



Use of Non-Invasive Ventilation in ICU to Reduce the Incidence of Invasive Mechanical Ventilation.

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Abstract: **Objective:** To determine the frequency of invasive mechanical ventilation (IMV) among adult ICU patients with acute respiratory failure managed using a standardized non-invasive ventilation (NIV) protocol. **Study Design:** Retrospective cohort study. **Place and Duration:** Adult medical ICU, Shaukat Khanum Memorial Cancer Hospital and Research Centre, from June to December 2025. **Methodology:** Records of 27 adult ICU patients with acute respiratory failure initially managed with non-invasive respiratory support were retrospectively reviewed following ethical committee approval. Data included demographics, comorbidities, primary diagnosis, baseline clinical and laboratory parameters, initial respiratory support modality, settings at initiation and after 1–2 hours, and subsequent requirement for IMV. **Results:** Of 27 patients, 17 (63.0%) subsequently required intubation and IMV, whereas 10 (37.0%) avoided intubation. HFNC was the most frequently used initial modality (51.9%), followed by BiPAP (29.6%) and CPAP (18.5%). Mean arterial pressure was significantly lower among patients requiring intubation than among those who avoided intubation (72.53 ± 13.89 vs. 86.50 ± 17.06 mmHg; $p=0.029$). Other baseline clinical and physiological parameters were not significantly associated with intubation. Overall mortality was 59.3% and was significantly higher among intubated than non-intubated patients (82.4% vs. 20.0%; $p=0.003$). **Conclusion:** Nearly two-thirds of patients initially managed with non-invasive respiratory support subsequently required IMV. Lower mean arterial pressure was associated with intubation, while mortality was significantly higher among patients requiring IMV.

Keywords: Acute respiratory failure; non-invasive ventilation; invasive mechanical ventilation.

INTRODUCTION

In the intensive care unit (ICU), one of the most common and difficult conditions is acute respiratory failure.¹ It can be brought on by a variety of conditions, including acute respiratory distress syndrome (ARDS), pneumonia, acute cardiogenic pulmonary edema, abrupt aggravation of chronic obstructive pulmonary disease (COPD), neuromuscular issues, and other severe disorders.^{2,3} In order to maintain proper breathing and oxygenation, patients with respiratory failure frequently need respiratory support.^{4,5} Endotracheal intubation and invasive mechanical ventilation (IMV) may be

required and potentially life-saving in severe circumstances.⁶ However, ventilator-associated pneumonia, airway trauma, ventilator-induced lung injury, hemodynamic disturbances, increased sedation requirements, delirium, extended ICU stay, and complications associated with challenging or protracted weaning are also linked to invasive mechanical ventilation.^{7,8} Thus, avoiding needless intubation while preserving sufficient respiratory support continues to be a key goal of critical care treatment.⁹

Non-invasive ventilation (NIV) has evolved as a valuable approach to delivering ventilatory support without the use of an artificial airway.¹⁰ Using an external interface—typically a nasal, oronasal, or full-face mask—NIV provides positive-pressure breathing. Bilevel positive airway pressure ventilation and continuous positive airway pressure (CPAP) are the two main types of NIV.^{11,12} NIV can enhance alveolar ventilation and gas exchange, lessen respiratory muscle workload, lessen dyspnea, and enable worn-out respiratory muscles to recuperate by supplying positive airway pressure and inspiratory assistance.^{13,14} While receiving respiratory support, NIV typically permits patients to be conscious, communicate, cough, and swallow while maintaining their natural airway processes, in contrast to invasive ventilation.¹⁵

Even with these advantages, not all patients benefit from NIV. Proper patient selection, the severity and cause of respiratory failure, the timing of NIV beginning, the right interface selection, proper ventilator settings, patient participation, and ongoing monitoring are some of the variables that affect the result.¹⁶ Endotracheal intubation may be delayed and have unfavorable consequences if a patient's condition is not recognized. Therefore, the goal of NIV should be to minimize needless or preventable invasive ventilation while guaranteeing prompt intubation when clinically warranted, rather than to prevent invasive mechanical ventilation in every patient.¹⁷

