# Where Should Noninvasive Ventilation Be Delivered?

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**Noninvasive ventilation (NIV) has assumed an important role in the management of certain types of respiratory failure in acute-care hospitals. However, the optimal location for NIV has been a matter of debate. Some have argued that all patients begun on NIV in the acute-care setting should go to an intensive care unit (ICU), but this is impractical because ICU beds are often unavailable, and it may not be a sensible use of resources. Also, relatively few studies have examined the question of location for NIV. One problem is that various units' capabilities to deliver NIV differ substantially, even in the same hospital. Choosing the appropriate environment for NIV requires consideration of the patient's need for monitoring, the monitoring capabilities of the unit, including both technical and personnel resources (nursing and respiratory therapy), and the staff's skill and experience. In some hospitals NIV is begun most often in the emergency department, but is most often managed in an ICU. Step-down units are often good locations for NIV, but many institutions do not have step-down units. With ICU beds at a premium, many hospitals are forced to manage some NIV patients on general wards, which can be safely done with more stable patients if the ward is suitably monitored and experienced. When deciding where to locate the patient, clinicians must be familiar with the capabilities of the units in their facility and try to match the patient's need for monitoring and the unit's capabilities.** *Key words: noninvasive ventilation, NIV, respiratory failure, acute care, intensive care, monitoring, emergency department*. [Respir Care 2009;54(1):62–69. © 2009 Daedalus Enterprises]

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Table 1. Advantages and Disadvantages of Locations for NIV in Acute and Subacute Conditions

| Location | Advantages | Disadvantages |
|---|---|---|
| Pre-hospital | Rapid application | Limited equipment and monitoring<br>Lack of evidence |
| Emergency department | Rapid application<br>Close monitoring in high-intensity room | Temporary location<br>Staff may lack NIV skill and experience |
| Intensive care unit | 1:1 nurse/patient ratio, usually with dedicated respiratory therapist<br>Maximal monitoring capabilities | Resource-intensive and excessively costly for stable patients<br>Beds in short supply |
| Step-down unit | 1:2 to 1:4 nurse/patient ratio and central monitoring available<br>Often have dedicated respiratory therapist<br>Develop specialized NIV skills and suitable for most acute NIV applications | Many hospitals lack such units<br>Excessive resource-use for stable patients<br>NIV skills differ between units |
| General ward | Suitable for stable patients for more efficient use of resources<br>Beds more often available than in ICU or step-down unit<br>Some offer central monitoring, have NIV skills | Not suitable for patients who require close monitoring<br>Many lack experience or skill with NIV |
| Long-term acute care | Good location for transitioning from tracheostomy to NIV<br>More time to initiate stable long-term patients on NIV<br>Rehabilitation and physical therapy services available | Not suitable for acutely ill patients<br>Many lack experience and skill with NIV |

NIV = noninvasive ventilation

## Introduction

Noninvasive ventilation (NIV) has gained increasing worldwide acceptance at acute-care hospitals over the past decade, and is now considered the ventilation modality of first choice for selected patients with acute respiratory failure (ARF) related to exacerbation of chronic obstructive pulmonary disease (COPD), acute cardiogenic pulmonary edema, or immunocompromise.[1,2] When applied appropriately, NIV lowers morbidity and mortality, and permits more efficient use of scarce medical resources, compared to the previously standard medical therapy.[3,4] NIV reduces the risk of ventilator-associated pneumonia[5] and may shorten stay in the intensive care unit (ICU) and/or hospital.[6] Also, because NIV requires less intensive monitoring than invasive ventilation, clinicians can administer NIV outside the ICU, particularly in institutions where ICU beds are in short supply.[7] But less monitoring might increase the risk that deterioration won't be promptly recognized and treated. Thus, the question of how to determine the proper location for NIV has generated much discussion and debate.

