eligible for OTI.[52] NIV has also been found useful in patients being ventilated through an endotracheal tube[17,53] and more and more publications are dealing with the utility of NIV during surgery and in patients who develop respiratory failure in the early postoperative period.[54-56]

We have been seeing, then, the wider application of NIV techniques in respiratory medicine wards, home care, ICUs, intermediate respiratory care units, operating theaters, bronchoscopy units, emergency rooms and, very recently, out-of-hospital emergency care settings and ambulance units.[57-62] Excellent, highly recommendable reviews of NIV in both CRI and ARI patients are available in the literature.[1,23,24,28,31,63-65]

NIV Interfaces and Respirators

The most important technical requirements for NIV will now be described, with particular emphasis on the latest developments in masks and respirators.

NIV Interfaces

The success of NIV depends in great measure on the interface, the element of interaction between the patient and the respirator. A perfect balance of mask efficacy and patient comfort and tolerance must be achieved. Various interfaces and systems have been proposed for NIV: the nasal pillow, the nasal mask, the full face mask, the total face mask, and most recently the helmet systems.[64,66,67] The mask-related complications that develop most often are rejection due to discomfort, claustrophobia, facial erythema, leaks, skin rashes, conjunctivitis, and pressure sores—the most feared.[1,3,68] All technical improvements in masks have as their objective to enhance tolerance and reduce the development of complications.

Nasal Mask

The development of the nasal mask was what led to a resurgence in the use of NIV during the 1990s.[5] A great variety of nasal masks are currently available, with a large range of sizes and shapes sold by suppliers. Access to one mask or another, however, is affected by geographic location, given the business policies that hold sway in marketing to our health care system. A traditional debate is whether it is better to use commercially available masks or have them custom made.[4,69,70] Making a mask to fit a patient requires manual skill, physical space dedicated to the task, and a certain amount of training to hone skills. Specially designed masks are useful when 24-hour ventilation is needed and when alternative points of support for the mask are necessary. Such masks have less dead space, adapt well to the patient's physiognomy, and stay in place. Their main drawback is the time needed to make them and the assignment of a staff member to be responsible for their fabrication. The problem of whether to use individually tailored masks, therefore, is one of effectiveness rather than efficacy.[71] Most respiratory medicine departments that work with NIV use commercial models.

A good mask should have the following basic features: provide a sealed shell that is fairly rigid, offer little resistance to flow, and have minimal dead space. It should be comfortable, light, easy to put on, odorless, latex-free, adaptable to different sizes, and esthetically pleasing.[1,71] And all of that should be available at as low a price as possible. The mask should be stable when worn, lightweight, easy to remove, and not cause skin breakdown. Masks on the market use from 2 to 5 points of support and most are fixed by Velcro, straps, or headgear.[72] Finally, to alleviate pressure at support points on the patient's face and prevent sores, masks are made of various materials, such as gel or silicon, that minimize skin contact. The use of spacer devices or hydrocolloid dressings on support points to relieve skin pressure is another strategy that usually gives good results. Small or minimasks allow a patient to wear glasses without interrupting mechanical ventilation.[1]

The nasal mask is the main choice of patients who use NIV over long periods at home. Switching patients with decubitus ulcers among several different models with different support points may be a feasible strategy for maintaining effective ventilation. Rhinorrhea, truly annoying for some patients, can be managed by administering vasoconstrictors or topical corticosteroids. The efficacy of nasal ventilation depends on the patient's keeping a closed mouth, so chin straps or support harnesses can help keep mouth leaks under control, although sometimes the problem can be solved by having the patient sleep on his or her side, head on a pillow.

An alternative to a mask is the nasal pillow, the name given to a device consisting of two tubes that are inserted inside the nares and through which the flow from the respirator enters directly. Since the device does not rest on the nose, it may be useful if pressure sores have developed or if the patient is claustrophobic. Another alternative is an oral device,[73] which is used mainly in neuromuscular patients with high ventilator dependence. Switching from a nasal mask to an oral device allows NIV to be maintained 24 hours a day for long periods, rendering tracheostomy unnecessary or postponing the procedure.[74] The mouthpiece tube can be attached to a wheelchair, facilitating compatibility between mechanical ventilation and social life.

Face Mask

Facial masks were developed in an effort to increase tolerance of NIV, particularly in patients with acute respiratory failure.[75,76] A variety of factors converge to limit the utility of nasal masks in uncooperative patients, such as those with ARI, tachypnea, and anxiety. One is leakage, a problem of such major importance that it alone can compromise the efficacy of NIV. A stubborn mouth leak decreases alveolar ventilation, reduces the positive pressure that affects respiratory muscles, and renders NIV less effective in reducing work of breathing. The need to administer the high flows that are usual in patients with ARI can also increase nasal resistance and likewise diminish the efficacy of ventilation delivered through a nasal mask. The face mask, covering both the nose and mouth, allows the patient to receive gases through both natural routes, eliminating the problem of mouth leaks and the increase of nasal resistance.[75]

A comparative study of 3 models of masks showed that although nasal masks were better tolerated, they were less effective in reducing $PaCO_2$ due to leaks.[77] That finding gives a certain degree of support to the widespread notion that face masks are the interface of choice for patients with ARI. Face masks interfere with feeding, communication, and expectoration, and they can give rise to claustrophobia in a large number of patients. Modern face masks have an anti-asphyxia, anti-rebreathing valve that allows patients to continue breathing spontaneously in case the respirator malfunctions. They are also equipped with fast-release clips to give immediate access to the airway if necessary—for example for an emergency OTI. A study attempting to improve tolerance to face masks by Lloys et al[78] showed that filling the seal interface with water rather than air reduced the incidence of pressure sores. Patients who cannot be effectively ventilated through a nasal mask may be considered for long-term home ventilation through face masks, although such cases will be exceptional.[1,12,28]

Total Face Mask and the Helmet System

Criner et al[79] developed the total face mask with the intention of making NIV more comfortable. The total face mask is sealed around the entire perimeter of the patient's face, thereby avoiding the placement of direct pressure on anatomical structures. The authors found that leaks were eliminated, such that ventilation and patient well-being improved.

A transparent helmet system has recently been proposed as having certain advantages over face masks.[80,81] Tolerance is good and patient interaction with the surrounding environment is satisfactory. There is little risk of pressure sores from the system for fixing the helmet in place, and adaptation is perfect regardless of the patient's facial structure.[82] Two helmet systems are available for NIV: the CaStar helmet (Starmed, SPA, Mirandola, Italy), designed to apply CPAP in patients with hypoxemic ARI, and the Sea-Long Medical Systems hood (San Antonio, TX, USA), developed to administer hyperbaric oxygen therapy.[83]

The CaStar helmet is manufactured in a transparent, biocompatible plastic material that is polyvinyl chloride-free on the front, allowing the patient to look out, read, and interact with the environment. A ring device keeps the helmet fixed to a lower section, which is fixed by a crossed harness. A soft membrane seals the helmet against leaks and side ports attach to the respirator's inspiratory and expiratory circuits. A disposable nasogastric tube can be inserted through the helmet to allow intake of a liquid diet. A helmet developed specifically to reduce rebreathing in NIV has a low internal volume, an anti-asphyxia valve, and an internal insufflation system.[83]

Complications like pressure sores, conjunctivitis, and gastric distension are reduced when the helmet is used. However, Cavaliere et al[84] described transient injury to the tympanic membrane during treatment because of loss of the protective action of the tympani tensor muscles, and they recommended using ear plugs when the helmet is worn. Other rare complications that have been described are related to pressure from the helmet on cervical structures, notably upper limb edema, venous thrombosis and axillary lesions because of decubitus positioning. Esquinas et al[83] have described hand and forearm paresthesias and weakness in a patient receiving NIV by helmet.

Studies have shown that helmet systems seem to be

more effective than facial masks in reducing the rate of OTI. They are better tolerated and do not represent a greater burden for nursing staff.[80,81,85,86] Greater patient well-being means that treatment can be carried out for longer periods and the lower incidence of leaks means that higher pressures can be administered. The use of helmets in ARI patients in an appropriate setting (an ICU or intermediate respiratory care unit) allows NIV to be provided to more patients and those with more severe disease. The indications for NIV have thus been gradually extended to acute cases and to complementary use during other procedures such as bronchoscopy.[87]

Types of Respirators

A variety of respirators can be used for NIV, from conventional units and sophisticated ICU models to small portable ventilators whose performance is satisfactory in spite of their simplicity. What makes ventilation noninvasive is not the machine itself but rather the interface. Traditionally, respirators are volume limited or pressure limited.[88,89] CPAP is not a ventilatory modality in and of itself, even though its use is extended to patients with certain types of respiratory insufficiency, mainly those with acute pulmonary edema.[90]

Volumetric ventilators. Volumetric ventilators are set to deliver a specific volume during each ventilatory cycle, regardless of the pressure reached by that volume in the airways.[1,12,23,24] Such respirators are heavier and more expensive than pressure units, but they are usually equipped with alarms and batteries that guarantee that they will work in the absence of a power supply.[91,92] The standard circuit on this type of respirator incorporates an expiratory valve to remove air exhaled by the patient. If necessary, a device can be added to the valve to maintain positive pressure during expiration. The models most often used in Spain—the PLV-100 (Respironics, Boulogne, France), Airox Home 1 (Bio MS, Pau Cedex, France), EOLE 3 (Saime SA, Savigny, Le Temple, France), PV 501 (Breas, Surrey, UK), and LP10 (Puritan Bennett, Pleasanton, CA, USA)—are very similar and whichever one is used depends more on administrative issues related to suppliers' commercial policies than to efficacy.[12] All have a control panel from which the following parameters can be set[93-95]:

– *Tidal volume.* Tidal volume, the constant programed in volumetric ventilation, is recommended to be set around 10 to 15 mL/kg depending on patient tolerance, arterial blood gas response, leaks, and patient condition. The tidal volumes for NIV are greater than —generally nearly double—the volumes needed for endotracheal ventilation.[1,12] Most patients receive tidal volumes around 900 to 1200 mL once they have properly adapted to NIV with this type of respirator.