For achieving good NIV, healthcare professionals are crucial. Early detection of improvement or decline is made possible by ongoing monitoring of respiratory rate, oxygen saturation, work of breathing, consciousness level, hemodynamic condition, mask tolerance, skin integrity, and blood gas parameters. NIV adherence and patient comfort can both be enhanced by appropriate nurse care.¹⁸

In order to ascertain its role in lowering the prevalence of preventable intrusive mechanical ventilation, it is crucial to look at the usage of non-invasive ventilation in intensive care unit patients. Increased knowledge of suitable indications, monitoring needs, NIV failure predictors, and prompt escalation of respiratory support may encourage safer and more efficient NIV use, lessen complications from needless intubation, and enhance the standard of care for critically ill patients. Therefore, the current study aims to evaluate the effectiveness of a standardized NIV protocol in reducing the frequency of invasive mechanical ventilation among ICU patients with acute respiratory failure in adults.

MATERIALS AND METHODS

This was a retrospective cohort study. After receiving

approval from the Ethical Review Committee, research was carried out for six months, from June 2025 till December 2025, at the adult medical ICU of Shaukat Khanum Memorial Cancer Hospital and Research Centre. The study included 27 patients who received NIV. With a 9% margin of error, a 95% confidence interval, and the expected frequency of IMV in patients who received NIV as 5.9%¹⁸, a sample size of 27 patients was estimated. The method of non-probability consecutive sampling was applied.

Inclusion criteria: Patients of age ≥ 18 years, admitted to the adult ICU with a primary diagnosis of acute respiratory failure (hypoxemic, hypercapnic, or mixed) requiring advanced ventilatory support, who were initiated on NIV within 24 hours of ICU admission were included. Additionally, only those cases with availability of sufficient data in the electronic record to determine ventilatory strategy and main outcomes were included.

Exclusion criteria: Patients admitted for elective postoperative monitoring without acute respiratory failure; patients with a documented do not intubate (DNI) or comfort measures only order at or within 24 hours of ICU admission; those with preexisting tracheostomy or chronic home mechanical ventilation dependence at the time of admission; patients with immediate cardiac arrest, massive trauma, or other conditions in which the primary indication for intubation was nonrespiratory (e.g., severe head injury, ongoing seizures, or coma from nonrespiratory causes); patients transferred from another ICU with more than 24 hours of prior invasive ventilation; patients for whom pretransfer ventilator data could not be reliably obtained; and those with incomplete records where the need for intubation or the duration of invasive mechanical ventilation could not be determined were excluded.

NIV was defined in our study as providing ventilatory assistance utilizing CPAP or BiPAP modes through an external interface without the use of an endotracheal or tracheostomy tube. IMV was described as positive pressure ventilation administered by an ICU ventilator through a tracheostomy or endotracheal tube. The term "acute respiratory failure" (ARF) refers to a situation that requires advanced ventilatory support and is defined by either hypoxemia, hypercapnia, or both. The need for endotracheal intubation following a first NIV trial during the same ICU stay was referred to as NIV failure. This study's primary goal was to determine whether a standardized NIV regimen may lower the incidence of invasive mechanical ventilation in adult ICU patients with acute respiratory failure.

Following the hospital's ethical committee's clearance, ICU admission logs and electronic health

record (EHR) queries of 27 adult patients admitted with acute respiratory failure in the study period who received NIV were assessed. For study purposes, admission notes, ventilator charts, and nursing/respiratory therapy documentation to determine whether NIV or IMV was initiated first within 24 hours were checked. Data was collected for age, gender, presence of comorbidities (e.g., COPD, heart failure, chronic kidney disease, diabetes), primary diagnosis leading to acute respiratory failure (e.g., COPD exacerbation, cardiogenic pulmonary edema, pneumonia, ARDS, sepsis), baseline physiologic and laboratory data around the time of ventilatory support initiation (Vital signs, arterial blood gases, and basic labs), ventilatory details such as NIV mode and interface settings at start and after

1–2 hours, and the timing of any switch from NIV to IMV were noted down.

