



Noninvasive Ventilation in Step-Down Units Organization

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Abstract

When the demand for intensive care unit (ICU) beds is greater than their availability, clinicians should be aware of patients who really need or benefit from ICU. Step-down units are good options for suitable noninvasive mechanical ventilation (NIV) patients who can be treated successfully with less personnel and sources.

Keywords

Step-down unit · Noninvasive mechanical ventilation · Mortality · Length of stay

Step-down unit was initially defined as a patient-care organization for monitoring and nursing care for cardiac patients who are not stable enough for discharge to the ward but no longer require full intensive care [1, 2]. Step-down unit is also called as high dependency unit, transitional unit, respiratory intermediate unit, Level 2 care, and progressive care unit since first definition in 1968 by Gotsman MS, Schrire V [1]. There is still great heterogeneity and each definition includes diverse severity of patients in some means.

The increase in the elderly population with multiple serious comorbidities has triggered a great surge in the need for intensive care beds. To expand the number of ICU beds is very expensive. Because it means not only the equipment but also more specialized medical personnel, human resources, and supplies. When the demand

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for ICU is greater than their availability, to optimize utilization of ICU beds, clinicians should be aware of patients who really need or benefit from ICU and are also stable enough to discharge from ICU as soon as the readiness is accrued. Discharging the right patient at the right time reduces length of stay and readmissions, but early discharge is associated with increased mortality [3–5]. Like weaning invasive mechanical ventilation, ‘weaning from ICU’ should have objective criteria to identify suitable patients and time. Recently Maik Hiller et al. published an expert consensus, a total of 28 discharge criteria for adult ICU patients including respiratory, cardiovascular, central nervous, and urogenital systems. And there are also criteria concerned with pain, fluid loss and drainages, medication and nutrition, patient diagnosis, prognosis and preferences, and lastly four institution-specific criteria [6]. Respiratory and cardiovascular system criteria are mostly concerned with maintaining airway, effective cough, respiratory rate (RR) ($10 \leq RR \leq 30$ (pm)), heart rate (HR) ($50 \leq HR \leq 110$ (bpm)), mean arterial pressure ($60 < MAP \leq 110$ mmHg), bleeding, and need for low-dose vasoactive. Most of these criteria end with the ‘patient’s individual baseline value is met’, ‘adequately handled’, or ‘available required technology/staff capabilities’ in the receiving unit. We believe each center should define its own discharging criteria according to matching patients’ needs and step-down unit/ward capabilities.

Step-down units are good options for suitable patients who can be treated successfully with less personnel and sources.

The ratio of nurse-to-patient number and ability to provide specific organ failure determine step-down unit constitutively. Patients requiring invasive mechanical ventilation or dialysis should be followed in a level 3 intensive care unit (ICU). Patients with respiratory failure requiring noninvasive mechanical ventilation (NIV) but not multiorgan failure can be treated successfully in step-down units.

Besides the patient’s characteristics and monitoring needs, the risk of NIV failure is important for the decision of where to administer NIV (Table 17.1). For example, patients with acute respiratory failure on chronic respiratory failure due to Chronic obstructive pulmonary disease (COPD) and/or pulmonary edema are good candidates for step-down units because NIV success is quite well in this population. Patients who have various risk factors of NIV failure are better treated in ICU. Also, the capabilities of the unit should be adequate both in terms of medical personnel skills and technology.

Patients who do not require ICU-level monitoring but do require close observation that cannot be provided in a general ward can be treated successfully in step-down units. However, capabilities differ between hospitals. Therefore, clinicians’ awareness of the equipment and personnel skills of different units in the hospital, and thus the correct selection of the NIV application site, are associated with NIV’s success outside the ICU.

NIV patients should be monitored regularly at least for respiratory, consciousness, and hemodynamic parameters by trained personnel 24 h a day. Arterial blood gases should be evaluated after the first 1 h with clinical signs of tachypnea, dyspnea, and usage of accessory respiratory muscles. Hemodynamic assessment can be monitored noninvasively every 10 min initially. It is also necessary to follow skin perfusion (cyanotic, cold, etc.). ECG monitoring at least second lead should be

Table 17.1 Risk factors for NIV failure in patients with acute respiratory failure (adapted from [9])

Hypercapnic Respiratory Failure	Hypoxemic Respiratory Failure
Poor neurologic score (Glasgow Coma Score < 11)	Diagnosis of ARDS or pneumonia
Tachypnea (>35 breaths/min)	Age > 40 years
pH < 7.25	Hypotension (systolic blood pressure < 90 mmHg)
APACHE score > 29	Metabolic acidosis (pH <7.25)
Asynchronous breathing	Low oxygenation index (PaO ₂ /FIO ₂)
Edentulous	Simplified Acute Physiology Score II >34
Excessive air leak	Failure to improve oxygenation within first hour of NIV (PaO ₂ /FIO ₂ < 175 mmHg)
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	
APACHE: Acute physiology and chronic health evaluation, ARDS: Acute respiratory distress syndrome	
FIO ₂ : Fraction of inspired oxygen, NIV: Noninvasive ventilation PaO ₂ : Partial arterial pressure of oxygen	
[10, 11, 12]	[13, 14, 15]

available [7]. It is crucial to have necessary medical equipment such as oximeters, ECGs, blood pressure monitors, and intubation tools for prompt and effective interventions. A step-down unit should provide at least a nurse-to-patient ratio of 1:2.5 to 1:4 per shift and medical personnel available 24 h a day [8].

