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SERIES "NONINVASIVE VENTILATION IN ACUTE AND CHRONIC RESPIRATORY FAILURE"
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Where to perform noninvasive ventilation?

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Where to perform noninvasive ventilation? M.W. Elliott, M. Confalonieri, S. Nava. ©ERS Journals Ltd 2002.
ABSTRACT: Noninvasive positive-pressure ventilation (NPPV) has been shown to be a means of reducing the need for endotracheal intubation, which when effective reduces the complication rate and improves outcome. Because paralysis and sedation are not needed and because the patient is not necessarily dependent upon a machine for respiration, ventilation outside the intensive care unit (ICU) is an option. A number of studies have shown that NPPV for acute exacerbations of chronic obstructive pulmonary disease (COPD) can be effective in the non-ICU environment, though usually in patients with less severe exacerbations. However, there have been no direct comparisons of the application of NPPV in different locations.

The likelihood of success of the technique is an important factor in deciding where NPPV should be performed. Ready access to invasive ventilation is important when NPPV is not indicated from the outset or fails after an initial trial. In acute exacerbations of COPD, NPPV is less likely to be successful the more severe the exacerbation, as measured by the severity of acidosis. Good tolerance of NPPV, which translates into an improvement in pH and a fall in respiratory rate, predicts a successful outcome and is a useful way of monitoring progress.

NPPV has been shown to be cost effective both in the ICU and when performed on general wards. A dedicated intermediate care unit with particular expertise in noninvasive modes of ventilation may provide the best environment, both in terms of outcome, but also cost effectiveness.

The ideal location for noninvasive positive-pressure ventilation will vary from country to country and indeed from hospital to hospital, depending upon local factors. However, the most important factor is that staff be adequately trained in the technique and be available throughout the 24-h period.
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Noninvasive positive-pressure ventilation (NPPV) has been shown to be an effective treatment for ventilatory failure, particularly resulting from acute exacerbations of chronic obstructive pulmonary disease (COPD) [1–10], but also hypoxaemic respiratory failure [11], community acquired pneumonia [12], cardiogenic pulmonary oedema [13, 14], following solid organ transplants [15], and in immunocompromised patients [16] in 16 randomized-controlled trials (RCTs). There have also been two RCTs of NPPV in weaning [17, 18]. These studies have been performed in a variety of different countries in varying ward environments and have established NPPV as an important tool in the management of patients with respiratory failure.

Definitions

In any discussion concerning the location of an acute NPPV service it is important to note that the model of hospital care differs from country to country and that the "intensive care unit" (ICU), "high dependency unit (HDU)" and "general ward" will have different levels of staffing, facilities for monitoring *etc*. Therefore, care must be taken in the extrapolation of results obtained in one study environment to other hospitals and countries. The UK King's Fund panel [19] have defined intensive care as: "A service for patients with potentially recoverable diseases who can benefit from more detailed observation and treatment than is generally

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available in the standard wards and departments". Unfortunately, this broad definition does not assist in the problem of comparisons of individual ICUs between studies. The definition of HDU is even less clear with some HDUs allowing invasive monitoring whilst in others only noninvasive monitoring is performed. In some countries specific respiratory ICUs and intermediate ICUs have been developed.

For the purpose of this article the following definitions were used. ICU: a high ratio of staff to patients and facilities for invasive ventilation and monitoring; intermediate respiratory ICU or HDU: continuous monitoring of vital signs in a specified clinical area with a staffing ratio between an ICU and a general ward; general ward: unselected emergency admissions taken and therefore although most have a particular speciality interest, patients with a variety of conditions and degrees of severity are cared for in the same clinical area. Variable nurse staffing levels but not as intensive as HDUs and ICUs.

These definitions are based largely on staffing levels but the types of ventilator which are available within and outside the ICU also vary and may have an important effect upon the effectiveness of NPPV. The ability to deliver a high inspiratory oxygen fraction (F_{I,O_2}) is of particular relevance in patients with hypoxaemic respiratory failure. Most portable ventilators do not have a gas blender and therefore it is impossible to deliver a high F_{I,O_2}. In addition the operator does not know exactly what concentration of oxygen the patient is receiving. The principal limitation to the use of home ventilators during acute respiratory failure (ARF) is the lack of direct "on-line" monitoring of pressure, volume and flow provided by these devices. The evaluation of patient-ventilator asynchrony is very difficult if not impossible without visualization of flow and pressure waveforms [20]. These are important features, especially during the first period of ventilation when it is important to assess the patient-ventilator interaction, respiratory mechanics, and the expired tidal volume (V_T) [21]. A bench study has recently demonstrated the inaccuracy of V_T delivered by some home mechanical ventilators when the pressure imposed on the ventilator is increased to simulate high airway resistance [22]. In other words, some of the commercially available devices fail to provide the desired V_T constantly during volume ventilation. This represents an evident limit on the use of these devices when the respiratory load is greatly increased as is the case in some patients with ARF. Newer ventilators specifically designed for NPPV in the hospital environment for patients with ARF overcome some of these problems.