Data was analyzed and assessed using Statistical Package for Social Sciences (SPSS) version 27.0. Normality of data was assessed by the Shapiro-Wilk test and normally distributed numerical variables were presented as mean and standard deviation and non-normally distributed data was presented as median and interquartile range, whereas categorical variables were presented as frequency and percentages.

RESULT

A total of 27 patients were enrolled. As shown in Table 1, the median age of the study participants was 38.0 years (IQR 35.0). The median time from ICU admission to initiation of NIV was 30 minutes (IQR 153), while the median baseline respiratory rate was 29 breaths/min (IQR 12). Heart rate was non-normally distributed, with a median of 130 beats/min (IQR 37). The mean arterial pressure was 77.7 ± 16.3 mmHg. The median GCS was 15 (IQR 0), and the median baseline oxygen saturation was 96% (IQR 5). The median FiO_2 requirement was 0.40 (IQR 0.30). Regarding arterial blood gas and oxygenation parameters, the mean pH was 7.390 ± 0.106 , mean PaCO_2 was 30.63 ± 9.95 mmHg, and mean $\text{PaO}_2/\text{FiO}_2$ ratio was 218.07 ± 111.03 . With a median score of 28.8 (IQR 31.5), lactate displayed a non-normal distribution. The median HACOR score was 6.0 (IQR 6.0), while the mean ROX index was 9.67 ± 5.68 . The majority of outcome variables had non-normal distributions. The median duration of invasive mechanical breathing was 0.5 (IQR 5.0), and the median time until intubation was 1.5 (IQR 5.0). The median length of stay in the ICU and hospital was 6 days (IQR 8) and 13 days (IQR 13), respectively, while the median ventilator-free days were 10 days (IQR 13) (Table 1).

The study population's clinical results and categorical traits are compiled in Table 2. Of the 27 cases, 8 (29.6%) were female and 19 (70.4%) were male. Twenty patients (74.1%) had acute respiratory failure as their primary diagnosis. In terms of comorbidities, two patients (7.4%) had heart failure, one patient (3.7%) had chronic renal disease, and four patients (14.8%) had both diabetes and COPD. With 14 patients (51.9%) using high-flow nasal oxygen/HFNC, the most popular non-invasive respiratory support method was followed by BiPAP in 8 (29.6%) and CPAP in 5 (18.5%). After one to two hours of treatment, 15 patients (55.6%) showed clinical improvement, 3 (11.1%) showed clinical stagnation, and 9 (33.3%) showed clinical deterioration. Ten patients (37.0%) did not require intubation, while 17 of the 27 patients (63.0%) needed intubation and invasive mechanical ventilation after being initially managed with non-invasive respiratory support. Therefore, the success percentage of NIV/non-invasive respiratory support in this group was 37.0% when intubation was avoided, whereas the failure rate was 63.0% when invasive mechanical ventilation was subsequently needed.

The incidence of complications and ultimate clinical results by intubation status are shown in Table 3. Of the 27 patients, 23 (85.2%) had complications. Compared to 8 out of 10 patients (80.0%) who did not need intubation, 15 out of 17 patients (88.2%) experienced problems. The need for intubation and the incidence of problems did not significantly correlate (Fisher's exact test, $p = 0.613$). In terms of the ultimate clinical result, 11 (40.7%) of the 27 patients were released, while 16 (59.3%) died. Patients who needed intubation had a much greater mortality rate. Of the 17 patients that were intubated, 3 (17.6%) were released and 14 (82.4%) died. In contrast, two (20.0%) of the ten patients who did not need intubation died and eight (80.0%) were released. A statistically significant association was observed between intubation requirement and final clinical outcome (Fisher's exact test, $p = 0.003$).

