Original Article

Vajira Med J
Journal of Urban Medicine

Exploring Factors Associated with Intolerance of Helmet Noninvasive Ventilation in High-Risk Postextubation Patients

Napat Jirawat MD, MSc[1,2], **Napplika Kongpolprom** MD, MSc[2]

[1] *Division of Pulmonary and Critical Care Medicine, Department of Medicine, Faculty of Medicine Vajira Hospital, Navamindradhiraj University, Bangkok 10300, Thailand*

[2] *Division of Pulmonary and Critical Care Medicine, Department of Medicine, Faculty of Medicine, Chulalongkorn University, King Chulalongkorn Memorial Hospital, The Thai Red Cross Society, Bangkok 10330, Thailand*

ABSTRACT

OBJECTIVE: Studies on the use of helmet noninvasive ventilation (NIV) to prevent postextubation respiratory failure in high-risk patients are limited compared with other types of NIV. Only one randomized controlled trial (RCT) has reported that patients may have high helmet NIV intolerance. This study aimed to determine the prevalence of helmet NIV intolerance among high-risk postextubation patients and identify factors associated with this intolerance.

METHODS: This retrospective cohort study included patients at high risk of postextubation failure between June 2022 and June 2023. This study was based on an RCT that included 114 patients at high risk of postextubation failure. A subgroup analysis was performed on patients who received helmet NIV. The primary outcome was the prevalence of helmet NIV intolerance. The secondary outcome was factors associated with helmet NIV intolerance.

RESULTS: Of the 114 patients, 57 received helmet NIV. Of the 57 patients, 43 (75.4%) exhibited intolerance. A higher prevalence of cancer was observed among patients with helmet NIV intolerance, along with lower initial heart rates and higher partial pressure of oxygen in arterial blood/fraction of inspired oxygen ratios. No significant differences in the etiology of respiratory failure or severity scores, including Acute Physiology and Chronic Health Evaluation II and Sequential Organ Failure Assessment scores, were observed between the two groups. Additionally, the 48-h extubation success rate was comparable. Multivariate analysis revealed that a lower heart rate was a significant factor associated with helmet NIV intolerance.

CONCLUSION: During the postextubation period in high-risk patients, helmet NIV use was significantly associated with a high rate of intolerance. However, no differences in extubation success were observed. Lower initial heart rate was a significant factor associated with helmet NIV intolerance.

KEYWORDS: extubation success, helmet noninvasive ventilation, high-risk extubation failure, noninvasive ventilation intolerance

Corresponding author: Napat Jirawat, napat.jir@nmu.ac.th
Received: 5 November 2024
Revised: 21 January 2025
Accepted: 13 February 2025
Vajira Med J 2025;69(2):e271709
http://dx.doi.org/10.62691/vmj.2025.271709

INTRODUCTION

Noninvasive ventilation (NIV) plays a crucial role in preventing postextubation respiratory failure[1-4]. NIV is superior to conventional oxygen therapy in reducing the reintubation rate, particularly in patients at high risk of extubation failure[5-7]. Age > 65 years, preexisting cardiac or pulmonary disease, acute physiology and chronic health evaluation II (APACHE II) score > 12, body mass index (BMI) > 30 kg/m^2, difficult or prolonged weaning for >7 days, and Charlson comorbidity index > 2 on the day of extubation are risk factors associated with a high risk of extubation failure[5,8-10]. NIV mitigates the risk of respiratory failure by optimizing gas exchange, reducing the work of breathing, and enhancing alveolar recruitment[2].

The face mask is the most common NIV interface used to prevent postextubation respiratory failure. However, face mask NIV has certain limitations, including improper mask fit, which leads to air leakage and ineffective pressure delivery, thereby reducing its efficacy. The helmet is an alternative NIV interface that has gained prominence during the COVID-19 pandemic. Helmet NIV has proven effective in reducing the intubation rate in patients with hypoxemic respiratory failure[11]. Additionally, helmet NIV has been reported to be associated with lower in-hospital mortality and reintubation rates than face mask NIV[12-14].