Evidence for different locations for an acute noninvasive ventilation service

Chronic obstructive pulmonary disease

Most RCTs have studied patients with COPD and are therefore the main focus of this discussion. Early RCTs comparing NPPV with conventional therapy in the ICU showed that successful NPPV is possible. Most striking was the reduction in the need for intubation [2, 3], which in the largest study translated into improved survival and reduced length of both ICU and hospital stays [2]. Complications, particularly pneumonia and other infectious complications were markedly reduced [2, 11, 15, 17]. These studies were performed in units committed to the noninvasive approach and with particular expertize and this factor more than any other may have been important in determining the outcome. However, these studies do show that NPPV is feasible and, when successfully applied, effective.

The use of NPPV opens up new opportunities for the management of patients with ventilatory failure with regard to location. With NPPV paralysis and sedation are not needed and ventilation outside the ICU is an option. Treatment outside the ICU is an attractive option given the considerable pressure on ICU beds in some countries, the high costs and that for some patients admission to ICU is a distressing experience [23].

There have been a number of prospective randomized controlled studies of NPPV outside the ICU [1, 4–6, 8]. These studies showed varying results with none providing a conclusive statement on the role of NPPV, largely because the studies lacked sufficient statistical power. In the largest study (n=236), performed in general respiratory wards in 13 centres, NPPV was applied by the usual ward staff using a bilevel device in the spontaneous mode according to a simple protocol [10]. This was powered to pick up a 50% difference in "treatment failure", a surrogate for the need for intubation, defined by *a priori* criteria. Treatment failure was reduced from 27% to 15% by NPPV ($p<0.05$) and in-hospital mortality was also reduced from 20% to 10% ($p<0.05$). Subgroup analysis suggested that the outcome in patients with pH <7.3 after initial treatment was inferior to that in the studies performed in the ICU. It should be appreciated that it was not just location which differed between the ICU studies and this one; a very simple ventilator was used according to a protocol compared with more sophisticated individually adjusted ventilation in the ICU studies. However, this study does suggest that with adequate staff training NPPV can be applied with benefit outside the ICU by the usual ward staff and that early introduction of NPPV on a general ward results in a better outcome than providing no ventilatory support for acidotic patients outside the ICU. The study certainly does not suggest that NPPV should be performed on a general ward in preference to an ICU or a higher-dependency setting.

Conditions other than chronic obstructive pulmonary disease

There are no RCTs of NPPV outside the ICU in hypoxaemic respiratory failure or weaning and it is therefore only in patients with exacerbations of COPD that there is an evidence base for NPPV use outside of the ICU. The study of ANTONELLI *et al.*

[11] in which conventional mechanical ventilation and NPPV were compared in patients with acute hypoxic respiratory failure, showed NPPV to be as effective as conventional ventilation at improving gas exchange. Patients receiving NPPV had significantly lower rates of serious complications and those successfully treated with NPPV had shorter ICU stays. *Post hoc* subgroup analysis of patients with simplified acute physiological scores (SAPS) of <16 and those of $\geqslant 16$ showed that patients in the latter group had similar outcomes irrespective of the type of ventilation. However, NPPV was superior to conventional mechanical ventilation in patients with SAPS <16.

As with acute exacerbations of COPD it would therefore appear that it is possible to successfully manage patients with milder disease with NPPV. Further data are needed but it would be reasonable for selected patients to have a trial of NPPV on an experienced noninvasive unit outside the ICU, although rapid access to intubation and mechanical ventilation must be available.

Should noninvasive ventilation be started in the emergency department?