– *Respiratory rate.* Given that we are trying to allow respiratory muscles to rest, a breathing rate that is slightly higher than the patient's resting rate should be programed in order to anticipate ventilatory drive. Although patients can display anxiety and develop tachypnea when NIV is initiated, adequate ventilation can usually be achieved at a respiratory rate of 18 to 20 breaths/min after a short period of adjustment. Assist-control ventilation, which is the most commonly applied NIV modality, allows the patient to increase respiratory rate upon demand over the preset rate as needed. Nevertheless, ventilation is controlled nearly all the time for most patients, particularly for those with neuromuscular diseases.

– *Inspiratory-expiratory ratio.* The ratio of inspiration to expiration allows the amount of time spent inhaling and exhaling to be defined. A ratio of 1:1 gives equal time to each. At a respiratory rate of 20 breaths/min, a 1:1 ratio means that the patient has 1.5 seconds to inhale and 1.5 seconds to exhale. Prolonging expiratory time, using ratios of 1:2 or 1:3, is recommended for patients with obstructive disease. Shortening inspiratory time involves having the same volume of air reaching the patient in less time, such that inspiratory tidal volume must be greater and, therefore, higher mask pressures are reached. It may be desirable for some patients to reach higher peak pressures during inspiration, although in general higher pressures are related to the development of leaks and decreased tolerance to NIV, leading to the development of flatulence when the upper esophageal sphincter opens. Leger et al[3] observed that 50% of the 276 patients they studied experienced abdominal distension related to the passage of air to the stomach. Two such patients, both with Duchenne's muscular dystrophy, even withdrew from NIV as a result. Adjusting respirator parameters in an effort to reduce peak pressure without compromising efficacy of ventilation is one way to alleviate this problem.[96] Reducing the volume released by the respirator can alleviate patient discomfort, although at the risk of lowering the insufflation pressure and losing some degree of ventilatory efficacy. Similarly, peak pressure can be regulated by using a steeper ramp on devices equipped with that function or by varying the inspiration–expiration ratio.[3,24] As the technical specifications of respirators differ, changing the model used or the ventilatory modality may also be effective.[97]

– *Sensitivity, or pressure trigger.* Most volumetric respirators incorporate a pressure trigger by which changes in pressure inside the ventilatory circuit originate the switch from inspiration to expiration or vice versa. The theory behind NIV is that treatment aims to provide as much rest as possible for the patient's respiratory muscles, such that the effort needed to activate the respirator should be minimal. Therefore, the NIV trigger setting should allow the respirator to activate inspiration upon detecting the slightest effort on the patient's part, should effort arise, but should not allow automatic cycling.[98] The technical specifications of each

respirator indicate the value for setting this parameter.

– *Alarms.* Equipping a respirator with alarms is highly useful for patients receiving endotracheal ventilation, but alarms may be of little value in NIV. A low pressure alarm would warn of disconnection or circuit leakage, allowing the caregiver in charge of a neuromuscular disease patient to examine the system and correct the problem. A high pressure alarm detains airflow once a certain circuit pressure is reached, in order to prevent middle-ear complications due to pressure changes. However, many patients undergoing NIV cough or drool at night, triggering the alarm, and when the problem goes on all night, sleep becomes impossible. Moreover, real excesses of pressure are solved by way of mouth leaks, and the risk of barotrauma is therefore practically nil. For those reasons, few alarms are usually set when NIV is used.

Volumetric ventilators were at first the most popular way to provide NIV, as they were the most widely known, the ones that ICU staffs were the most familiar with, and the ones that generated the most confidence for use with tracheostomized patients. Later, pressure ventilators, which are simpler and cheaper, became more widely applied, and can now be said to be the most widely used for NIV. Many studies have demonstrated the effective equivalence of volumetric and pressure respirators and the greater tolerance and subjective response to the latter.[10,99,100] Published guidelines recommend choosing a respirator in function of the experience of the medical team and the model they are most familiar with. However, volumetric ventilators present specific advantages in certain situations. Because they are equipped with alarms and batteries, they are the respirators of choice for home ventilation of tracheostomized patients.[17] Likewise, they are the first choice for adequately ventilating neuromuscular disease patients and those requiring high insufflation pressures (patients who have chest restriction or who are obese).[1] Volumetric respirators also offer the possibility of carrying out maximal insufflation maneuvers, thereby relieving the burden of expiratory muscles.[101-104] Such assistance is as important as the relief afforded to inspiratory muscles. In neuromuscular disease patients, the loss of the cough reflex, with consequent retention of secretions and the development of respiratory infections, even pneumonia, is the situation that most often leads to NIV failure and the need to perform a tracheostomy.[102,103] Maximal insufflation is, therefore, a treatment of vital importance for such patients and the ability of volumetric ventilators to provide it means that they have a clear advantage over pressure ventilators. The prescription of maximal insufflation has to be made on demand, in response to a particular patient's condition.

Pressure ventilators. The portability, size, efficacy, tolerance and low cost of pressure respirators have meant that they are ideal for patients with CRI who need only nocturnal ventilation. Moreover, as a result of features that will be described below and of the possibility of providing positive pressure support, pressure respirators are preferred for patients with ARI.[1] In pressure ventilation the device is set for a particular inspiratory positive airway pressure (IPAP), generally between 10 and 20 cm H_2O, and an expiratory positive airway pressure (EPAP) that is usually lower than 6 cm H_2O. When the patient begins to inhale, the respirator supplies air until the programed IPAP is reached, without taking into consideration the real volume administered, given that the volume will depend on the patient's ventilatory pattern. It is the patient him or herself who determines the respiratory rate and inhalation time; meanwhile the respirator is able to detect such ventilatory activity by way of a highly sensitive trigger. The best synchrony between the patient and the respirator facilitates the reduction of work load for the diaphragm and increases the patient's sense of well-being.[105]

The standard circuit for this type of respirator is quite simple, as there is no expiratory valve. To prevent the effects of rebreathing CO_2, an anti-rebreathing valve is incorporated. That valve and the provision of positive expiratory pressure together mean that exhaled air with CO_2 is always leaving the mask. Pressure respirators usually have a control panel that is simpler than those of volumetric ventilators. The parameters that can usually be set are as follows[1,12,23,24,107]:

– *IPAP, or pressure support.* The maximum inspiratory pressures available on various ventilators vary from 20 to 40 cm H_2O, although most patients receive IPAP between 10 and 20 cm H_2O, a level that complements the pressure generated spontaneously by the patient. Such IPAP levels have proven effective based on clinical and gasometric criteria and are well tolerated by patients. Pressures over 20 cm H_2O can lead the patient to initiate active expiration before the end of insufflation by the respirator, a situation that favors the loss of patient–ventilator synchrony and increased work of breathing for the patient. Some authors start ventilation with low pressures and proceed to increase them according to patient tolerance, whereas others prefer to begin with higher pressures and decrease them only if intolerance develops.[1]

– *EPAP.* An EPAP is usually set to prevent rebreathing in obese patients with very low residual functional capacity to maintain alveoli open and, particularly, in patients with COPD in order to counterbalance intrinsic positive end-expiratory pressure. An EPAP of up to 6 cm H_2O, the maximum that can be used, has been shown to have no deleterious hemodynamic effects. Nevertheless, several authors have warned that the risk of death from acute myocardial infarction increases when EPAP is applied in a subgroup of patients with acute pulmonary edema.[108] Mehta et al[109] had to interrupt a trial upon observation of a much higher incidence of heart attacks in the group of patients treated with positive pressure than in the group treated with CPAP (71% vs 31%,

respectively). More recently, Pang et al[110] published a meta-analysis of trials carried out in patients with acute pulmonary edema treated with NIV, finding no evidence of negative effects of NIV in such patients. Therefore, while new studies are awaited, those authors recommend that CPAP applied between 10 and 12.5 cm H_2O be considered the treatment of choice, reserving pressure support ventilation for those with significant hypercapnia or clear clinical deterioration in spite of CPAP.[110]

– *Trigger.* As mentioned, these respirators usually have a sensitive trigger valve able to detect variations in flow.[98,111] The inspiratory effort made by the patient activates the programed IPAP and the reduction of inspiratory flow indicates a switch to expiration. A trigger responsive to flow presents certain advantages over a trigger responsive to pressure on volumetric ventilators, as the flow trigger is more sensitive and may be better tolerated. Less effort is needed to open the supply valve, which leads to a clear decrease in time and effort needed to trigger the respirator. Optimum ventilation from a respirator requires that the device respond rapidly to the inspiratory and expiratory flow and that it provide a high inspiratory flow that satisfies the patient. It is sometimes useful to be able to choose the cut point in inspiratory flow reduction, and also to be able to opt for automatic expiratory cycling after a preset inspiratory time.[107] As not all respirators incorporate this feature, it must be looked for. A thorough understanding of a given ventilator model is more useful than being able to manage various devices imperfectly.