This paper addresses the issue of determining the proper location for pre-hospital and hospitalized patients receiving NIV. First I will describe the monitoring capabilities of the various possible NIV locations and discuss the medical literature related to NIV in those locations. Table 1 summarizes the advantages and disadvantages of the various locations. I'll then discuss surveys that have assessed NIV locations in acute-care hospitals and analyze current recommendations on NIV location. Finally, I will present a practical approach for determining what location is best suited to a particular patient.

## Possible NIV Locations

### Pre-Hospital Setting

Delays in the initiation of NIV can be costly, particularly with conditions that evolve rapidly, such as acute cardiogenic pulmonary edema, so emergency-response teams have incorporated continuous positive airway pressure (CPAP) devices in their ambulances, for suspected acute cardiogenic pulmonary edema in the field. In the Houston area, in a 2-year prospective study that included 138 patients treated with pre-hospital mask CPAP, 56% had congestive heart failure, 28% had COPD, and 16% had ARF of other causes.[8] The overall CPAP failure rate was 26%, and COPD, ARF of other causes, and air leak were identified as risk factors for failure. The pre-hospital CPAP failure rate was comparable to that of similar patients admitted to the hospital and treated with NIV.

A Parisian group randomized 124 patients seen pre-hospital with suspected acute cardiogenic pulmonary edema to receive CPAP of 7.5 cm $H_2O$ via face mask, either immediately or delayed by 15 min.[9] Compared to delayed

therapy, immediate therapy relieved dyspnea more rapidly and lowered the intubation and hospital mortality rates. These findings highlight the importance of starting NIV as soon as possible in the pre-hospital setting, even though monitoring and diagnostic capabilities are limited. The pre-hospital setting is potentially advantageous for NIV because it permits earlier initiation; the clinician/patient ratio can be as high as 2:1; and a low CPAP pressure is unlikely to do harm, as long as the patient is closely observed and patients who fail NIV therapy are promptly intubated.

**Emergency Department**

NIV is commonly started in the emergency department (ED), particularly in hospitals with busy EDs, because NIV initiation should not be delayed until the patient can be transferred to another unit. Also, most EDs have special high-intensity areas suitable for NIV initiation, have a nurse/patient ratio of up to 1:1, and have continuous observation. However, once stabilized the patient should be sent to another ward as soon as possible so as not to retard patient flow through the ED.

Studies of NIV in the ED have reported inconsistent findings. In one early randomized trial, Wood et al[10] found a strong trend toward higher mortality in the NIV group than the control group, but that study was flawed by unequal randomized groups; there were more patients with COPD in the control group, which favored greater success in the control group, and undue delay of intubation (average nearly 24 h) in the NIV group. In a subsequent retrospective study of 58 consecutive patients started on NIV in an ED, 30 had COPD, 16 had congestive heart failure, and 6 had a combination of the two. Another 6 had muscle weakness, pneumonia, or sleep apnea. The overall success rate was 74%, which was predictable based on a favorable arterial-blood-gas response within the first 30 min. I think those authors were perhaps a bit overzealous when they concluded that a trial of NIV is suitable for "any patient with ARF capable of cooperating with the [respiratory] therapist."[11] Nonetheless, early initiation of NIV is strongly encouraged in the ED for appropriate patients, to avoid delay that could contribute to NIV failure.

**Intensive Care Unit**

The ICU offers the most intensive monitoring and therapeutic capabilities in the hospital for acutely ill patients with ARF, including a 1:1 to 1:2 nurse/patient ratio, continuous observation of vital signs, electrocardiography, and gas exchange, and usually a dedicated respiratory therapist (RT). In most hospitals, patients leaving the ED or initiated on NIV on a general ward will be transferred to the ICU for further stabilization. In an ICU, airway secretion problems, vomiting, or mask removal can be handled promptly. Most of the randomized controlled trials on NIV for ARF have been based in ICUs and demonstrated the well-established benefits of NIV for COPD exacerbation, acute cardiogenic pulmonary edema, and immunocompromised patients.[12] Clearly the ICU is the appropriate location for even the sickest patients on NIV. The question is how to determine which patients can be managed safely outside of the ICU.