The type of treatment that is undertaken in the the emergency department and the length of time that patients typically stay there varies from hospital to hospital and from country to country. In some, patients remain in the emergency department for a very short period whereas in others they may remain there for a day or more. Two studies in which NPPV was initiated in the emergency department [4, 6] both failed to show any advantage to NPPV over conventional therapy. There are a number of possible explanations for this, which include the fact that patients are usually admitted to the ICU when other therapies have failed whereas most of those presenting to the emergency department have not received any treatment and therefore a proportion are going to improve after initiation of standard medical therapy. In a 1-yr period prevalence study [24], 20% of 983 patients with acute exacerbations of COPD were acidotic on arrival at the emergency department in Leeds and of these 20% had completely corrected their pH by the time of arrival on the ward. There was a weak relationship between the oxygen tension in arterial blood on arrival at hospital and the presence of acidosis, suggesting that in at least some patients respiratory acidosis had been precipitated by high-flow oxygen therapy administered in the ambulance on the way to hospital. It is important to note that the only study that showed an unequivocal benefit from NPPV outside the ICU [10] recruited patients who remained acidotic and tachypnoeic on arrival on the ward after treatment in the emergency department. The need for rapid access to facilities for intubation and mechanical ventilation is an important message from the negative study of Wood *et al.* [6], in which there was a trend towards worse outcome with NPPV, which was attributed in part to delays in intubation in the NPPV group. It should also be noted that this was a mixed population of patients and the two groups were not well matched hence this may also have explained some of the differences. Further potential problems relating to the provision of NPPV in the emergency department include the wide heterogeneity of disorders treated there; staff need to be skilled in the management of disorders of many different organ systems and it may not be possible to train them adequately in NPPV given the many other demands placed upon them. Furthermore, COPD patients with acute ventilatory failure need a longer length of stay to recover a stable status than that generally available in the emergency department.

NPPV has been shown to be of benefit in patients with cardiogenic pulmonary oedema (CPO) [13, 14, 25] and if NPPV is to be administered to these patients it needs to be early on after admission, which will usually mean in the emergency department. Continuous positive airway pressure (CPAP) is the usual mode of choice, but it is important that ventilators capable of delivering a high F_{I,O_2} be available for when NPPV is necessary.

There are some patients with a variety of aetiologies for respiratory failure who present to the emergency department *in extremis* and require immediate ventilatory support, for whom intubation is not considered appropriate. This could be because the patient's previous history is well known or they have made an advance directive precluding intubation and mechanical ventilation. In these patients a trial of NPPV could be considered. In this situation it would be reasonable to start NPPV in the emergency department in order to stabilize the patient for transfer to the ward on which NPPV is normally performed. In other patients where the clinical findings suggest that intubation would not be appropriate, but the medical notes or a family member are not available, NPPV can be used to buy time to obtain further information or to allow the patient to recover to the point at which they can make their opinion about their future management known. However if there is no improvement the patient should be intubated and transferred to the ICU.

In summary, most patients presenting to an emergency department with an acute exacerbation of COPD do not need NPPV, but particular attention should be paid to controlled oxygen therapy. NPPV may be needed in a few patients who are *in extremis* and for whom intubation is not considered appropriate. If it is normal policy for patients to receive the first 24-h treatment in the emergency department, then NPPV should be started there in those who remain acidotic and tachypnoeic a short time after standard medication has been administered and oxygen therapy optimized. Noninvasive CPAP or bilevel ventilation for patients with acute CPO will usually be delivered in the emergency department. For these reasons it is necessary for staff working in the emergency department to be trained in, and to develop skills in NPPV. This may best be achieved by attachment and rotation through the unit providing the major focus for NPPV in the institution.

Where should noninvasive positive-pressure ventilation be performed?

Factors which need to be considered when deciding where NPPV should be performed are summarized in table 1. There have been no direct comparisons between outcome from NPPV in the ICU, in intermediate units and on a general ward and it is unlikely that there ever will be such a trial. It should be appreciated that while there is some overlap, the skills needed for NPPV are different to those required for invasive ventilation and the outcome from NPPV is likely to be better on a general ward where the staff have a lot of experience of NPPV than on an ICU with high nurse, therapist and doctor to patient ratios and a high level of monitoring, but little experience of NPPV. The patient's perspective is also important; many find their experience of ICU to be unpleasant [23] and the less intensive atmosphere of a noninvasive unit may be less distressing, although there is no evidence to support this assertion. Factors to be considered include whether or not intubation is felt to be appropriate should NPPV fail, the presence of other system failure, comorbidity, the severity of the respiratory failure and the likelihood of success with NPPV. Nurses, physiotherapists or respiratory therapists may be the primary-care giver and this will depend upon local availability, enthusiasm and expertize. Patients who cannot sustain ventilation for more than a minute or two when acutely unwell require continuous observation. Patients with this severity of ventilatory failure are often confused and usually require high inflation pressures. Continuous observation is needed to ensure that the patient does not remove the mask and that leaks are minimized. Even if the patient does not remove the mask there is a tendency for the Velcro straps of the head gear to gradually work loose with high pressures and for mask leaks to develop.