Despite these advantages, studies on helmet NIV use among high-risk postextubation patients are limited. Only one randomized controlled trial (RCT) has compared helmet with face mask NIV in patients at high risk of extubation failure. The finding revealed no significant difference in extubation success[15]. Additionally, this trial reported a high rate of helmet NIV intolerance, a finding that is inconsistent with previous studies showing the efficacy of helmet NIV[16-19]. This discrepancy highlights the need for further investigation.

Therefore, this study aimed to assess the prevalence of helmet NIV intolerance in high-risk postextubation patients based on data from an RCT and investigate factors associated with this intolerance.

METHODS

This was a retrospective cohort study including patients at high risk of extubation failure who received helmet NIV at King Chulalongkorn Memorial Hospital, Thai Red Cross Society, Bangkok, Thailand, between June 2022 and June 2023.

Written informed consent was obtained from all patients or their relatives before inclusion. A retrospective analysis was then conducted based on the initial results from an RCT comprising 114 patients entitled "Comparison of extubation success between prophylactic helmet NIV and facemask NIV in high-risk postextubation patients: a randomized controlled trial". This trial was approved by the Institutional Review Board of the Faculty of Medicine Vajira Hospital (IRB number 186/66E or COA number 197/2566) (TCTR20240731006).

A subgroup analysis was performed on patients at high risk of extubation failure who received helmet NIV. The inclusion criteria were age > 65 years, chronic cardiac or lung disease, APACHE II score > 12, BMI > 30 kg/m^2, difficult or prolonged weaning for > 7 days, and Charlson comorbidity index > 2 on the day of extubation. Preexisting cardiac disease was defined as left ventricular dysfunction (left ventricular ejection fraction < 45% from any cause), history of cardiogenic pulmonary edema, documented ischemic heart disease, or permanent atrial fibrillation. Preexisting chronic pulmonary diseases included chronic obstructive pulmonary disease, obesity hypoventilation syndrome, and restrictive lung disease from any cause[5,8-10]. The exclusion criteria were long-term NIV use, chronic neuromuscular disease, traumatic brain injury requiring intubation, accidental or self-extubation, do-not-resuscitate status after extubation, and contraindications to NIV.

During the study, either a helmet or face mask interface was used with a critical care ventilator. The initial ventilator settings were standardized, with a positive end-expiratory pressure (PEEP) set at 5 centimeter of water (cmH_2O), which was gradually increased by 2–3 cmH_2O to achieve oxygen saturation > 90% with a fraction of inspired oxygen (FiO_2) < 0.6. Pressure support was applied above PEEP level of at least 4 cmH_2O, which was gradually increased by 2–3 cmH_2O to maintain a respiratory rate below 30 breaths/min. Both interfaces were used in each group for 24 h after extubation. Apart from interface differences, both groups received identical standard treatment, nursing care, and management according to the protocol. A 4-h break, with a maximum of 60 min per session, was provided to the helmet NIV and facemask NIV. During the break, an oxygen cannula with a flow rate of 1–5 L/min was used to maintain oxygen saturation above 90%. The total duration of NIV use was at least 18 h. After NIV, an oxygen cannula delivering 1–5 L/min was used to maintain oxygen saturation above 90%.

The primary outcome was the prevalence of helmet NIV intolerance, which was defined as patient discomfort after adapting to a standardized ventilator setting without signs or symptoms of postextubation respiratory failure. For patients who experienced NIV intolerance, a high-flow nasal cannula set to a flow rate of 50 L/min with FiO_2 adjusted to maintain an oxygen saturation of at least 92% was used. The secondary outcome was factors associated with helmet NIV intolerance.

Demographic data and the prevalence of helmet NIV intolerance were analyzed using descriptive statistics, including percentages, means, and standard deviations. The Chi-square test, Fisher's exact test, Independent t-test as well as Mann-Whitney U test were used for statistical analyses. Medians and interquartile ranges were used for nonnormally distributed data. Factors associated with helmet NIV intolerance were assessed using combined and multivariate regression analyses. In the univariate analysis, crude odds ratios and 95% confidence intervals were used to evaluate the strength of the association. Factors with a p-value < 0.20 were included in the multiple logistic regression model. A p-value < 0.05 was considered statistically significant. Adjusted odds ratios with 95% confidence intervals were calculated to determine the strength of the association. All statistical analyses were performed using Stata 16.