– *Ramp or rise time*. As respiratory rate and inspiratory time are determined by the patient, there is no setting for an inspiratory–expiratory ratio as is provided by volumetric ventilators. Some models, such as the BiPAP® by Respironics incorporate the possibility of regulating inspiratory time, but only if the nonstandard timed mode is specially chosen.[1] The possibility of modifying peak pressure during inspiration is only available on pressure ventilators with a rise time or ramp feature that allows the fixing of different times for reaching the peak pressure setting.

Some severely ill or highly dyspneic patients may need higher flows than those administered by respirators operating in standard mode. In such cases, in which a patient is in great need of air and is fighting against his or her own respiratory impedance as well as that of the respirator, it can be very effective to increase inspiratory flows to up to 100 L/min. When increasing inspiratory flow with the aim of decreasing inspiratory time and extending expiratory time, it is important to remember that shortening inhalation can lead to a significant increase in respiratory rate.[107]

Pressure ventilators are lighter, more economical devices than their volumetric counterparts, and their use has therefore spread in recent years.[1,7] The most commonly used respirators in Spain are the previously mentioned BiPAP®, the VPAP III (ResMed Spain, SL, Madrid) and Eole Helia (Saime, SA) models, although the marketplace never ceases to produce ever more fully-equipped devices with improvements in alarms, batteries, oxygen mixers, or displayed readings, such as the possibility of seeing the tidal volume being supplied. If a respirator is not equipped with these features, it should not be used for ventilation through an endotracheal tube in critically ill patients. However, these respirators have become the first choice in treating most patients with ARI arising from any condition, thanks to their ability to compensate for small leaks, their sensitive triggering of an inspiratory cycle, rapid supply of the preset pressure and flow, the option of setting an expiratory cycle time to prevent problems caused by leaks in low-flow cycles, and their ability to allow tachypnea to be managed by guaranteeing a certain number of breathing cycles if the patient fails to trigger inspiration.[13,28,31] Pressure ventilation decreases work of breathing, increases a patient's sense of well-being, and relieves breathlessness significantly. Changes in the patient's level of consciousness and improvements in both pH and $PaCO_2$ upon starting NIV are the main factors that predict success.[112,113] It must be remembered that NIV does not replace OTI, and it is therefore necessary to attend to signs and symptoms that indicate deterioration in order to consider initiating invasive ventilation. Such symptoms would be the presence of hemodynamic instability, cardiac arrest, excessive secretions, significantly altered levels of consciousness, or the presence of facial burns, surgical wounds, or injuries that prevent the mask from being held properly in place.[1]

The most common causes of pressure respirator failure are related to defective response to the patient's ventilatory demands (which are generally more complex in severely ill patients), whether due to problems arising from the ventilator's ability to supply what is required (generation of flow volumes, cycling, and patient synchrony) or due to face mask leaks. Significant leakage may mean that the respirator will prove unable to detect the end of a patient's inspiratory cycle and delay the start of expiration.[114]

The recently introduced BiPAP Vision® model (Respironics) has become more widely used in critical care areas, as it combines the possibility of providing bi-level NIV and proportional assist ventilation (PAV). The BiPAP Vision® is equipped with alarms, an air–oxygen mixer, and an integrated panel that displays the pressure, volume and flow waveforms. The screen displays 3 areas of information (Figure). The first shows the mode in which the respirator is functioning, and the second displays pressure, volume, and flow waveforms simultaneously, including the units of measure and time, and information can be viewed as bar charts or waveforms. The third area on the screen shows the numerical values of parameters related to both the patient and the system.[115]

The New PAV Modality

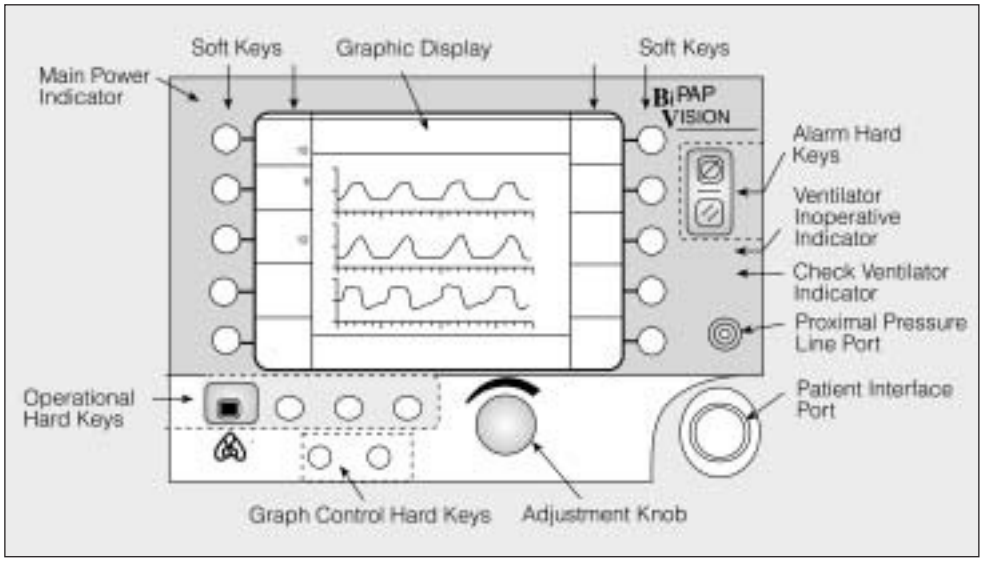

Figure. Control panel of the BiPAP Vision® pressure respirator (Respironics, Boulogne, France).

PAV was proposed to improve patient–respirator interaction, based on experience with conventional modes of ventilation whose benefits and limitations are currently well-established.[116,117] PAV is a method of synchronized partial assistance in which the respirator generates pressure in function of the patient's immediate breathing effort, amplifying the patient's inspiratory effort without preset values for either volume or pressure. The proportion of respiratory assistance to provide can be selected by adjusting flow and volume signals. Although from a theoretical point of view, PAV is a highly interesting modality, little information is currently available on its application in patients with exacerbated COPD and its application outside experimental contexts is unusual.[118-122] Vitacca et al[123] found that tidal volume, minute volume, and gas exchange improved in PAV-treated patients with exacerbated COPD and that their work of breathing decreased. Gay et al[124] observed that patient tolerance of PAV is better than their acceptance of traditional pressure support. At present, therefore, PAV must still be considered experimental.

Technical Aspects of NIV

NIV is a complex treatment modality that differs from other measures such as surgery or drug therapy. Our approach to NIV will depend on whether we have a patient with ARI or CRI. If NIV is prescribed for patients with ARI or with exacerbated CRI, the objectives will be mainly to alleviate dyspnea, reduce work of breathing, and correct arterial blood gases. Indirectly, NIV application will reduce the need for OTI.[1] The patient's comfort is a secondary consideration in such cases. However, when we are trying to facilitate a stable patient's adaptation to NIV, his or her comfort and tolerance of the technique is what should concern us in the initial stages. Once the patient has adapted to the respirator, the time comes to optimize ventilation. The long-term objectives of NIV are mainly to prolong survival, improve quality of life and the functional status of the patient.[1] Such achievements will not be feasible unless adaptation to the respirator and good tolerance have already been established, and that is why it becomes our principal aim.[1] In few medical disciplines can we see such a direct relationship between adherence to treatment and success as we see in the CRI patient undergoing NIV.

NIV in Patients With ARI or Exacerbated CRI

The setting in which a patient with NIV is started can vary greatly. Good adaptation has been achieved in hospital emergency rooms, respiratory medicine wards, intermediate care units, and ICUs.[61] NIV is currently being used more and more in settings outside the hospital, meaning that ventilatory assistance can be given while patients with respiratory insufficiency are being transported from a remote location to a referral hospital.[160-163] Faced with geographic complications in delivering care and the fact that some hospitals have limited resources, the use of NIV in ambulances is of clear utility when transferring patients with respiratory insufficiency. Spain has not yet gained experience with this service, although the numbers of patients so-managed in the United States of America, France, Germany, United Kingdom, Ireland, and Sweden have been increasing exponentially.[61] The provision of the service here will undoubtedly open up new employment opportunities for health caregivers who are experienced with NIV.