If NPPV is only to be provided on the ICU the number of patients needing ICU care will increase and this may not be necessary or appropriate. The study of PLANT *et al.* [10] has shown that NPPV is an option outside the ICU, but the outcome for patients with a pH <7.3 was not as good as that seen for comparable patients in the studies performed in a higher-dependency setting. Also for reasons of training, through put, quality of service and skill retention NPPV is best performed in a single location, intermediate between ICU and the general ward [24]. However, intermediate respiratory units are not widely available throughout Europe [26]. These units can be effective and data from the USA suggest that they are cost-effective [27]. A study of 756 consecutive patients admitted to 26 respiratory intermediate care units in Italy with: a nurse to patient ratio ranging from 1:2.5 to 1:4 per shift, availability of adequate continuous noninvasive monitoring, expertize in NPPV and intubation in case of NPPV failure, physician availability 24 h a day showed a better outcome than that expected on the basis of Acute Physiology, Age and Chronic Heath Evaluation (APACHE) II scores [28]. The median APACHE II score was 18 (range 1–43). The predicted inpatient mortality risk rate was 22% while the actual inpatient mortality rate was 16%. The highest proportion (47%) were admitted from the emergency department, 19% from other medical wards, 18% were transferred from the ICU, 13% from specialist respiratory wards, and 2% were transferred following surgery. All but 32 had respiratory failure on admission. The reasons for admission to the respiratory ICU (RICU) were monitoring for expected clinical instability (n=221), mechanical ventilation (n=473) and weaning (n=59). A total of 586 patients needed mechanical ventilation during their stay in the RICU, 425 were treated with noninvasive techniques as first line (374 by noninvasive positive pressure, 51 by iron lung), and 161 underwent invasive mechanical ventilation (63 intubated, 98 tracheostomies). All but 48 patients had chronic respiratory disease, mainly COPD (n=451).

The best location for a NPPV service will depend critically upon local factors, particularly the skill levels of doctors, nurses and therapists in looking after patients receiving NPPV. Severely ill patients, who do not need NPPV, may benefit from the extra monitoring and nurse staffing available in a higher-dependency setting.

Table 1. – Where should noninvasive positive-pressure ventilation be carried out?

Factors to be considered
Location of staff with training and expertize in noninvasive positive-pressure ventilation
Adequate staff available throughout 24-h period
Rapid access to endotracheal intubation and invasive mechanical ventilation
Severity of respiratory failure and likelihood of success
Facilities for monitoring

Monitoring

The monitoring required during NPPV is summarized in table 2. There are no RCTs which address the issue of whether monitoring improves outcome. Monitoring serves two roles; firstly safety to warn of impending catastrophe and secondly optimization of ventilator settings. VITACCA *et al.* [29] have shown that setting a ventilator on the basis of physiologically derived information results in more complete

Table 2. – Monitoring during noninvasive positive-pressure ventilation (NPPV)

Essential
Regular clinical observation
Continuous pulse oximetry
Arterial blood gases after 1–4 h NPPV and after 1 h of any change in ventilator settings or F_{I,O_2}
Respiratory rate
Desirable
Electrocardiogram
More detailed physiological information such as leak, expired V_T, and measure of ventilator patient asynchrony

F_{I,O_2}: inspiratory oxygen fraction; V_T: tidal volume.

respiratory-muscle unloading than when the ventilator was set, by experienced operators, using clinical judgement alone. The evaluation of patient-ventilator asynchrony is difficult without visualization of flow and pressure waveforms [20]. ELY *et al.* [30] showed that patients could be weaned from assisted ventilation more rapidly when the results of physiological measurements were made available to medical staff. Even for experienced practitioners decisions based on physiological measurements are superior to clinical judgement in setting the ventilator and deciding the appropriate management strategy. Further work is needed to establish which parameters should be monitored to optimize NPPV. It should be remembered however that high technology monitoring is never a substitute for good clinical observation [31].