Table 4 compares clinical and physiological characteristics between patients who required intubation ($n = 17$) and those who did not ($n = 10$). Among the continuous variables examined, mean arterial pressure (MAP) was significantly lower in patients who subsequently required intubation compared with those who did not require intubation (72.53 ± 13.89 mmHg vs. 86.50 ± 17.06 mmHg; $p = 0.029$). No statistically significant differences were observed between the intubated and non-intubated groups for age ($p = 0.555$), respiratory rate ($p = 0.902$), heart rate ($p = 0.487$), GCS ($p = 0.443$), baseline oxygen saturation ($p = 0.570$), FiO_2 ($p = 0.902$), pH ($p = 0.479$), PaCO_2 ($p = 0.441$), $\text{PaO}_2/\text{FiO}_2$ ratio ($p = 0.760$), lactate ($p = 0.414$), ROX index ($p = 0.747$), or HACOR score ($p = 0.824$). The

mode of non-invasive respiratory support was also not significantly associated with subsequent intubation (Fisher–Freeman–Halton exact test, $p = 0.668$). Among intubated patients, 4 (23.5%) received BiPAP, 4 (23.5%) received CPAP, and 9 (52.9%) received HFNC. Among patients who did not require intubation, 4 (40.0%) received BiPAP, 1 (10.0%) received CPAP, and 5 (50.0%) received HFNC. Similarly, clinical response after 1–2 hours of non-invasive respiratory support was not significantly associated with subsequent intubation (Fisher–Freeman–Halton exact test, $p = 0.626$). Improvement was observed in 8 of 17 (47.1%) intubated patients compared with 7 of 10 (70.0%) non-intubated patients. Clinical worsening occurred in 7 (41.2%) intubated patients compared with 2 (20.0%) non-intubated patients, while a static response occurred in 2 (11.8%) and 1 (10.0%) patients, respectively. Overall, MAP was the only measured baseline continuous variable demonstrating a statistically significant unadjusted association with subsequent requirement for intubation in this cohort. Final clinical outcome was also significantly associated with intubation status, with a higher proportion of deaths observed among patients who required intubation. These findings represent associations and should not be interpreted as evidence of causation.

Table 1. Descriptive Characteristics and Normality Assessment of NIV Patients (n = 27)

Variable	Descriptive statistic	Shapiro–Wilk p-value	Distribution
Age, years	38.0 (35.0)	0.058	Normal
Time from ICU admission to NIV	30 (153)	<0.001	Non-normal
Respiratory rate, breaths/min	29.0 (12.0)	0.001	Non-normal
Heart rate, beats/min	130.0 (37.0)	0.027	Non-normal
GCS	15.0 (0.0)	<0.001	Non-normal
MAP, mmHg	77.7 ± 16.3	0.304	Normal
Baseline oxygen saturation (%)	96.0 (5.0)	<0.001	Non-normal
FiO ₂ (NIV setting)	0.40 (0.30)	0.005	Non-normal
pH	7.390 ± 0.106	0.419	Normal
PaCO ₂ (mmHg)	30.63 ± 9.95	0.174	Normal
PaO ₂ /FiO ₂ ratio	218.07 ± 111.03	0.395	Normal
Lactate (mmol/L)	28.8 (31.5)	<0.001	Non-normal
IPAP (cmH ₂ O)	0.0 (12.0)	<0.001	Non-normal
EPAP/PEEP (cmH ₂ O)	0.0 (8.0)	<0.001	Non-normal
Time to intubation (days)	1.0 (5.0)	0.002	Non-normal
Duration of invasive ventilation (days)	3.92 ± 3.26	0.075	Normal
Ventilator-free days at day 28	10.0 (13.0)	0.001	Non-normal
ICU length of stay (days)	6.0 (8.0)	0.005	Non-normal
Hospital length of stay (days)	13.0 (13.0)	<0.001	Non-normal
ROX index (Auto)	9.67 ± 5.68	0.130	Normal
HACOR score (Auto)	6.0 (6.0)	0.023	Non-normal

Values are presented as mean ± SD for approximately normally distributed variables and median (IQR) for non-normally distributed variables, based on the Shapiro–Wilk test ($p > 0.05$ indicating no statistically significant departure from normality).