Only a few years ago, the question of whether to apply NIV on a conventional ward or in an ICU arose whenever a patient reached a hospital, but the dilemma is now being resolved by the establishment of intermediate respiratory care units.[125-130] A recent task force formed

under the auspices of the European Respiratory Society established the characteristics such units should have.[131] The admission criteria give priority to patients with single organ failure or respiratory system failure, ARI patients needing monitoring though not necessarily mechanical ventilation, and tracheostomized patients in need of mechanical ventilation. The main technique applied in such units will be NIV, although the means to provide invasive ventilation must be available for use when needed. Monitoring capability that must be available includes electrocardiography, oximetry, noninvasive blood pressure, and respiratory rate. A minimum of 1 nurse for every 4 patients, 1 senior staff physician, and 1 respiratory physical therapist should be available around the clock. The task force also defined 3 types of unit according to level of nursing care, type of monitoring, and availability of artificial ventilation: ICUs, intermediate care units, and monitoring units (Table).[131]

Given the lack of such care units in Spain (another challenge for pulmonologists, policy makers, and health care administrators), each hospital has adapted to the circumstances according to local characteristics, with varying ways of implementing NIV, often acting heroically and taking risks.[132] NIV is in vogue and we all want to use it, and really, placing a mask, some straps, and pressing the on/off switch of a respirator is not so very complicated. However, we often forget a very important fact about NIV, that it requires dedication.[28] The problems that arise are not related to staff training but rather to insufficient resources —mainly human resources and time. Trying to apply NIV without the availability of 24-hour physician care or specialized nursing care supposes more risk than benefit. The greatest expression of this can be seen in the ventilation of acute cases. Various authors have suggested that NIV requires more health care staff time in the first hours of use than conventional treatment does.[133] Servera and Sancho[107] found that a nurse spends 65 to 90 minutes with a patient when NIV is started and that the time spent during the first day can be as long as 3 hours. Using such a time-consuming modality can lead to a situation in which the care of other patients on a traditional respiratory medicine ward is neglected, generating unacceptable negative discrimination. Severa and Sancho make reference to a single nurse. However, in most hospitals in Spain, this work is carried out by staff physicians themselves at great personal cost that generally goes unrecognized.[134]

NIV should be available 24 hours a day.[28] Findings from a study by Plant et al[135] indicated that if NIV were used in all COPD patients who presented a pH less than 7.35 after receiving conventional emergency care for a short period, a referral hospital serving an area of 250 000 inhabitants would have to treat 70 patients annually—and that estimate only takes into consideration COPD patients. The BTS guidelines for applying NIV in patients with acute need establishes that all hospitals that receive this type of patient should be equipped with the appropriate infrastructure, meaning a designated space and assigned staff.[28] A team leader should decide where the patient should be treated, check that equipment is ready for use, update protocols, supervise training of team members, and take charge of record keeping and quality control measures.[107] To those duties must be added the time needed for teaching and researching. NIV clearly now calls for a specifically trained staff that is wholly dedicated to the task.[136]

NIV in Patients With Stable CRI

The adaptation period for CRI patients starting NIV usually takes place during scheduled hospital admission, although initiation has also been reported to occur in day hospitals, sleep units, outpatient clinics, and even in the patient's own home.[1,125,137] No studies have compared

TABLE
Levels of Care for Patients With Severe Respiratory Diseases

	Intensive Care Units	Intermediate Respiratory Care Units	Respiratory Monitoring Units
Main criteria			
Nurse: bed ratio	>1:3	1:3 or 1:4	<1:4
Equipment	Complex respirators for life support	Respirators for noninvasive ventilatilation and the possibility of using complex respirators	Respirators for noninvasive ventilation
Treatment	Respiratory failure related to lung disease or other organ failure	Single-organ failure (lung)	Single-organ failure (lung)
Physician care	24 h	Immediately available 24 h	On-call within the hospital
Mechanical ventilation	Invasive and noninvasive, as needed	Noninvasive, and invasive if needed	Noninvasive if needed
Secondary criteria			
Bronchoscopy and arterial blood gas measurement	Available within the unit	Available within the unit	Not necessarily available with in the unit

different initiation procedures, however. Perhaps more important than the setting in which adaptation takes place is the motivation and dedication of caregivers charged with carrying it out. As we have already emphasized, the success of treatment depends on the patient's cooperation. Therefore, it is essential for the medical team to establish an atmosphere of trust and safety. All the time invested during the first stages of adaptation to NIV will provide the best guarantee of later success. Time, calm, explaining what is being done and why, helping the patient express his or her fears and worries, and always being open to any suggestion and ready to correct problems as they arise are the main means at our disposal. Such strategies require bedside presence at least in the first 2 hours after starting NIV. If we are considering long-term ventilation, we have to prove ourselves tolerant, flexible, and blessed with never-ending patience at this stage in the process. The keys to success in long-term NIV are precisely these 3 qualities: tolerance, flexibility, and patience.

The patient must be familiarized with the technique during the day, so that he or she can try to tolerate the respirator during sleep, although occasionally effective ventilation is achieved during the first night. We should be aware that the results of NIV are not immediately evident.[138] Blood gases may improve slowly over the course of several weeks,[1] and some time may pass before the patient is able to sleep with the respirator all night. It may even happen that the patient is never able to sleep with the respirator, because of lack of tolerance of nocturnal ventilation, and we will have to settle for daytime ventilation only, for a longer or shorter period of time. Arterial blood sampling will therefore be postponed until we are certain we are working with a patient who is adhering to treatment and in stable phase.[1] Furthermore, the $PaCO_2$ that must be reached and maintained in these patients is unknown. Some patients experience clear improvement of symptoms and sleep quality in spite of only achieving slight changes in arterial blood gases. We should therefore not become fixed on achieving improved $PaCO_2$.[1]

Factors That Affect Management

Various factors affect the long-term management of NIV treatment, such that 4 prototypical patients can be defined. The first type would be a patient with nonprogressive disease who is well adapted to nocturnal ventilation, shows good adherence to treatment and has optimal results, without evident problems related to NIV. Such a patient would the ideal, the one we would all like to treat.

A second type would be a patient with a progressive neuromuscular disease. The most severe cases are those of patients with amyotrophic lateral sclerosis.[139-143] Decision making in such cases lags behind the course of the disease. NIV needs to be considered against the background of the impact of the disease on the patient from both physical and emotional points of view, and the impact on the family must also be taken into account, as the principal caregiver plays a crucial role in the success or failure of NIV. Ferraro et al[144] established that the approach to managing these patients should go beyond the treatment of respiratory complications to encompass education of the patient and family members, the treatment of symptoms, nutritional management, and end-stage palliative care. The best results are achieved when NIV is introduced at the early phases of ventilatory failure, even in patients with bulbar involvement, given that NIV can be highly effective and well tolerated when bulbar involvement is not yet severe.[144] It is always recommendable to perform a test run if a patient remains unconvinced that NIV can provide relief or if there is any doubt about the effectiveness of the treatment. Finally, we should not forget that a patient may decide to suspend treatment at any point in the course of his or her illness, regardless of what airway access is being used, and that we must respect that decision. This situation may develop even in patients who are fully respirator dependent.[145,146] The possibility of prolonging life by performing a tracheostomy must be considered with a great deal of common sense and always with fully informed participants and competent training of the person who assumes the role of caregiver.

A third type of patient would be one with poor adherence to treatment. The direct consequence of this is diminished efficacy of NIV. Behind lack of adherence are hidden many factors related to inadequate patient education, social problems, depression, isolation, denial of the severity of the underlying disease, or failure to perceive a benefit from treatment.[1] We can have an effect on many of these factors by dedicating time to get to know the patient better in his or her own context and intervening in those matters we believe are causing poor adherence to NIV. Insisting on the importance of the prescribed treatment, giving the patient time before trying again, accepting reduced application of the treatment (daytime rather than nighttime use, not using NIV on weekends, using it on alternating days), or even withdrawing NIV altogether might all be valid strategies to follow.

Finally, a fourth type of patient would be the one for whom NIV is ineffective in spite of good adaptation, tolerance, and adherence to treatment. We should consider whether NIV may be failing because of the technical problems that are usually responsible for undermining efficacy and patient comfort. According to some reports, NIV is ineffective in 7% to 42% of patients, mainly those with exacerbated COPD or neuromuscular diseases.[3,24] The main reasons are problems related to the interface (leaks, eye irritation, claustrophobia, skin sores, congestion, or nasal dryness) and the development of side effects arising from NIV itself.[147-149] Among the problems that lead to withdrawal from NIV, gastric distension is the most common and must be dealt with, as explained above, by changing the respirator.[1,97,150] Glottic narrowing with high inspiratory volumes and poor sleep quality with frequent awakening

related to severe mouth leaks have also been described.[151] As explained, poor adherence to treatment and the progression of the underlying disease may be the reasons for failure of NIV. If such is the case, options that might solve the problem are to increase the number of hours per day of ventilation or to ventilate through a tracheostomy. When patients receiving NIV with pressure respirators remain hypercapnic, the possibility of rebreathing should be suspected and a slightly higher EPAP should be set (up to 6 cm H_2O) or a switch to a volumetric ventilator can be considered.

We must also remember that in certain situations a patient may become unstable. Weight gain or loss, pregnancy, trips to high altitude areas, exacerbation of the underlying disease, and even dental extractions might be cited as causes.[1] Even though withdrawing nasal ventilation has been reported to be prejudicial to patients,[152-154] many patients report that they abandon the respirator on weekends, trips, or after cataract operations and that these interruptions are well-tolerated and without repercussions on gas exchange.