**Step-Down Unit**

Some hospitals have specialized units for patients who do not require ICU-level monitoring but do require closer observation than can be provided on a general ward. The purposes and capabilities of these units differ between institutions, and they go by various names, including intermediate care unit, respiratory intensive care unit, step-down unit, and high-dependency unit. The nurse/patient ratio ranges from 1:2 to 1:4, and they usually offer continuous monitoring of oxygen saturation, electrocardiography, and vital signs via central telemetry. Some have arterial line monitoring, but they eschew central hemodynamic monitoring. Considering that RT coverage is usually comparable to that of an ICU, these units are appropriate for administration of NIV in most cases, with the possible exception of the least stable patients who may still require ICU-level monitoring. In addition, considering that the characteristics of step-down units differ between hospitals, their use as NIV sites may differ as well.

In an Italian cohort study of the management of mechanical ventilation in respiratory care units, 425 (56%) of 756 patients were treated with NIV, compared to 161 (22%) treated with invasive ventilation.[13] Forty-seven percent of patients were sent directly from the ED without passing through the ICU, and only 18% were transferred directly from the ICU. Sixty percent of the NIV patients had COPD, and the overall NIV success rate was 74%. Those authors concluded that a respiratory care unit is a good location for NIV.

**General Wards**

General wards also differ considerably in their capabilities to manage patients on NIV, even within an institution. The nurse/patient ratio ranges from 1:4 to 1:10, and there may be no central telemetry. General wards that have nursing staff experienced with NIV, readily available skilled RTs, and central telemetry may be capable of delivering NIV safely to selected patients with ARF. However, caution should be exercised, especially when initiating NIV, because general wards are usually not adequate to monitor patients at risk of sudden deterioration. Emphasizing this point is the randomized controlled trial by Plant et al,[14]

which was performed on "general respiratory wards" of hospitals in the United Kingdom. Trained nurses administered NIV with a simple bi-level ventilator, which significantly lowered the overall intubation and mortality rates, compared to controls. However, in the subgroup of patients with pH $<$ 7.30, the intubation and mortality rates were not significantly different, which led those authors to speculate that these sicker patients might have been better managed in an ICU. However, shortages of ICU beds sometimes necessitate the management of NIV patients on regular medical floors.

In a prospective cohort study of 76 consecutive patients managed with NIV on general medical floors in a single institution, Farha et al[7] found that 31% of 62 patients who did not have do-not-intubate orders failed NIV and were transferred to the ICU, and only half of the 14 do-not-intubate patients died. All ICU beds were occupied 38% of the time, which perhaps explains why some of the non-do-not-intubate patients were managed on general wards. They also found that increased secretions, a non-COPD diagnosis, and infiltrates on chest radiograph correlated with NIV failure. They concluded that the success rate of NIV in their series was comparable to that reported in studies from ICUs (though they acknowledged the inherent selection bias in their study design) and that NIV "can be used outside the ICU."[7]

### Long-Term Acute-Care Hospitals

Long-term acute-care hospitals are playing an increasingly important role in managing patients with prolonged bouts of respiratory failure precipitated by acute episodes. Some acute-care hospitals house long-term acute-care units on their campuses. Many other long-term acute-care hospitals are free-standing, but they serve an important role in taking over care of patients whose respiratory failure persists after initial stabilization. As NIV sees more frequent use in the acute-care setting, more patients are transferred to long-term acute-care hospitals that use NIV, and some long-term acute-care hospitals institute NIV to facilitate weaning in selected tracheostomized patients. Long-term acute-care hospitals often have wards that specialize in the care of patients with prolonged respiratory failure, and they have a nurse staffing level similar to that of a general ward. They also provide more intensive physical and occupational therapy services than do acute-care hospitals, to help rehabilitate weaning patients. In addition, RTs are available at all times, and continuous central monitoring of ventilators and continuous monitoring of oximetry and vital signs are usually available, at least for some beds.