The oxygen saturation should be maintained at $\geqslant$92% [32] to avoid the twin dangers of hypoxia and worsening hypercapnia due to altering the dead space to V_T ratio [33]. Arterial blood gases should be checked at baseline and after 1–4 h because a number of studies have shown that the change in arterial blood gas tensions, particularly pH, after a short period of NPPV predicts a successful outcome [1, 2, 34–37]. An improvement in pH and/or carbon dioxide tension in arterial blood (P_{a,CO_2}) at 30 min [38], 1 h [35] or after a longer period [35, 36] predict successful NPPV. Arterial blood gas tensions should be checked within 1 h of any change in ventilator settings or F_{I,O_2}. Finally continuous or intermittent recording of respiratory rate may be useful in determining the likely outcome with NPPV. Patients who have been intubated and are likely to fail a weaning attempt adopt a pattern of rapid shallow breathing when disconnected from the ventilator [39], indicating that they are breathing against an unsustainable load. A reduction in respiratory rate with NPPV has been variably shown in a number of studies, with larger falls generally being associated with a successful outcome from NPPV [2, 35, 36] though this is not always seen [40]. Data from the largest study [41] showed that at enrolment [H^+] (odds ratio (OR) 1.22 $nmol^{-1} \cdot L^{-1}$ 95% confidence interval (CI) 1.09–1.37, p<0.01) and P_{a,CO_2} (OR 1.14 kPa^{-1} 95% CI 1.14–1.81, p<0.01) were associated with treatment failure. After 4 h of therapy improvement in acidosis (OR 0.89 $nmol^{-1} \cdot L^{-1}$ (95% CI 0.82–0.97), p<0.01) and/or fall in respiratory rate (OR 0.92 $breath^{-1} \cdot min^{-1}$ (95% CI 0.84–0.99), p=0.04) were associated with success. If at least one of these two parameters improved, successful NPPV was likely.

Implications for staffing and training

Training requirements for NPPV are summarized in table 3. NPPV has been reported to be a time consuming procedure [42] but as with any new technique there is a learning curve and the same group have subsequently published more encouraging results [43]. A number of studies in the ICU, have shown that to start with a significant amount of time is required to establish the patient on NPPV, but this drops off substantially in subsequent days [3, 44, 45]. It is possible therefore that NPPV may have a much greater impact on nursing workload outside the ICU, where nurses have responsibility for a larger number of patients. In the study of BOTT *et al.* [1] there was no difference in nursing workload, assessed by asking the senior nurse to rate, on a visual analogue scale, the amount of care needed in the conventional and NPPV groups. However, this is an insensitive way of measuring nursing needs and in addition some of the potential extra work associated with NPPV was performed by supernumerary research staff. In the study of PLANT *et al.* [10], NPPV resulted in a modest increase in nursing workload, assessed using an end-of-bed log, in the first 8 h of the admission, equating to 26 min, but no difference was identified thereafter. However, there is no data on the effect of NPPV on the care that other patients on the ward received nor whether the outcome would have been better if the nurses had spent more time with the patients receiving NPPV. In other words although this study showed that NPPV was feasible in the general ward environment it does not mean that it was the optimal situation. Furthermore, even if good results can be obtained it may be at the expense of the care of other patients. Most of the centres that participated in the study had little or no previous experience of NPPV and therefore required training in mask fitting and application of NPPV. The mean amount of formal training given in the first 3 months of opening a ward by the research doctor and nurse was 7.6 h (SD 3.6). Thereafter each centre received 0.9 $h \cdot month^{-1}$ (SD 0.82) to maintain the skills. It should be appreciated that there was no need to make subtle adjustments to the ventilator settings which were all done according to protocol. Much more training would be needed if more sophisticated ventilators were used. However, it underlines the fact that NPPV, in whatever location, is not just a question of purchasing the necessary equipment but also of staff training. Although a considerable amount of input is likely when a unit first starts to provide a NPPV service thereafter, as long as a critical mass of nurses and therapists remain, new staff will gain the necessary skills from their colleagues. In view of the fact that NPPV in the more severely-ill patient may require as much input as an invasively ventilated patient [44] there should usually be one nurse responsible for no more than three or four patients, though clearly this will be depend upon the care needs of the other patients. In the less severely

Table 3. – Training requirements

Understanding rationale for assisted ventilation
Mask and headgear fitting techniques
Ventilator circuit assembly
Theory of operation and adjusting ventilation to achieve desired outcome
Cleaning and general maintenance
Problem solving - the ability to recognise serious situations and act accordingly
Above all medical, nursing and technical staff need to be convinced that the technique works
Specific educational programs may help acceptance of NPPV among personnel

affected patient NPPV can be successful with a lower level of staffing [10].