An important cause of NIV failure is the loss of an effective cough mechanism.[1] Expiratory muscle involvement, which is common in advanced stages of various neuromuscular diseases, can compromise ventilation in patients with copious secretions. The same is true during episodes of aspiration or when a concomitant respiratory infection develops. Although no controlled trials are available on the various cough assist techniques available, they seem to have been useful in such situations. Tzeng and Bach[155] analyzed patients with neuromuscular diseases who developed respiratory decompensation. Their therapeutic protocol consisted of applying NIV 24 hours a day along with manual cough assist maneuvers and mechanical aids whenever arterial hemoglobin saturation fell below 90%. The mechanical device used to assist the cough was the In-Exsufflator® (JH Emerson Company, Cambridge, MA, USA). Those authors demonstrated that most patients who followed the protocol could be managed at home, significantly reducing the need for hospitalization. It has been shown that a cough can be effective if a patient is able to generate expiratory flows over 160 L/min spontaneously or by way of mechanical assistance.[102] Various devices available on the market allow a patient to reach sufficient volumes to generate an effective cough. The In-Exsufflator®, developed during the polio epidemics, generates a positive pressure of 30 to 40 cm H_2O followed by a negative pressure of the same magnitude, simulating expiratory flows that are similar to those of a normal cough. They are used in combination with manual cough assist techniques. Periodic maximal insufflations from a volumetric ventilator are an efficient alternative for patients who are already using those devices at home. The volume from the respirator is increased in order to insufflate volumes approaching 80% of the patient's theoretical vital capacity.[155] This is the modality most often used in Spain, as mentioned earlier. Other devices used to assist coughing that employ thoracic percussion techniques, vibrations, or oscillations are based on anecdotal evidence and are not employed in Spain.

The Future of NIV

There is no doubt that NIV has a future, and we should not forget that its future is in our hands. All has not yet been said on the matter of indications for NIV. We can expect that a greater number of patients in a variety of clinical situations will benefit from NIV techniques and that they will be considered for application at earlier stages of disease. The use of NIV should be accompanied by the planning of rigorously designed trials, giving more work to those who work to this area.[156] Patients, in turn, are going to live longer, leading to the maintenance of therapies like NIV until very advanced stages of disease, thereby engendering ethical dilemmas in which the common sense of health caregivers will have to come to the forefront. The increasing importance of the chronically ill patient will be felt by the health care system. As mentioned by Rodenstein,[157] the patient does not now die from a disease but rather lives with it and its consequences. The disease is not cured but is rather managed, and this is going to pose the problem of how far to go and up to what point we should treat. NIV, which is complex but not aggressive, as its name implies, is going to be a point of contention among various caregivers, patients, and relatives if we do not establish protocols for how to proceed with the consensus of all parties involved. The patient will have much to say about what he or she expects of the doctors responsible for care in the decision making process and about the therapeutic measures available.[158]

The spreading use of NIV inside hospitals (respiratory medicine wards, intermediate care units, bronchoscopy units, operating theaters and recovery wards, ICUs, emergency services, day hospitals, and more) and outside (out-of-hospital emergency units and ambulance services) will broaden horizons beyond what we can presently imagine, favoring the creation of new jobs for NIV specialists. The immediate future will involve helping pulmonologists, opinion leaders, and health care managers to understand the need to support intermediate respiratory care units and take up the challenge of their planning and creation, without scrimping on the necessary resources—mainly human resources. The growth of NIV will be closely linked to the encouragement of these special care units.

The application of technology to the creation of new interfaces and respirators will allow us to enhance tolerance of the technique and minimize adverse effects, leading to improved adherence to treatment and the achievement of better results. The helmet or hood systems and PAV are examples that illustrate such recent advances. New generations of respirators will relegate volumetric ventilators and pressure respirators to the past, making room for other ventilation systems such as turbine-driven units.

The possibilities for social fulfillment that NIV provides our patients have meant that the image of the chronic respiratory disease patient has been changing. Breaking the vicious circle of immobility and lack of self-respect and self-confidence that characterizes these patients will also be part of our job in the future, as NIV helps open a new world for many with respiratory insufficiency.[159,160]

REFERENCES

1. Mehta S, Hill NS. Noninvasive ventilation. Am J Respir Crit Care Med 2001;163:540-77.
2. Díaz Lobato S, Gómez Mendieta MA, Mayoralas Alises S. ¿Ventilación mecánica no invasiva o no invasora? Arch Bronconeumol 2001;37:52-3.
3. Leger P, Bedicam JM, Cornette A, Reybet-Degat O, Langevin B, Polu JM, et al. Nasal intermittent positive pressure. Long-term follow-up in patients with severe chronic respiratory insufficiency. Chest 1994;105:100-5.
4. Escarrabill J, Monasterio C, Estopá R. Ventilación no invasiva. Arch Bronconeumol 1994;30:109-13.
5. Sullivan CE, Issa FG, Berthon-Jones M, Eves L. Reversal of obstructive sleep apnea by continuous positive airway pressure applied through the nares. Lancet 1981;1:862-5.
6. Rideau Y, Gatin G, Bach J, Gines G. Prolongation of life in Duchenne's muscular dystrophy. Acta Neurol Belg 1983;5: 118-24.
7. De Lucas P, Rodríguez González-Moro JM, Paz González L, Santa-Cruz Siminiani A, Cubillo Marcos JM. Estado actual de la ventilación mecánica domiciliaria en España: resultados de una encuesta de ámbito nacional. Arch Bronconeumol 2000;36: 545-50.
8. Escarrabill J, Díaz Lobato S, Masa JF, De Lucas P, Servera E, Barrot E, et al. Hospital based long-term home respiratory care in Spain. Chest 1999;116(Suppl):318.
9. Nauffal D, Doménech R, Martínez García MA, Compte L, Macian V, Perpiñá M. Noninvasive positive pressure home ventilation in restrictive disorders: outcome and impact on health-related quality of life. Respir Med 2002;96:777-83.
10. Laserna E, Barrot E, Belaustegui A, Quintana E, Hernández A, Castillo J. Ventilación no invasiva en cifoescoliosis. Estudio comparativo entre respirador volumétrico y soporte de presión (BIPAP). Arch Bronconeumol 2003;39:13-8.
11. Echave-Sustaeta J, Pérez González V, Verdugo M, García Cosio FJ, Villena V, Álvarez C, et al. Ventilación mecánica en hospitalización neumológica. Evolución en el período 1994-2000. Arch Bronconeumol 2002;38:160-5.
12. Estopá R, Villasante C, De Lucas P, Ponce de León L, Mosteiro M, Masa JF, et al. Normativa sobre la ventilación mecánica a domicilio. Arch Bronconeumol 2001;37:142-9.
13. Dueñas-Pareja Y, López-Martín S, García-García J, Melchor R, Rodríguez-Nieto MJ, González-Mangado N, et al. Ventilación no invasiva en pacientes con encefalopatía hipercápnica grave en una sala de hospitalización convencional. Arch Bronconeumol 2002;38:372-5.
14. De Miguel J, Jara B, Hermida JA, Juretschke MA. Tratamiento con Bi-PAP en pacientes con parálisis diafragmática bilateral. Arch Bronconeumol 2000;36:286-9.
15. Fernández Vázquez E, Sáez Roca G, Valdivia Salas MM. Parálisis diafragmática bilateral idiopática. Tratamiento con Bi-PAP. Arch Bronconeumol 2002;38:252.
16. Jareño J, Villegas F, Callol L. Herniación diafragmática gigante del adulto y ventilación mecánica no invasiva. A propósito de un caso clínico. Arch Bronconeumol 1998;34: 315.
17. Díaz Lobato S, Gómez Mendieta MA, Mayoralas Alises S. Aplicaciones de la ventilación mecánica no invasiva en pacientes que reciben ventilación endotraqueal. Arch Bronconeumol 2002;38: 281-4.
18. Masa JF, Celli BR, Riesco JA, De Cos JS, Disdier C, Sojo A. Noninvasive positive pressure ventilation and not oxygen may prevent overt ventilatory failure in patients with chest wall diseases. Chest 1997;112:207-13.
19. Masa JF. Ventilación mecánica domiciliaria: perspectivas actuales. Arch Bronconeumol 1994;30:29-39.
20. Masa JF, Celli BR, Riesco JA, Hernandez M, Sanchez De Cos J, Disdier C. The obesity hypoventilation syndrome can be treated with noninvasive mechanical ventilation. Chest 2001;119:1102-7.
21. Corrado A, Gorini N. Negative-pressure ventilation: is there still a role? Eur Respir J 2002;20:187-97.
22. Rodríguez Roisin R, Marrades RM. Enfermedad pulmonar obstructiva crónica y ventilación no invasiva: una evidencia creciente. Arch Bronconeumol 2001;37:88-95.
23. American Respiratory Care Foundation. Consensus Conference: non-invasive positive pressure ventilation. Respir Care 1997;42:364-9.
24. Consensus Conference. Clinical indications for noninvasive positive pressure ventilation in chronic respiratory failure due to restrictive lung disease, COPD, and nocturnal hypoventilation: a Consensus Conference Report. Chest 1999;116:521-34.
25. Wijkstra PJ, Lacasse Y, Guyatt GH, Goldstein RS. Nocturnal non-invasive positive ventilation for stable chronic obstructive pulmonary disease. Cochrane Database Sys Rev 2002;3: CD002878.
26. Muir JF, De la Salmoniere A, Cuvelier A, Chevret S, Tengang B. Survival of severe hypercapnic COPD under long-term home mechanical ventilation with NIPPV + oxygen versus oxygen therapy alone. Preliminary results of a European multicenter trial. Am J Respir Crit Care Med 1999;161:A262.
27. Clini E, Sturani C. The Italian multicenter study of noninvasive nocturnal pressure support ventilation (NPSV) in COPD patients. Am J Resp Crit Care Med 1999;259:A295.
28. British Thoracic Society Standards of Care Committee. Non-invasive ventilation in acute respiratory failure. Thorax 2002;57:192-211.
29. Peter JV, Moran JL, Phillips-Hughes J, Warn D. Noninvasive ventilation in acute respiratory failure—a meta-analysis update. Crit Care Med 2002;30:555-62.
30. Keenan SP, Sinuff T, Cook DJ, Hill NS. Which patients with acute exacerbation of chronic obstructive pulmonary disease benefit from noninvasive positive-pressure ventilation? A systematic review of the literature. Ann Intern Med 2003;138:861-70.
31. Brochard L, Mancebo J, Elliott MW. Noninvasive ventilation for acute respiratory failure. Eur Respir J 2002;19:712-21.
32. Pierson DJ. Indications for mechanical ventilation in adults with acute respiratory failure. Respir Care 2002;47:249-62.
33. Ram FS, Lightowler JV, Wedzicha JA. Non-invasive positive pressure ventilation for treatment of respiratory failure due to exacerbations of chronic obstructive pulmonary disease. Cochrane Database Syst Rev 2003;1:CD004104.
34. Fernández-Guerra J, López-Campos JL, Perea-Milla E, Pons J, Rivera R, Moreno LF. Metaanálisis de la eficacia de la ventilación no invasiva en la exacerbación aguda de la enfermedad pulmonar obstructiva crónica. Med Clin (Barc) 2003;120:281-6.
35. Lightowler JV, Wedzicha JA, Elliot MW, Ram FS. Non-invasive positive pressure ventilation to treat respiratory failure resulting from exacerbations of chronic obstructive pulmonary disease: Cochrane systematic review and meta-analysis. BMJ 2003;326:185.
36. Elliot MW. Non-invasive ventilation in acute exacerbations of chronic obstructive pulmonary disease: a new gold standard? Intensive Care Med 2002;28:1691-4.
37. Pauwels RA, Buist AS, Calverley PM, Jenkins CR, Hurd SS, GOLD Scientific Committee. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease. NHLBI/WHO Global Initiative for Chronic Obstructive Lung Disease (GOLD) Workshop summary. Am J Respir Crit Care Med 2001;163:1256-76.
38. Fernández MM, Villagra A, Blanch L, Fernández R. Non-invasive mechanical ventilation in status asthmaticus. Intensive Care Med 2001;27:486-92.
39. Soroksky A, Stav D, Shpirer I. A pilot prospective, randomized, placebo-controlled trial of bilevel positive airway pressure in acute asthmatic attack. Chest 2003;123:1018-25.
40. Granton JT, Shapiro C, Kesten S. Noninvasive nocturnal ventilatory support in advanced lung disease from cystic fibrosis. Respir Care 2002;47:675-81.