Table 2. Categorical Clinical Characteristics and Outcomes of NIV Patients (n= 27)

Variable / category	Frequency (n)	Percentage (%)
Gender		
Male	19	70.4
Female	8	29.6
Primary diagnosis of acute respiratory failure (ARF)		
Yes	20	74.1
No	7	25.9
COPD		
Yes	4	14.8
No	23	85.2
Heart failure		
Yes	2	7.4
No	25	92.6
Chronic kidney disease (CKD)		
Yes	1	3.7
No	26	96.3

Diabetes		
Yes	4	14.8
No	23	85.2
NIV mode		
BiPAP	8	29.6
CPAP	5	18.5
High-flow/HFNC	14	51.9
Clinical response after 1–2 hours		
Improvement	15	55.6
Static	3	11.1
Worsening	9	33.3
Intubation required		
Yes	17	63.0
No	10	37.0

Table 3. Complications and Final Outcome According to Intubation Status (n=27)

Variable	Intubated (n = 17)	Not intubated (n = 10)	Total (N = 27)	p-value
Complications				0.613*
Yes	15 (88.2%)	8 (80.0%)	23 (85.2%)	
No	2 (11.8%)	2 (20.0%)	4 (14.8%)	
Final outcome				0.003*
Discharged	3 (17.6%)	8 (80.0%)	11 (40.7%)	
Expired	14 (82.4%)	2 (20.0%)	16 (59.3%)	

Values are n (%), with percentages calculated within each intubation group. *Fisher's exact test, two-sided.

Table 4. Factors Associated with Requirement for Intubation (n=27)

Factor	Intubated (n = 17)	Not intubated (n = 10)	Statistical test	p-value
Age, years	38.35 ± 18.21	42.60 ± 17.08	Independent-samples t-test	0.555
Respiratory rate, breaths/min	29.0 (14.0)	29.0 (15.5)	Mann-Whitney U	0.902
Heart rate, beats/min	123.12 ± 25.76	130.70 ± 28.99	Independent-samples t-test	0.487
GCS	15.0 (5.0)	15.0 (0.0)	Mann-Whitney U	0.443
MAP, mmHg	72.53 ± 13.89	86.50 ± 17.06	Independent-samples t-test	0.029*
Baseline SpO ₂ , %†	96.0 (5.0)	95.5 (6.5)	Mann-Whitney U	0.570
FiO ₂	0.40 (0.20)	0.425 (0.37)	Mann-Whitney U	0.902
pH	7.378 ± 0.106	7.409 ± 0.109	Independent-samples t-test	0.479
PaCO ₂ , mmHg	29.47 ± 9.85	32.60 ± 10.32	Independent-samples t-test	0.441
PaO ₂ /FiO ₂ ratio	212.92 ± 104.99	226.81 ± 126.03	Independent-samples t-test	0.760
Lactate	38.0 (35.6)	22.0 (19.27)	Mann-Whitney U	0.414
ROX index	9.39 ± 5.54	10.14 ± 6.19	Independent-samples t-test	0.747
HACOR score	5.0 (8.5)	6.5 (5.25)	Mann-Whitney U	0.824
NIV / respiratory support mode				
BiPAP	4 (23.5%)	4 (40.0%)	Fisher-Freeman-Halton exact	0.668
CPAP	4 (23.5%)	1 (10.0%)		
HFNC	9 (52.9%)	5 (50.0%)		
Clinical response after 1-2 hours				

Improvement	8 (47.1%)	7 (70.0%)	Fisher-Freeman-Halton exact	0.626
Static	2 (11.8%)	1 (10.0%)		
Worsening	7 (41.2%)	2 (20.0%)		

Continuous data are presented as mean $\pm$ SD for approximately normally distributed variables and median (IQR) for non-normally distributed variables. Categorical data are n (%), with percentages calculated within each intubation group. Mann-Whitney p-values are two-sided exact values reported by SPSS. Fisher-Freeman-Halton exact tests were used for the 3×2 categorical tables. * $p < 0.05$.