Economics of noninvasive ventilation

Economic analysis in medicine is complex and as a result many diagnostic and therapeutic technologies have been adopted into practice without any consideration of the economic implications. Even techniques with a clear clinical advantage may not be endorsed in the current healthcare climate without a favourable cost-effectiveness analysis. The first step in an economic analysis is to calculate the cost of an intervention. Relevant costs for ventilation include equipment, supplies, capital and overheads. More complex, is the calculation of the costs for the care of patients, including medical and paramedical time and the level of assistance, laboratory and pharmacy costs, nutrition and ventilation costs. The daily cost of NPPV has been reported to be similar to that of standard medical therapy [3] or invasive ventilation (calculated only on the first day of treatment) [44]. According to the different studies and countries, the mean daily cost of NPPV varies from US$850 [44] to US$1500 [3, 46]; the difference is mainly due to the salaries of the personnel, which are much higher in the USA than in Europe. The second step is to evaluate the outcome for the patients. The outcomes may be calculated in terms of economic resources saved or created, efficacy of the treatment in improving survival, or in the case of NPPV the rate of intubation, or as the impact of a technique to ameliorate quality of life.

Though the findings are not consistent it has been shown in some of the larger studies that NPPV can shorten the length of ICU and/or hospital stay, compared for example with medical therapy or invasive ventilation [2, 3, 7, 11, 15, 16]. In no study has NPPV been shown to lengthen the duration of hospital stay. Although not the primary aim of the studies the finding of a reduced hospital, and particularly ICU length of stay, creates or saves resources and thereby indicates a cost benefit from NPPV.

Cost-effectiveness is the most "popular" way to perform an economic analysis. To date there is only one study analysing this in detail, in patients with an acute exacerbation of COPD, using base care modelled for a tertiary care teaching hospital [47]. The two alternatives considered were NPPV and standard medical therapy, while the main outcomes modelled and calculated were costs, mortality and intubation rates. To determine clinical effectiveness KEENAN *et al.* [47] used a meta-analysis of randomized trials. Then a decision tree was constructed and probabilities were applied at each chance node using research evidence and a comprehensive regional database. KEENAN *et al.* [47] concluded that NPPV was more effective than standard treatment in reducing hospital mortality and at the same time less expensive, with a cost saving of about US$2,500 per patient admission. The major problem with this kind of analysis is that the clinical data come from different studies, not all with a well-defined selection of patients, so that applicability to a large population is not possible. Furthermore the different models and costs of healthcare in different countries, and indeed between different institutions within the same country, make comparisons very difficult.

Another factor that may have a major impact on economic analysis is the location in which NPPV is performed. The opening of intermediate respiratory units, providing for example, noninvasive monitoring and NPPV, and not needing major expenditure on building a dedicated area with a better nurse/patient ratio than the general ward and some basic monitoring (*i.e.* electrocardiogram and arterial oxygen saturation), may be an excellent alternative to the "classical" ICU [26]. It has been shown that the daily costs of a ventilated patient may be reduced by two-thirds, when NPPV is performed in a specialized respiratory unit, rather than in an ICU [27]. These costs can be reduced still further when NPPV is performed on a general ward, though effectiveness may not be so good primarily because of fewer nurses to deliver care to an individual patient.

Despite the possible money savings, the system of payment is a major problem. If the reimbursments are made through the diagnosis-related group (DRG) system, the daily loss per patient is ~$350 [46]. In countries where reimbursement is made on the basis of DRGs there is an urgent need to provide adequate reimbursement for NPPV. If this is not done clinicians may be compelled, by their managers, to intubate patients because this attracts more realistic reimbursement. This is to the detriment of patients, because of the worse outcomes when NPPV is not used, and at a greater cost to payers.

Conclusion

Staff training and experience is more important than location, and adequate numbers of staff skilled in noninvasive positive-pressure ventilation must be available throughout the 24-h period. Because of the demands of looking after these acutely-ill patients, and to aid training and skill retention, noninvasive positive-pressure ventilation is usually best carried out in one single sex location with one nurse responsible for no more than three to four patients in total. Basic monitoring should be available. Whether this is called an intensive care unit, a high dependency unit or is part of a general ward is largely irrelevant. Available data suggests that noninvasive positive-pressure ventilation for acute and chronic respiratory failure is a cost- effective intervention.

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