41. Madden BP, Kariyawasam H, Siddiqi AJ, Machin A, Pryor JA, Hodson ME. Noninvasive ventilation in cystic fibrosis patients with acute or chronic respiratory failure. Eur Respir J 2002;19:310-3.
42. Navalesi P, Pollini A. Acute respiratory failure in patients with severe community-acquired pneumonia: a prospective randomized evaluation of noninvasive ventilation. Am J Respir Crit Care Med 2000;162:761-2.
43. Antonelli M, Conti G. Noninvasive positive pressure ventilation as treatment for acute respiratory failure in critically ill patients. Crit Care 2000;4:15-22.
44. Giacomini M, Iapichino G, Cigada M, Minuto A, Facchini R, Noto A, et al. Short-term noninvasive pressure support ventilation prevents ICU admittance in patients with acute cardiogenic pulmonary edema. Chest 2003;123:2057-61.
45. Confalonieri M, Calderini E, Terraciano S, Chidini G, Celeste E, Puccio G, et al. Noninvasive ventilation for treating acute respiratory failure in AIDS patients with *Pneumocystis carinii* pneumonia. Intensive Care Med 2002;28:1233-8.
46. Hill NS. Noninvasive ventilation for immunocompromised patients. N Engl J Med 2001;344:522-4.
47. Antonelli M, Conti C, Bufi M, Costa MG, Lappa A, Rocco M, et al. Noninvasive ventilation for treatment of acute respiratory failure in patients undergoing solid organ transplantation. JAMA 2000;283:235-41.
48. Benhamou D, Muir JF, Melen B. Mechanical ventilation in elderly patients. Monaldi Arch Chest Dis 1998;53:547-51.
49. Meert AP, Close L, Hardy M, Berghmans T, Markiewicz E, Sculier JP. Noninvasive ventilation: application to the cancer patient admitted in the intensive care unit. Support Care Cancer 2003;11:56-9.
50. Claudett KB, Rek Burneo CA, De la Cerda P, Claudett MB, Romero A, Esquinas A, et al. Ventilación mecánica no invasiva en pacientes con cáncer e insuficiencia respiratoria aguda. Revista Iberoamericana de Ventilación Mecánica No Invasiva 2003;1:35-41.
51. Smailes ST. Noninvasive positive pressure ventilation in burns. Burns 2002;28:795-801.
52. Meduri GU, Fox RC, Abou-Shala N, Leeper KV, Wunderink RG. Noninvasive mechanical ventilation via face mask in patients with acute respiratory failure who refused endotracheal intubation. Crit Care Med 1994;22:1584-90.
53. Nava S, Ambrosino N, Clini E, Prato M, Orlando G, Vitacca M, et al. Non-invasive mechanical ventilation in the weaning of patients with respiratory failure due to chronic obstructive pulmonary disease: a randomized study. Ann Intern Med 1998;128: 721-8.
54. Aguiló R, Togores B, Pons S, Rubí M, Barbé F, Agustí AGN. Noninvasive ventilator support after lung resectional surgery. Chest 1997;112:1117-217.
55. González Lorenzo F, Díaz Lobato S, Pérez Grueso F, Villamor León J. Noninvasive mechanical ventilation and corrective surgery for treatment of a child with severe kyphoscoliosis. Pediatr Pulmonol 2001;32:403-5.
56. Tobias JD. Noninvasive ventilation using bilevel positive airway pressure to treat impending respiratory failure in the postanesthesia care unit. J Clin Anesth 2000;12:409-12.
57. Del Castillo D, Barrot E, Laserna E, Otero R, Cayuela A, Castillo Gómez J. Ventilación no invasiva por soporte de presión en pacientes con enfermedad pulmonar obstructiva crónica en insuficiencia respiratoria aguda hipercápnica ingresados en una unidad de hospitalización convencional de neumología. Med Clin (Barc) 2003;120:647-51.
58. Wood KA, Lewis L, Von Harz B, Kollef MH. The use of noninvasive positive pressure ventilation in the emergency department. Chest 1998;113:1339-46.
59. Severa E, Pérez M, Marín L, Vergara P, Castano R. Noninvasive nasal mask ventilation: beyond the ICU for an exacerbation of chronic respiratory insufficiency. Chest 1995;1089:1572-6.
60. Antonelli M, Conti G. Non-invasive ventilation in intensive care unit patients. Cur Opin Crit Care 2000;6:11-6.
61. Esquinas A, González G, Lasdica S, Laca M, Zevallos J. Recomendaciones de organización de los servicios de urgencias y emergencias. Revista Iberoamericana de Ventilación Mecánica No Invasiva 2003;1:42-5.
62. Antonelli M, Conti G, Rocco M, Arcangeli A, Cavaliere F, Proietti R, et al. Noninvasive positive-pressure ventilation vs. conventional oxygen supplementation in hypoxemic patients undergoing diagnostic bronchoscopy. Chest 2002;121:1149-54.
63. Norregaard O. Noninvasive ventilation in children. Eur Respir J 2002;20:1332-42.
64. Schonhofer B, Sortor-Leger S. Equipment needs for noninvasive mechanical ventilation. Eur Respir J 2002;20:1029-36.
65. American Thoracic Society. International Consensus Conferences in Intensive Care Medicine: noninvasive positive pressure ventilation in acute respiratory failure. Am J Respir Crit Care Med 2001;163:283-91.
66. Clini E. Patient ventilator interfaces: practical aspects in the chronic situation. Monaldi Arch Chest Dis 1997;52:76-9.
67. Leger SS, Leger P. The art of interface. Tools for administering noninvasive ventilation. Med Klin 1999;94:35-9.
68. Jones DJ, Braid GM, Wedzicha JA. Nasal masks for domiciliary positive pressure ventilation: patient usage and complications. Thorax 1994;49:811-2.
69. Tsuboi T, Ohi M, Kita H, Otsuka N, Hirata H, Noguchi T, et al. The efficacy of a custom-fabricated nasal mask on gas exchange during nasal intermittent positive pressure ventilation. Eur Respir J 1999;13:152-6.
70. Le Drezen A, Petitet C, Blouch G, Leroyer C, Clavier J. Construction of a light-weight molded nasal mask for assisted nasal ventilation. Rev Mal Respir 1995;12:637-8.
71. Mosteiro M, Farrero E, Escarrabill J. Eficacia de ventilación nasal con máscara moldeada a medida utilizando un aparato de soporte ventilatorio. Arch Bronconeumol 1996;32:317.
72. Cornette A, Mougel D. Ventilatory assistance via the nasal route: masks and fittings. Eur Respir Rev 1993;3:250-3.
73. Bach JR, Alba AS, Bohatiuk G, Saporito L, Lee M. Mouth intermittent positive pressure ventilation in the management of postpolio respiratory insufficiency. Chest 1987;91:859-64.
74. Bach JR, Alba AS, Saporito LR. Intermittent positive pressure ventilation via the mouth as an alternative to tracheostomy for 257 ventilator users. Chest 1993;103:174-82.
75. 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;31:468-73.
76. Gregoretti C. Evaluation of patient skin breakdown and comfort with a new face mask for non-invasive ventilation: a multicenter study. Intensive Care Med 2002;28:278-84.
77. Navalesi P, Fanfulla F, Frigeiro P, Gregoretti C, Nava S. Physiologic evaluation of noninvasive mechanical ventilation delivered with three types of masks in patients with chronic hypercapnic respiratory failure. Crit Care Med 2000;28:1785-90.
78. Lloys A, Madrid C, Solá M, Segura M, Tarrés E, Mas A. Efecto del sellado con agua de la máscara facial para ventilación no invasiva en la aparición de úlceras faciales por presión. Enferm Intensiva 2003;14:3-6.
79. Criner GJ, Travaline JM, Brennan KJ, Kreimer DT. Efficacy of a new full face mask for noninvasive positive pressure. Chest 1994;106:1109-15.
80. Scandroglio M, Piccolo U, Mazzone E, Agrati P, Aspesi M, Gamberoni C, et al. Use and nursing of the helmet in delivering non invasive ventilation. Minerva Anestesiol 2002;68:475-80.
81. Antonelli M, Conti G, Pelosi P, Gregoretti C, Pennisi MA, Costa R, et al. New treatment of acute hypoxemic respiratory failure: noninvasive pressure support ventilation delivered by helmet: a pilot controlled trial. Crit Care Med 2002;30:602-8.
82. Ferrario D, Lucchini A. Helmet delivered CPAP for in-patients. Minerva Anestesiol 2002;68:481-4.
83. Esquinas A, Carrillo A, Raimondi N, Chiappero G, Ceraso D, Laca M, et al. Interfase en ventilación no invasiva. Sistema Helmet. Revista Iberoamericana de Ventilación No Invasiva 2003;1:16-21.
84. Cavaliere F, Masieri S, Conti G, Antonelli M, Pennisi MA, Filipo R, et al. Effects of non-invasive ventilation on middle ear function in healthy volunteers. Intensive Care Med 2003;29:611-4.
85. Pelosi P, Severgnini P, Aspesi M, Gamberoni C, Chiumello D, Fachinetti C, et al. Non-invasive ventilation delivered by conventional interfaces and helmet in the emergency department. Eur J Emerg Med 2003;10:79-86.
86. Chiumello D, Pelosi P, Carlesso E, Severgnini P, Aspesi M, Gamberoni C, et al. Noninvasive positive pressure ventilation delivered by helmet vs. standard face mask [in press]. Intensive