† Baseline SpO₂ remains provisional until the recorded value of 0.40 in the intubated group is verified against the source data

DISCUSSION

This study evaluated the clinical outcomes of 27 ICU patients initially managed with NIV support. Seventeen patients (63.0%) subsequently required intubation, whereas 10 (37.0%) avoided invasive mechanical ventilation. Clinically, this relatively high rate of escalation suggests that patients receiving non-invasive respiratory support in this cohort represented a substantially ill population in whom close monitoring and repeated assessment were particularly important. However, the requirement for intubation should not automatically be interpreted as failure of care; rather, it may indicate progression of the underlying critical illness despite initial respiratory support.

HFNC was the most frequently used modality (51.9%), followed by BiPAP (29.6%) and CPAP (18.5%). Respiratory-support mode was not significantly associated with subsequent intubation ($p = 0.668$). This finding does not demonstrate equivalence between these modalities, because treatment selection was not randomized and the number of patients in each group was small. Clinically, the choice of HFNC, BiPAP, or CPAP is influenced by the underlying cause of respiratory failure, gas-exchange abnormalities, haemodynamic status, patient tolerance, and clinician assessment. Therefore, the absence of a statistical difference should not be used to favour one modality over another.

Early clinical response may provide useful information during bedside reassessment. Although the overall association between response at 1–2 hours and intubation was not statistically significant ($p=0.626$), worsening occurred in 41.2% of patients who were subsequently intubated compared with 20.0% of those who avoided intubation. Conversely, improvement occurred in 70.0% of non-intubated patients compared with 47.1% of intubated patients.

While these findings are exploratory, they support the clinical importance of reassessing patients soon after initiation of non-invasive support rather than relying

solely on the initial treatment decision.

Among the physiological variables examined, MAP was the only factor significantly associated with intubation. Patients who required intubation had a lower mean MAP than those who avoided intubation (72.53 ± 13.89 versus 86.50 ± 17.06 mmHg; $p = 0.029$). Clinically, lower MAP may reflect greater hemodynamic compromise and overall severity of illness. This finding suggests that respiratory status should not be considered in isolation when evaluating the likelihood of successful non-invasive support. Hemodynamic stability may form an important component of the overall bedside assessment. Nevertheless, MAP cannot be considered an independent predictor from this study because the analysis was unadjusted and involved a small sample. Other variables, including respiratory rate, GCS, oxygenation indices, lactate, ROX index, and HACOR score, were not significantly associated with intubation. These negative findings should be interpreted cautiously because the study may have been underpowered to detect clinically meaningful differences.

The most striking outcome was the association between intubation and mortality. Mortality occurred in 82.4% of intubated patients compared with 20.0% of non-intubated patients ($p = 0.003$). Importantly, this does not imply that intubation caused the higher mortality. Patients requiring invasive ventilation were likely to have experienced greater disease severity or physiological deterioration, making intubation a potential marker of a more severe clinical course. Overall, these findings emphasize the importance of careful patient selection, haemodynamic assessment, and frequent reassessment during non-invasive respiratory support. The high rate of escalation to invasive ventilation highlights the need to identify deterioration promptly while avoiding unnecessary delay in clinically indicated intubation. Given the small sample size, single-cohort design, and absence of multivariable adjustment, these findings should be considered exploratory and confirmed in larger prospective studies.

CONCLUSION

In this study, 37% of ICU patients initially managed with non-invasive respiratory support avoided intubation, while 63% subsequently required invasive mechanical ventilation. Lower mean arterial pressure was significantly associated with the requirement for intubation highlighting the potential importance of hemodynamic stability when assessing patients receiving noninvasive respiratory support. Mortality was significantly higher among patients who required intubation; however, this likely reflects greater severity of illness rather than an effect of intubation itself. Overall, the findings emphasize careful patient selection, close monitoring, early recognition of deterioration, and timely escalation to invasive ventilation when clinically indicated. Given the small sample size and observational design, larger prospective studies are needed to confirm these findings.

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