RESULTS

A total of 114 patients were included in this study. Among them, 57 received helmet NIV immediately after extubation (Figure 1). The prevalence of helmet NIV intolerance during the postextubation period was 75.4% (Figure 2). Table 1 shows the baseline characteristics of the helmet NIV group. General baseline characteristics, including age, gender, BMI, and underlying diseases, were comparable between the tolerance and intolerance groups. The prevalence of cancer was significantly higher in the intolerance group. No differences in the severity of the current disease, preexisting comorbidities, initial vital signs, gas exchange, weaning parameters, weaning time, volume status, etiologies of respiratory failure, duration of mechanical ventilation, NIV settings, and extubation success were observed between the two groups. However, the intolerance group exhibited a lower heart rate, higher partial pressure of oxygen in arterial blood (PaO_2)/FiO_2 ratio, and shorter NIV duration. No differences in the reintubation rate within 7 days, etiologies of reintubation, adverse events during NIV, or hemodynamic and gas exchange parameters at 30 min, 2 h, 24 h, and 48 h were observed between the two groups. However, the helmet NIV intolerance group exhibited a lower heart rate 30 min after extubation (Table 2).

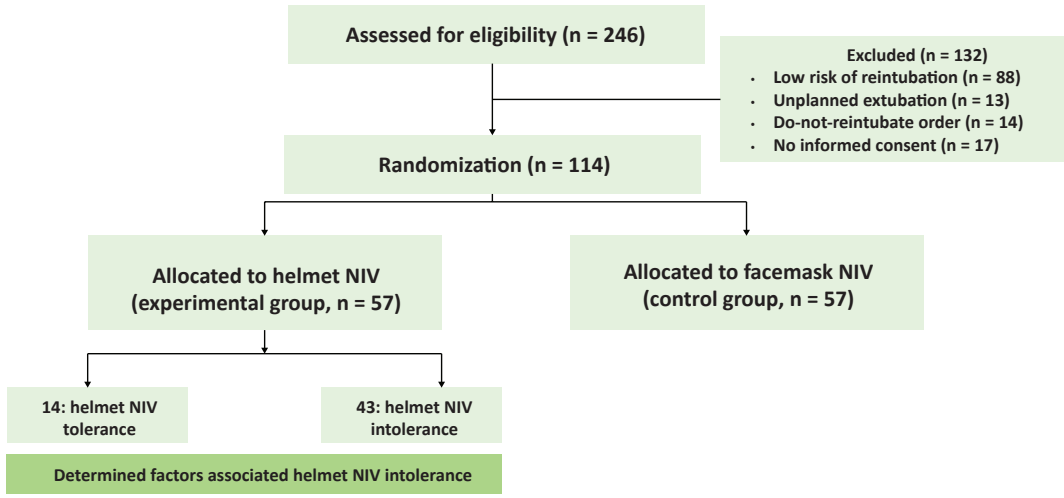

Figure 1 Flowchart of participants in the study

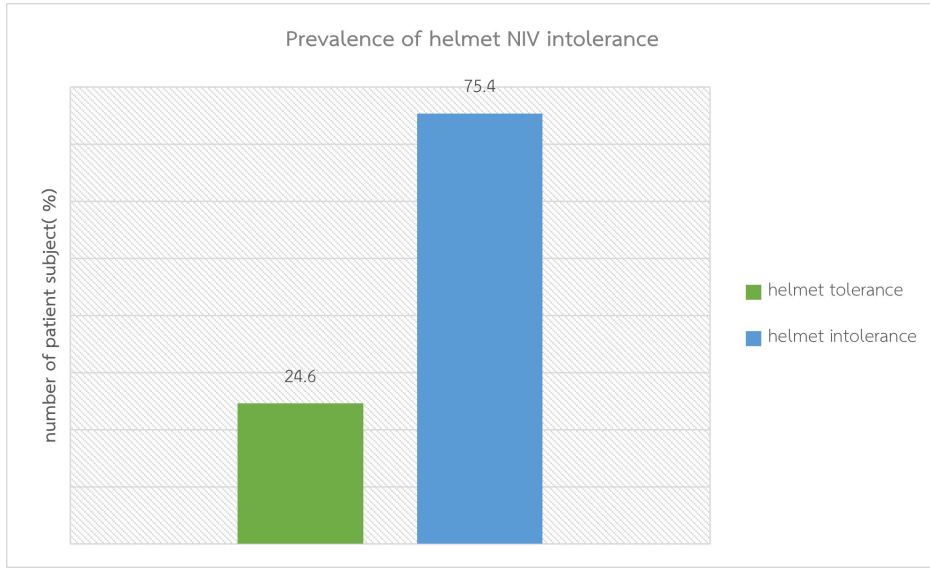

Figure 2 Prevalence of helmet NIV intolerance

Table 1 Patient's baseline characteristic

Baseline characteristics	Helmet NIV tolerance (n = 14)	Helmet NIV intolerance (n = 43)	P-value
Gender Male, n (%)	5 (35.71)	21 (48.84)	0.39
Age (years), mean ± SD	56 ± 18.32	65.93 ± 15.74	0.06
BMI (kg/m^2), mean ± SD	23.88 ± 5.93	24.4 ± 5.58	0.77
Underlying diseases, n (%)			
Hypertension	7 (50.00)	32 (74.42)	0.11
Diabetes mellitus	9 (64.29)	26 (60.47)	0.80
Congestive heart failure	5 (35.71)	15 (34.88)	0.99
Renal impairment	11 (78.57)	22 (51.16)	0.07
Conservative treatment	3 (21.43)	14 (32.56)	0.51