Care Med 2003.
87. Antonelli M, Pennisi MA, Conti G, Bello G, Maggiore SM, Michetti V, et al. Fiberoptic bronchoscopy during noninvasive positive pressure ventilation delivered by helmet. Intensive Care Med 2003;29:126-9.
88. Chatburn RL. Classification of mechanical ventilators. Respir Care 1992;37:1009-25.
89. American Association for Respiratory Care. Consensus statement on the essentials of mechanical ventilators. Respir Care 1992;37:1000-8.
90. Kallio T, Kuisma M, Alaspaa A, Rosenberg PH. The use of prehospital continuous positive airway pressure treatment in presumed acute severe pulmonary edema. Prehosp Emerg Care 2003;7:209-13.
91. Campbell RS, Johannigman JA, Branson RD, Austin PN, Matacia G, Banks GR. Battery duration of portable ventilators: effects of control variable, positive end-expiratory pressure, and inspired oxygen concentration. Respir Care 2002;47:1173-83.
92. Grace K. The ventilator: selection of mechanical ventilators. Crit Care Clin 1998;14:563-80.
93. Disdier C, Masa JF, Julian de Sande G. Ventilación no invasiva. In: Villasante C, editor. Enfermedades respiratorias. Vol I. Madrid: Grupo Aula Médica S.L., 2002; p. 231-41.
94. Quiroga JM, Menéndez de León B, Pascual C. Ventilación mecánica convencional. In: Villasante C, editor. Enfermedades respiratorias. Vol I. Madrid: Grupo Aula Médica S.L., 2002; p. 243-9.
95. Estopá R. Ventilación mecánica a domicilio. In: Caminero JA, Fernández-Fau L, editors. Actualizaciones SEPAR. Vol 2. Barcelona: JR Prous S.A., 1996; p. 277-94.
96. Soudon PH. Tracheal versus noninvasive mechanical ventilation in neuromuscular patients: experience and evaluation. Monaldi Arch Chest Dis 1995;3:228-31.
97. Díaz Lobato S, García Tejero MT, Ruiz Cobos A, Villasante C. Changing ventilator: an option to take into account in the treatment of persistent vomiting during nasal ventilation. Respiration 1998;65:481-2.
98. Tobin M, Jubran A, Laghi F. Patient-ventilator interaction. Am J Respir Crit Care Med 2001;163:1059-63.
99. Vitacca M, Barbano L, D'Anna S, Porta R, Bianchi L, Ambrosino N. Comparison of five bilevel pressure ventilators in patients with chronic ventilatory failure: a physiologic study. Chest 2002; 122:2105-14.
100. Highcock MP, Morrish E, Jamieson S, Shneerson JM, Smith IE. An overnight comparison of two ventilators used in the treatment of chronic respiratory failure. Eur Respir J 2002;20:942-5.
101. Moran F, Bradley J. Non-invasive ventilation for cystic fibrosis. Cochrane Database Syst Rev 2003;2:CD002769.
102. Bach JR, Saporito LR. Criteria for extubation and tracheostomy tube removal for patients with ventilatory failure: a different approach to weaning. Chest 1996;110:1566-71.
103. Bach JR. Update and perspective on noninvasive respiratory muscle aids. Part 2: the expiratory aids. Chest 1994;105:1538-44.
104. Chatwin M, Ross E, Hart N, Nickol AH, Polkey MI, Simonds AK. Cough augmentation with mechanical insufflation/exsufflation in patients with neuromuscular weakness. Eur Respir J 2003;21:502-8.
105. Brochard L, Pluskwa F, Lemaire F. Improved efficacy of spontaneous breathing with inspiratory pressure support. Am Rev Respir Dis 1987;136:411-5.
106. Hill NS, Carlisle C, Kramer NR. Effect of a nonrebreathing exhalation valve on long-term nasal ventilation using a bilevel device. Chest 2002;122:84-91.
107. Servera E, Sancho J. Ventilación asistida ¿cuándo, dónde y por qué? In: Sánchez Agudo L, editor. Cuadernos de f.m.c. de la SEPAR. Avances en el manejo de la EPOC. Madrid: Medical & Marketing Communications 2002;4:9-21.
108. Wysocki M. Noninvasive ventilation in acute cardiogenic pulmonary edema: better than continuous positive airway pressure? Intensive Care Med 1999;25:1-2.
109. Mehta S, Jay GD, Woolard RH, Hipona RA, Connelly EM, Cimini DM, et al. Randomized prospective trial of bilevel versus continuous positive airway pressure in acute pulmonary edema. Crit Care Med 1997;25:620-8.
110. Pang D, Keenan SP, Cook DJ, Sibbald WJ. The effect of positive pressure airway support on mortality and the need for intubation in cardiogenic pulmonary edema. Chest 1998;114:1185-92.
111. Jubran A, Van de Graffe WB, Tobin MJ. Variability of patient-ventilator interaction with pressure support ventilation in patients with chronic obstructive pulmonary disease. Am J Respir Crit Care Med 1995;152:129-36.
112. Antón A, Güell R, Gómez J, Serrano J, Castellano A, Carrasco JL, et al. Predicting the result of noninvasive ventilation in severe acute exacerbations of patients with chronic airflow limitation. Chest 2000;117:828-33.
113. Lightowler JVJ, Elliott MW. Predicting the outcome from NIV for acute exacerbations of COPD. Thorax 2000;55:815-6.
114. Mehta S, McCool FD, Hill NS. Leak compensation in positive pressure ventilators: a lung model study. Eur Respir J 2001;17: 259-67.
115. Layfield C. Non-invasive BiPAP: implementation of a new service. Intensive Crit Care Nurs 2002;18:310-9.
116. Ambrosino N, Rossi A. Proportional assist ventilation (PAV): a significant advance or a futile struggle between logic and practice? Thorax 2002;57:272-6.
117. Grasso S, Ranieri VM. Proportional assist ventilation. Respir Care Clin N Am 2001;7:465-73.
118. Younes M, Puddy A, Roberts D, Light RB, Quesada A, Taylor K, et al. Proportional assist ventilation: results of an initial clinical trial. Am Rev Respir Dis 1992;145:121-9.
119. Fernández-Vivas M, Caturla-Such J, De la Rosa JG, Acosta-Escribano J, Álvarez-Sánchez B, Cánovas-Robles J. Noninvasive pressure support versus proportional assist ventilation in acute respiratory failure. Intensive Care Med 2003;29:1126-33.
120. Porta R, Appendini L, Vitacca M, Bianchi L, Donner CF, Poggi R, et al. Mask proportional assist vs pressure support ventilation in patients in clinically stable condition with chronic ventilatory failure. Chest 2002;122:479-88.
121. Wysocki M, Richard JC, Meshaka P. Noninvasive proportional assist ventilation compared with noninvasive pressure support ventilation in hypercapnic acute respiratory failure. Crit Care Med 2002;30:323-9.
122. Hart N, Hunt A, Polkey MI, Fauroux B, Lofaso F, Simonds AK. Comparison of proportional assist ventilation and pressure support ventilation in chronic respiratory failure due to neuromuscular and chest wall deformity. Thorax 2002;57:979-81.
123. Vitacca M, Clini E, Pagani M, Bianchi L, Rossi A, Ambrosino N. Physiologic effects of early administered mask proportional assist ventilation in patients with chronic obstructive pulmonary disease and acute respiratory failure. Crit Care Med 2000;28:1791-7.
124. Gay PC, Hess DR, Hill NS. Noninvasive proportional assist ventilation for acute respiratory insufficiency. Comparison with pressure support ventilation. Am J Respir Crit Care Med 2001;164:1606-11.
125. Elliott MW, Confalonieri M, Nava S. Where to perform noninvasive ventilation? Eur Respir J 2002;19:1159-66.
126. Confalonieri M, Kodric M, Garuti G. Respiratory intermediate (high dependency) unit care in Europe: models of service provision. Monaldi Arch Chest Dis 2001;56:248-53.
127. Confalonieri M, Gorini M, Ambrosino N, Mollica C, Corrado A, Scientific Group on Respiratory Intensive Care of the Italian Association of Hospital Pneumonologists. Respiratory intensive care units in Italy: a national census and prospective cohort study. Thorax 2001;56:373-8.
128. Muir JF, Mayaud C, Derenne JP. Respiratory high dependency care units (RHDCU) in France. Monaldi Arch Chest Dis 1999; 54:452-5.
129. Vitacca M. Where and how must we perform noninvasive mechanical ventilation? Monaldi Arch Chest Dis 1997;52:80-2.
130. Rossi A, Ambrosino N. The need for an intermediate cardiorespiratory unit. Monaldi Arch Chest Dis 1994;49:463-5.
131. Corrado A, Roussos C, Ambrosino N, Confalonieri M, Cuvelier A, Elliot M, et al. ERS Task Force: respiratory intermediate care units: a European survey. Eur Respir J 2002; 20:1343-50.
132. Torres A. Respiratory intensive care in Spain. Monaldi Arch Chest Dis 1999;54:441-3.
133. Nava S, Evangelisti I, Rampulla C, Campagnoni ML, Fracchia C, Rubini F. Human and financial costs of noninvasive mechanical ventilation in patients affected by COPD and acute respiratory failure. Chest 1997; 111:1631-8.
134. Díaz Lobato S. En defensa de la neumología. Arch Bronconeumol 1999;35:467-9.