Very little information is available on the use of NIV in long-term acute-care hospitals. In a survey of respiratory care directors at 17 long-term acute-care hospitals in Massachusetts and Rhode Island, with over 2,000 beds (unpublished data), 9 of the institutions used at least some NIV. Of 180 patients who were receiving mechanical ventilation at the time (early 2003), 76% had a tracheostomy and 24% received NIV. Of those on NIV, 74% had COPD, 20% had restrictive processes (including neuromuscular), and 6% had other conditions. Only 2 institutions had ever used NIV to facilitate decannulation of patients with a tracheostomy.

In summary, NIV can be started in the pre-hospital setting or EDs, but most of these patients will be transferred to other locations for optimal management. Also, the characteristics of specialized units differ between institutions, which makes it difficult to compare the results from different institutions.

## Where is NIV Actually Delivered in Acute-Care Hospitals?

Several studies have shed light on the locations of patients started on NIV in acute-care hospitals (see Table 1). In a prospective study at a Canadian institution, Paus-Jenssen et al[15] found that most NIV starts were in the ED, although this accounted for only a third of patients. Almost as many were started in the ICU, and slightly fewer were started in the step-down unit. Burns et al[16] surveyed practices at several Canadian and a few United States institutions and found a distribution similar to that found by Paus-Janssens et al, although fewer were located in step-down units. Maheshwari et al[17] surveyed the respiratory therapy directors of all acute-care hospitals in Massachusetts and Rhode Island and found that, on average, over half of NIV starts occurred in ICUs, a quarter in EDs, nearly a quarter on general medical wards, and very few in step-down units, which reflects the fact that few acute-care hospitals in that region have step-down units.

Schettino et al[18] prospectively collected data on 449 patients treated with NIV during one year at one institution. One fifth of the patients had NIV started in the ED, nearly half had NIV started in the ICU, and a third had NIV started on the general wards. Interestingly, those managed solely in the ED had the best outcomes; they had a 22.6% intubation rate and a 7.5% mortality rate. Those managed exclusively in the ICU had a 49.4% intubation rate and a 28.4% mortality rate. Those kept on the wards had a 27.3% intubation rate and 14.9% mortality rate. Schettino et al speculated that the differences in outcomes were related to the different severities of underlying illnesses in the various settings. Patients who stayed in the ED most often had acute cardiogenic pulmonary edema, and those in the ICU were more likely to have hypoxemic respiratory failure.

Interestingly, all of the studies found that a substantial (1/5 to 1/3) portion of patients were treated on a general medical ward, which raises questions about the safety of