Renal replacement therapy	8 (57.14)	9 (20.93)	0.01

Table 1 Patient's baseline characteristic (continued)

Baseline characteristics	Helmet NIV tolerance (n = 14)	Helmet NIV intolerance (n = 43)	P-value
Cirrhosis	0 (0)	8 (18.60)	0.18
Airway diseases			
COPD	2 (14.29)	5 (11.63)	0.99
Asthma	0 (0)	1 (2.33)	0.99
Bronchiectasis	0 (0)	2 (4.65)	0.99
Tracheobronchomalacia	0 (0)	1 (2.33)	0.99
Cancer	0 (0)	13 (30.23)	0.03*
Disease status of cancer			
Former	0 (0)	4 (9.30)	0.57
Current	0 (0)	9 (20.93)	0.10
Type of malignancy			
Solid organ malignancy			
CNS tumor	0 (0)	1 (2.33)	0.99
Lung cancer	0 (0)	2 (4.65)	0.99
Gastrointestinal malignancy	0 (0)	2 (4.76)	0.99
Gynecologic malignancy	0 (0)	2 (4.65)	0.99
Breast cancer	0 (0)	1 (2.33)	0.99
Hematologic malignancy	0 (0)	5 (11.63)	0.32
Connective tissue disease	1 (7.14)	1 (2.33)	0.43
The severity of the current disease and pre-existing comorbidities			
Charlson Comorbidity Index, median [Q1, Q3]	4.5 (3,7)	5 (3,8)	0.64
APACHE II, mean ± SD	14.21 ± 3.38	14.07 ± 2.76	0.87
SOFA score, median [Q1, Q3]	3 (2,6)	3 (2,4)	0.69
Vital signs			
RR (rpm), mean ± SD	18.07 ± 3.32	19.16 ± 2.96	0.25
MAP (mmHg), mean ± SD	90.07 ± 12.49	84.67 ± 11.34	0.14
HR (bpm), mean ± SD	95.64 ± 16.62	83.47 ± 12.29	0.005*
Gas exchange			
PaO_2/FiO_2, mean ± SD	339.33 ± 43.56	383.79 ± 84.26	0.014*
SaO_2/FiO_2, mean ± SD	357.32 ± 60.95	350.11 ± 68.25	0.73
pCO_2 (mmHg), mean ± SD	32.37 ± 4.96	32.66 ± 6.94	0.89
pH, mean ± SD	7.44 ± 0.05	7.45 ± 0.04	0.67
Weaning parameters			
Work of breathing score, median [Q1, Q3]	1 (1,2)	1 (1,2)	0.29
RSBI, mean ± SD	83.61 ± 10.41	79.07 ± 13.1	0.24
CPF (LPM), mean ± SD	190.71 ± 27.02	190.93 ± 29.79	0.98
NIF (cmH_2O), mean ± SD	-23.61 ± 4.33	-23.28 ± 3.38	0.77
Weaning time (minutes), mean ± SD	43.93 ± 10.14	48.09 ± 14	0.31
Volume status			
Net fluid (mL), median [Q1, Q3]	305 (-3681,1392)	476 (-566,1245)	0.34
Causes of respiratory failure, n (%)			
Pulmonary causes	10 (71.43)	30 (69.77)	0.99
Pneumonia	5 (35.71)	15 (34.88)	0.99
Aspiration	0 (0)	1 (2.33)	0.99