Continuous noninvasive monitoring, expertise in NIV implementation, and expert medical personnel are necessary to establish urgent endotracheal intubation in case of NIV failure or acute deterioration in patient's status. The expert team consists of mainly anesthesiologists or critical care specialists for both selecting suitable patients and applying/monitoring NIV. Pulmonologists should also be capable of following NIV patients outside the ICU as long as training is completed. Respiratory mechanics and gas exchange mechanisms physiopathology of respiratory failure, are already included in the most basic training of pulmonologists.

Conclusion

Step-down units are good options for treatment of suitable patients with NIV who do not need ICU monitoring. Thus, ICU beds can be available for more patients who really benefit. Clinicians are responsible for selecting the right patient where to apply NIV safely and successfully. This can be provided by awareness of the capabilities of different units in the hospital.

References

1. Gotsman MS, Schrire V. Acute myocardial infarction—an ideal concept of progressive coronary care. *S Afr Med J*. 1968;42:829–32.
2. Prin M, Wunsch H. The role of stepdown beds in hospital care. *Am J Respir Crit Care Med*. 2014;190(11):1210–6.
3. Wunsch H, Nguyen YL, Angus DC. Smoothing the way: improving admission to and discharge from the ICU. In: Flaatten H, Moreno RP, Putensen C, Rhodes A, editors. *Organization and management of intensive care*. Berlin: European Society of Intensive Care Medicine; 2010. p. 269–76.
4. Johnson DW, Schmidt UH, Bittner EA, Christensen B, Levi R, Pino RM. Delay of transfer from the intensive care unit: a prospective observational study of incidence, causes, and financial impact. *Crit Care*. 2013;17(4):R128.
5. Garland A, Connors AF Jr. Optimal timing of transfer out of the intensive care unit. *Am J Crit Care*. 2013;22(5):390–7.
6. Hiller M, Wittmann M, Bracht H, Bakker J. Delphi study to derive expert consensus on a set of criteria to evaluate discharge readiness for adult ICU patients to be discharged to a general ward—European perspective. *BMC Health Serv Res*. 2022;22:773.
7. Non-invasive ventilation in acute respiratory failure. *Thorax*. 2002;57:192–211.
8. Confalonieri M, Gorini M, Ambrosino N, Mollica C, Corrado A, Scientific Group on Respiratory Intensive Care of the Italian Association of Hospital Pneumologists. Respiratory intensive care units in Italy: a national census and prospective cohort study. *Thorax*. 2001;56(5):373–8.
9. Hill NS. Where should noninvasive ventilation be delivered? *Respir Care*. 2009;54(1):62–70.
10. Ambrosino N, Foglio K, Rubini F, Clini E, Nava S, Vitacca M. Non-invasive mechanical ventilation in acute respiratory failure due to chronic obstructive pulmonary disease: correlates for success. *Thorax*. 1995;50(7):755–7.
11. Soo Hoo GW, Santiago S, Williams AJ. Nasal mechanical ventilation for hypercapnic respiratory failure in chronic obstructive pulmonary disease: determinants of success and failure. *Crit Care Med*. 1994;22(8):1253–61.
12. Confalonieri M, Garuti G, Cattaruzza MS, Osborn JF, Antonelli M, Conti G, Italian Noninvasive Positive Pressure Ventilation (NPPV) Study Group, et al. A chart of failure risk for noninvasive ventilation in patients with COPD exacerbation. *Eur Respir J*. 2005;25(2):348–55.
13. Antonelli M, Conti G, Moro ML, Esquinas A, Gonzalez-Diaz G, Confalonieri M, et al. Predictors of failure of noninvasive positive pressure ventilation in patients with acute hypoxemic respiratory failure: a multi-center study. *Intensive Care Med*. 2001;27(11):1718–28.
14. Rana S, Jenad H, Gay PC, Buck CF, Hubmayr RD, Gajic O. Failure of non-invasive ventilation in patients with acute lung injury: observational cohort study. *Crit Care*. 2006;10(3):R79.
15. Antonelli M, Conti G, Esquinas A, Montini L, Maggiore SM, Bello G, et al. A multiple-center survey on the use in clinical practice of noninvasive ventilation as a first-line intervention for acute respiratory distress syndrome. *Crit Care Med*. 2007;35(1):18–25.