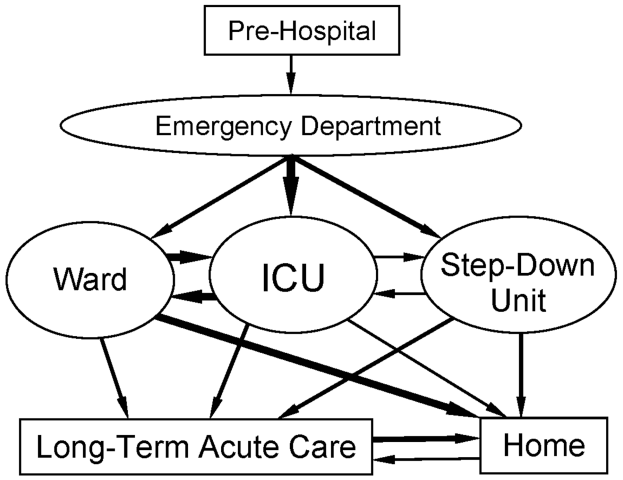


Fig. 1. Patient flow between locations where noninvasive ventilation (NIV) is used. The width of the arrows approximates the volume of flow. Some patients are started on NIV in the pre-hospital setting, but most NIV starts are initiated in the emergency department, intensive care unit (ICU), or general ward. Patients from the emergency department or ward are then transferred to the ICU or specialized step-down unit (if the hospital has one). After stabilization, the patient might return to the ward, from which he or she may be discharged home or may go to a long-term acute-care hospital. Some unstable patients are transferred to the ICU from the step-down unit. Others go from the ICU to the step-down unit if they are not yet ready for a general ward. These flow patterns differ between institutions and partly depend on bed and unit availability and the skill and experience of the staff.

such management. Schettino et al stated[18] that they do not have absolute criteria for deciding where to locate NIV patients, but they require that NIV patients managed on the wards can breathe spontaneously for more than an hour at a time without the assistance of NIV.

As shown in Figure 1, the location of patients who receive NIV in acute-care hospitals is a dynamic process. In a prospective study at a Canadian institution,[19] Sinuff et al found that, although most patients were started on NIV in the ED, the greatest proportion of time spent delivering NIV was in the ICU, with lesser portions in the step-down unit and general wards. This reflects a policy in that institution that favors placing new starts on NIV in the ICU. The distribution of starts and time spent delivering NIV are likely to differ between institutions, depending on practice patterns.

## Practical Approach to Determining the Best Location for NIV

Recommendations in the medical literature on choosing a location for NIV have ranged from a guideline that required that all patients initiated on NIV be transferred to an ICU, to the suggestion that many patients can be safely and effectively managed on a general ward. Developing universal recommendations is difficult because no 2 patients are exactly alike, and clinical units in and between hospitals differ considerably. The same patient might require management in an ICU in one institution and yet be appropriate for treatment in a step-down unit or even a general ward in another institution. Accordingly, rather than attempt to develop guidelines that apply in all institutions, a more sensible approach is to outline principles applicable across institutions to help decide where patients should be managed. Important factors to consider include the patient's need for monitoring, monitoring capabilities of the unit, and the skill and experience of the unit staff.

Table 2. Risk Factors for NIV Failure in Patients With Acute Hypercapnic Respiratory Failure

| |
|---|
| Poor neurologic score (Glasgow Coma Score < 11) |
| Tachypnea (> 35 breaths/min) |
| pH < 7.25 |
| APACHE score > 29 |
| Asynchronous breathing |
| Edentulous |
| Excessive air leak |
| Agitation |
| Excessive secretions |
| Poor tolerance |
| Poor adherence to therapy |
| No initial improvement within first 2 h of NIV: |
| No improvement in pH |
| Persistent tachypnea |
| Persistent hypercapnia |

NIV = noninvasive ventilation
APACHE = Acute Physiology and Chronic Health Evaluation
(Based on data in References 20-22.)

## The Patient's Need for Monitoring

The severity of the patient's respiratory compromise and risk of NIV failure determine the intensity of monitoring needed. Some patients admitted for non-respiratory reasons may need CPAP or bi-level ventilation for stable obstructive sleep apnea or chronic hypoventilation syndrome, and, other than to establish that the patient's therapy is continued at the desired settings, no other special monitoring is required. Patients begun on NIV for respiratory compromise require closer monitoring, but the intensity of monitoring differs considerably between individual patients.

One approach to determining the need for monitoring is to assess the patient's risk of NIV failure. Numerous studies have identified risk factors for NIV failure.[20-25] Table 2 lists NIV-failure risk factors with hypercapnic respiratory failure, and Table 3 lists risk factors with hypoxemic respiratory failure. Some of these are simple bedside as-

Table 3. Risk Factors for NIV Failure in Patients With Acute Hypoxemic Respiratory Failure

| |
|---|
| Diagnosis of ARDS or pneumonia |
| Age > 40 y |
| Hypotension (systolic blood pressure < 90 mm Hg) |
| Metabolic acidosis (pH < 7.25) |
| Low oxygenation index ($P_{aO_2}/F_{IO_2}$) |
| Simplified Acute Physiology Score II > 34 |
| Failure to improve oxygenation within first hour of NIV ($P_{aO_2}/F_{IO_2}$ > 175 mm Hg) |

ARDS = acute respiratory distress syndrome
$F_{IO_2}$ = fraction of inspired oxygen
(Based on data in References 23-25.)