Table 1 Patient's baseline characteristic (continued)

Baseline characteristics	Helmet NIV tolerance (n = 14)	Helmet NIV intolerance (n = 43)	P-value
ARDS	3 (21.43)	2 (4.65)	0.09
Bronchospasm	1 (7.14)	6 (13.95)	0.67
DAH	0 (0)	1 (2.33)	0.99
Pulmonary edema	6 (42.86)	13 (30.23)	0.52
Extra-pulmonary causes	8 (57.14)	20 (46.51)	0.49
Sepsis	6 (42.86)	17 (39.53)	0.83
Metabolic acidosis from other causes	5 (35.71)	7 (16.28)	0.14
Comatose status	1 (7.14)	6 (13.95)	0.67
Hemorrhagic shock	0 (0)	5 (11.63)	0.32
Duration of mechanical ventilation before extubation (days), median [Q1, Q3]	5 (3,7)	5 (3,7)	0.74
NIV settings			
PEEP (cmH_2O), mean ± SD	6.43 ± 1.28	6.05 ± 1.46	0.39
PS (cmH_2O), mean ± SD	13 ± 1.75	12.05 ± 2.33	0.17
VTi (mL), mean ± SD	1184.29 ± 182.58	1147.3 ± 170.27	0.49
VTe (mL), mean ± SD	1060.14 ± 169.89	1033.74 ± 161.44	0.60
FiO_2, mean ± SD	0.29 ± 0.05	0.29 ± 0.05	0.74
% Leakage, median [Q1, Q3]	10.25 (8,12)	10 (8,12)	0.58
NIV duration (hours), median [Q1, Q3]	24 (24,24)	4 (2,9)	< 0.001*
Extubation success	14 (100)	35 (81.4)	0.18

Abbreviations: APACHE II, acute physiology and chronic health evaluation II; ARDS, acute respiratory distress syndrome; BMI, body mass index; bpm, beats per minute; cmH_2O, centimeter of water; CNS, central nervous system; COPD, chronic obstructive pulmonary disease; CPF, cough peak flow; DAH, diffuse alveolar hemorrhage; FiO_2, fraction of inspired oxygen; HR, heart rate; kg/m^2, kilogram per square meter; LPM, litres per minute; MAP, mean arterial pressure; mL, milliliter; mmHg, millimeters of mercury; n, number of patients; NIF, negative inspiratory force; NIV, non-invasive ventilation; PaO_2, partial pressure of oxygen; pCO_2, partial pressure of carbon dioxide; PEEP, positive end expiratory pressure; pH, positive potential of the hydrogen ions; PS, pressure support; Q1, 25% quartile; Q3, 75% quartile; rpm, respirations per minute; RR, respiratory rate; RSBI, rapid shallow breathing index; SaO_2, saturation of oxygen in arterial blood; SD, standard deviation; SOFA, sequential organ failure assessment; VTe, expired tidal volume; VTi, inspired tidal volume
*, significant