135. Plant PK, Owen JL, Elliott MW. Early use of noninvasive ventilation for acute exacerbations of chronic obstructive pulmonary disease on general respiratory wards: a multicenter randomized controlled trial. Lancet 2000;355:1931-5.
136. Torres A, Rodríguez Roisin R. Cuidados intensivos respiratorios. ¿Generales o especializados? Arch Bronconeumol 1996;32:263-4.
137. Lisboa C, Díaz O, Fadic R. Ventilación mecánica no invasiva en pacientes con enfermedades neuromusculares y en pacientes con alteraciones de la caja torácica. Arch Bronconeumol 2003;39:314-20.
138. Hill NS, Eveloff SE, Carlisle CC, Goff SG. Efficacy of nocturnal nasal ventilation in patients with restrictive thoracic disease. Am Rev Respir Dis 1992;101:516-21.
139. Escarrabill J, Estopá R, Farrero E, Monasterio C, Manresa F. Long-term mechanical ventilation in amyotrophic lateral sclerosis. Respir Med 1998;92:438-41.
140. González-Lorenzo F, Díaz-Lobato S. Ventilación mecánica en pacientes con esclerosis lateral amiotrófica. Rev Neurol 2000;30:61-4.
141. Mayorales Alises S, Gómez Mendieta MA, Díaz Lobato S. Evolución de la esclerosis lateral amiotrófica a través de la función pulmonar. Arch Bronconeumol 2003;39:327-8.
142. Salord N, Miralda RM, Casan P. Evolución de la esclerosis lateral amiotrófica a través de la función pulmonar. Arch Bronconeumol 2002;38:452-4.
143. Butz M, Wollinsky KH, Wiedemuth-Catrinescu U, Sperfeld A, Winter S, Mehrkens HH, et al. Longitudinal effects of noninvasive positive-pressure ventilation in patients with amyotrophic lateral sclerosis. Am J Phys Med Rehabil 2003;82:597-604.
144. Farrero E, Prats E, Escarrabill J. Toma de decisiones en el manejo clínico de los pacientes con esclerosis lateral amiotrófica. Arch Bronconeumol 2003;39:226-32.
145. Polkey MI, Lyall RA, Craig Davidson A, Nigel Leigh P, Moxham J. Ethical and clinical issues in the use of home non-invasive mechanical ventilation for the palliation of breathlessness in motor neurone disease. Thorax 1999;54:367-71.
146. Ganzini L, Johnston WS, Silveira MJ. The final month of life in patients with ALS. Neurology 2002;59:428-31.
147. Servera E, Sancho J, Zafra MJ, Marín J. Secretion management must be considered when reporting success or failure of noninvasive ventilation. Chest 2003;123:1773.
148. Hill NS. Complications of noninvasive positive pressure ventilation. Respir Care 1997;42:432-42.
149. García Jiménez JD, Sánchez Segovia J, Herrera Carranza M, Maldonado Pérez JA, Castillo Quintero M, Ayerbe García R. Parámetros de adaptación en ventilación mecánica no invasiva. Estudio comparativo experimental. Arch Bronconeumol 2001;37:7-13.
150. Mayoralas Alises S, Gómez Mendieta MA, Díaz Lobato S. Aerofagia por ventilación mecánica no invasiva: primera manifestación de un carcinoma gástrico silente. Arch Bronconeumol 2003;39:321-3.
151. González MM, Parreira VF, Rodenstein DO. Non-invasive ventilation and sleep. Sleep Med Rev 2002;6:29-44.
152. De Miguel Díez J, De Lucas Ramos P, Pérez Parra JJ, Buendía García MJ, Cubillo Marcos JM, González-Moro JMR. Análisis de la retirada de la ventilación mecánica no invasiva en pacientes con síndrome de hipoventilación-obesidad. Resultados a medio plazo. Arch Bronconeumol 2003;39:292-7.
153. Masa JF, Sánchez de Cos J, Disdier C, Hernández M, Fuentes F. Nasal intermittent positive pressure ventilation. Analysis of its withdrawal. Chest 1995;107:382-8.
154. Karakurt S, Fanfulla F, Nava S. Is it safe for patients with chronic hypercapnic respiratory failure undergoing home noninvasive ventilation to discontinue ventilation briefly? Chest 2001;119:1379-86.
155. Tzeng AC, Bach JR. Prevention of pulmonary morbidity for patients with neuromuscular disease. Chest 2000;118:1390-6.
156. Gabrielli A, Caruso LJ, Layon AJ, Antonelli M. Yet another look at noninvasive positive-pressure ventilation. Chest 2003;124:428-31.
157. Rodenstein DO. ¿Qué deberemos aprender los neumólogos en los próximos años? Arch Bronconeumol 2002;38:189-90.
158. Solsona JF, Miró G, Ferrer M, Cabré L, Torres A. Los criterios de ingreso en la UCI del paciente con enfermedad pulmonar obstructiva crónica. Documento de consenso SEMICYUC-SEPAR. Arch Bronconeumol 2001;37:335-9.
159. Bach JR. Successful pregnancies for ventilator users. Am J Phys Med Rehabil 2003;82:226-9.
160. Díaz Lobato S, Mayoralas Alises S, Gómez Mendieta MA, Sanz Baena S, Martín Sánchez R, Díaz-Agero P. Análisis de los aspectos logísticos y organizativos de un crucero para pacientes con insuficiencia respiratoria crónica. La Expedición RESpIRA y el Crucero de la EPOC. Arch Bronconeumol 2003;39:266-73.