Table 4. Monitoring Capabilities Recommended for NIV in Acute Respiratory Failure

| |
|---|
| Continuous observation from central monitoring area |
| Frequent checks of: |
| Comfort |
| Tolerance |
| Mask fit |
| Air leak |
| Patient-ventilator synchrony |
| Vital signs, especially respiratory rate |
| Accessory muscle use |
| Ventilator tidal volume (aim for 6–7 mL/kg) |
| Continuous telemetry |
| Electrocardiogram trace |
| Oximetry |
| Blood gas values at baseline, after 1–2 h, and as indicated |

NIV = noninvasive ventilation

sessments, such as ease of arousability, agitation, cough integrity, and respiratory rate. Other methods require simple laboratory tests, such as pH. Other methods require evaluation instruments, such as the Acute Physiology and Chronic Health Evaluation II or Simplified Acute Physiology Score II, that require a calculation based on the initial screening and laboratory values. From a pragmatic point of view, when a quick decision is required, reliance on simple bedside observations and rapidly obtained laboratory values such as blood pH is preferable to calculations that require more extensive laboratory testing.

A patient with multiple risk factors for NIV failure should be in a closely monitored setting such as an ICU or step-down unit. Those with few or no risk factors have less need for monitoring and might be managed on a general ward in some hospitals. In addition, patients initially admitted to an ICU could be considered for ward transfer as their risk factors for failure abate.

Another approach to assessing the risk of NIV failure is to perform a bedside "weaning test." Giacomini et al[26] tested this approach in 58 consecutive patients who presented to the ED with acute cardiogenic pulmonary edema. After 90 min of pressure-support ventilation via face mask, the patient underwent a 15-min "weaning test" that consisted of NIV mask removal and oxygen supplementation. Patients who passed the test (no dyspnea or hemodynamic instability) were transferred to a general medical floor. Patients who failed the test were intubated and sent to an ICU. None of the 43 patients (74%) who passed the test was further ventilated or transferred to an ICU. Giacomini et al concluded that the test was useful in identifying patients who needed no further ventilatory assistance. However, it is unclear why they deemed it necessary to intubate all patients who failed the test. A similar approach might be used to decide a patient's location. NIV can be temporarily removed. If there is no deterioration for a period of time (30–60 min?) and the patient is capable of calling for help if needed, then the patient could be managed on a general ward. However, this approach has not been validated prospectively, and the period of stability required would depend on the monitoring capabilities of the particular ward.

### Monitoring Capabilities of the Unit

Most ICUs are fully capable of managing any patient treated with NIV. Ideally, all patients begun on NIV would be placed in ICUs initially, as some guidelines have recommended,[27] but that strategy is neither practical nor cost-effective. ICU beds in most North American hospitals are under intense pressure because the demand for such beds exceeds the supply. Not infrequently, no ICU bed is available when a patient is begun on NIV, and an alternative monitoring site must be sought. In addition, because patients begun on NIV should be hemodynamically stable, central hemodynamic monitoring is unnecessary. Thus, most patients can be monitored adequately in step-down units with central telemetry and continuous pulse oximetry. Table 4 lists recommended unit capabilities for monitoring patients begun on NIV for ARF. The requisite monitoring capabilities diminish as the patient stabilizes.

### Experience and Skill of Personnel

The experience and skill of the personnel who manage NIV are key components of success. Over an 8-year span in an Italian ICU, Carlucci et al[28] found that their overall NIV success rate remained steady despite an increasing severity of illness of patients treated with NIV. For pH < 7.25, the success rate of NIV for patients with COPD was 3-fold higher during the latter 4-year period than for the earlier. Carlucci et al concluded that increasing experience with NIV over time allowed caring for

sicker patients while maintaining the same success rate. Over a 7-year period in a French ICU, Girou et al[29] found that the utilization rate of NIV among almost 500 patients who presented with ARF due to either COPD or congestive heart failure rose from approximately 20% to over 80% of initial ventilator starts. During that same period, the rate of ventilator-associated pneumonia dropped from 20% to 8%, with a corresponding drop in mortality. Girou et al attributed the improved outcomes to routine use of NIV and a "learning effect." Although difficult to prove from studies such as these, both Carlucci et al and Girou et al attributed outcomes improvements to increasing experience and skill of the staff.

Optimal management of NIV requires that all members of the team be experienced and skillful. Physicians need to be adept at selecting patients who are likely to succeed with NIV and promptly intubating patients likely to fail NIV. In North America, RTs are the clinicians most often responsible for applying NIV. They must be skilled at selecting an appropriate mask, fitting it to optimize comfort, and adjusting the ventilator to efficiently alleviate respiratory distress. Nurses need to be knowledgeable about monitoring, to help avoid and detect problems.

Quantifying the experience and skill of a unit's staff is challenging because individuals differ considerably and personnel changes can have important effects. However, as units use more NIV, outcomes appear to improve.[28,29] Periodic in-services and updates probably help personnel maintain their skills and stay abreast of new developments.

## Summary

The optimal location for NIV delivery in acute-care hospitals has been a matter of debate, but relatively few studies have focused on this question. Part of the reason is that units' NIV-delivery capabilities differ substantially, even within the same hospital. Thus, placing the patient in the appropriate environment requires consideration of several factors, including the patient's need for monitoring; the monitoring capabilities of the unit, both technical and personnel resources (nursing and respiratory therapy); and the staff's skill and experience. In some hospitals, NIV is usually begun in the ED but most often managed in an ICU. Step-down units are often good locations to deliver NIV, but are not available in many acute-care institutions. With ICU beds at a premium, many hospitals are forced to manage some patients receiving NIV on general wards. When deciding a patient's location, clinicians must be familiar with the capabilities of the units in their facility, and try to match the patient's need for monitoring with the unit's capabilities.

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## Discussion

**Keenan:** Where I work we don't currently use NIV on the ward. We use NIV primarily in our high-dependency unit and ICU. In the ICU it's most often for post-extubation failure. I am concerned that we may be underutilizing NIV. Though we will initiate NIV on the wards for patients in respiratory distress, they must be transferred to our high-dependency unit, ICU, or post-anesthesia unit.

For those of you whose institutions allow NIV use on the wards, is it restricted to specific wards or is it widely available? My concern is how to allow it to be used on the wards. Though I believe that the ideal would be to limit NIV to 1 or 2 wards, to enhance nurse comfort, expertise, and patient safety, it is not always easy to move patients from ward to ward. Allowing NIV on all wards makes starting it easy, but I am concerned about patient safety when those responsible for these patients use NIV infrequently.

**Kacmarek:** At my institution NIV is not restricted to certain floors; its use is pretty widespread. But monitoring is available in every room where we do apply NIV, including electrocardiogram, pulse oximetry, and ventilator alarms that are annunciated to the hallway and the nursing station. We have training of the nursing staff. If nurses are naïve, then it's the RT's responsibility to instruct the nurses in what to look for, basic ventilator operation, et cetera.

We do the same things you mentioned for patients who are sicker; we do everything possible to move them to the ICU. Of course, we don't want to keep a patient with a pH of 7.15 out on the floor, but we do have patients with pH of 7.3 who are benefiting from NIV but can breathe without NIV for at least one hour maintained in the general medical/surgical units. We think that the electrocardiogram, pulse oximeter, and ventilator alarms are enough to assure that we would know if an NIV patient had a problem.

**Davies:** Something that has been effective for us in the general care area is supervisor rounds with nursing input. Patients on NIV can be in various locations, but now the care team is more attuned to the severity of the patient's condition. In the pulmonary step-down unit we have enhanced our monitoring capabilities with a remote monitoring system that alerts the RT to NIV alarms. The page to the RT indicates the room number to prevent time wasted with calls to the nursing station.

**Kacmarek:** On every shift we have the RT, the nurse supervisor, and the senior resident all meet to identify at-risk patients, so that everybody is aware of these patients, wherever they are in the hospital. The senior medical resident then looks for an avenue for those at most risk to get into the ICU.

**Gay:** In my institution we only use NIV in the ICU or step-down unit. If people hear the word "monitoring," they think of technology, and that's where we tend to concentrate our resources, but I think the best monitor is the caregiver at the bedside. I can beat any pulse oximeter or other technology by being at the bedside during that crucial initiation of NIV. That's why it has been most useful to us to have the highest-level RTs at the bedside in the step-down and ICU areas. It's the people.

**Nava:** Small community hospitals, especially in countries other than the United States, often face a serious lack of ICU beds. In the United States

you have a lot of ICU beds, compared to the rest of the world. In small hospitals and other countries NIV is often applied outside the ICU just to save space, and I think they have very nice results. Certain kinds of patients should be treated outside of the ICU, including immunocompromised patients, such as those who have received bone-marrow transplantation; you don't want to bring them into the ICU, partly because of the risk of infection in the ICU. Also patients with do-not-intubate orders may be treated outside the ICU, because with them you don't want very aggressive treatment. Many patients with cardiogenic pulmonary edema can also receive NIV outside the ICU, because with many of them their condition is not so severe so that they require ICU admission.

**Epstein:** A lot of hospitals, including mine, now have rapid-response teams. Do we have any data on whether those teams have increased NIV use on the floors? Presumably they're getting to patients sooner than we used to, when they're not as sick. Anybody know of any data?

**Hill:** I haven't seen any data on that. I think rapid-response teams need to be skilled at administering NIV, and if NIV is not a part of their routine armamentarium, it's a problem. It would be interesting to see what those teams are doing with NIV.

**Gay:** We published an abstract a couple of years ago, with our emergency crew. After we put NIV capabilities in all our helicopters, we *halved* the intubation rate for patients in transport. They had been intubating a lot of patients who didn't need it.

**Doyle:*** A lot of teaching hospitals have great coverage with physicians and residents and so on, but physicians I've talked to who cover at the community hospitals have concerns about leaving NIV patients not as well monitored, because when the NIV-experienced physician goes home, then nobody with substantial NIV experience is watching the patient, whether the patient is in the ward or elsewhere. I heard about one place where they set up an "NIV unit," for lack of a better term. It wasn't an ICU, but a dedicated area where the staff had good NIV training, so that when the physician went home, the patient still had good coverage. Have you heard about that model?

**Hill:** Yes, a physician in Missouri developed such a unit and sent me some data on their success rate, which looked pretty good. In essence they created a step-down unit. That requires resources and staff, and the hospital has to be willing to invest in it. It's a great solution, but a lot of small hospitals don't have the resources.

**Mehta:** I have been at Mount Sinai Hospital for 10 years now, and, of course, have been advocating for NIV that entire time. But there's a great deal of resistance to NIV from the nurses on the general wards. Their concerns include poor nurse-to-patient ratio, lack of monitoring capabilities, and their lack of comfort with the technique. Some of our ward beds are 300 meters from the nursing stations, so even if a patient yelled, they wouldn't hear it. Inability to use NIV on the general wards can delay the use of it, particularly in conditions such as cardiogenic pulmonary edema, and even a short delay might make NIV fail.

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