Table 2 Patient's baseline characteristics

Baseline characteristics	Helmet NIV tolerance (n = 14)	Helmet NIV intolerance (n = 43)	P-value
Reintubation rate within 7 days, n (%)	1 (7.14)	10 (23.26)	0.26
Time to reintubation (days), median [Q1, Q3]	0 (0,3.5)	0 (0,6)	0.25
Comfort score#, mean ± SD	5.5 ± 2.28	6.79 ± 2.18	0.06
Adverse events			
Pressure sore score, mean ± SD	0 (0,1)	0 (0,2)	0.92
Hot air, n (%)	0 (0)	8 (18.6)	0.18
Noise, n (%)	8 (57.14)	32 (74.42)	0.31
Asynchrony, n (%)	0 (0)	3 (6.98)	0.57
Others, n (%)	1 (7.14)	1 (2.33)	0.43
Parameter during extubation			
30 minutes after extubation			
RR (rpm), mean ± SD	19.21 ± 2.81	20.84 ± 1.91	0.06
MAP (mmHg), mean ± SD	88.57 ± 11.44	85.35 ± 11.57	0.37
HR (bpm), mean ± SD	94.29 ± 15.18	85.65 ± 12.49	0.038*
SaO_2/FiO_2, mean ± SD	354.32 ± 62.18	354.86 ± 63.26	0.98

Table 2 Patient's baseline characteristics (continued)

Baseline characteristics	Helmet NIV tolerance (n = 14)	Helmet NIV intolerance (n = 43)	P-value
% Leakage, median [Q1, Q3]	11 (8,15)	10 (5,15)	0.19
WOB score, median [Q1, Q3]	1 (1,2)	2 (1,2)	0.15
2 hours after extubation			
RR (rpm), mean ± SD	19.86 ± 2.21	20.72 ± 1.87	0.16
MAP (mmHg), mean ± SD	90 ± 11.64	85.81 ± 10.7	0.22
HR (bpm), mean ± SD	93.21 ± 13.73	85.67 ± 12.78	0.07
SaO_2/FiO_2, mean ± SD	364.21 ± 53.08	364.58 ± 65.05	0.98
PaO_2/FiO_2, mean ± SD	395.01 ± 88.71	406.78 ± 82.78	0.65
pCO_2 (mmHg), mean ± SD	33.44 ± 6.24	32.6 ± 6.51	0.67
pH, mean ± SD	7.45 ± 0.04	7.45 ± 0.03	0.87
% Leakage, median [Q1, Q3]	8 (5,12)	10 (5,15)	0.48
WOB score, median [Q1, Q3]	1 (1,2)	1 (1,2)	0.48
24 hours after extubation			
RR (rpm), mean ± SD	18.64 ± 2.34	19.91 ± 2.04	0.06
MAP (mmHg), mean ± SD	88.14 ± 11.71	84.14 ± 10.02	0.22
HR (bpm), mean ± SD	88.86 ± 12	85.14 ± 11.9	0.32
SaO_2/FiO_2, mean ± SD	365.21 ± 54.57	365.91 ± 64.87	0.97
PaO_2/FiO_2, mean ± SD	416.8 ± 100.58	405.17 ± 84.95	0.67
pCO_2 (mmHg), mean ± SD	31.71 ± 4.85	33.28 ± 6.07	0.25
pH, mean ± SD	7.46 ± 0.04	7.44 ± 0.03	0.38
% Leakage, median [Q1, Q3]	8 (5,12)	10 (5,15)	0.48
WOB score, median [Q1, Q3]	1 (1,2)	1 (1,2)	0.43
48 hours after extubation			
RR (rpm), mean ± SD	18.79 ± 1.37	19.44 ± 1.88	0.23
MAP (mmHg), mean ± SD	87.36 ± 10.58	83.81 ± 9.31	0.24
HR (bpm), mean ± SD	87.86 ± 12.49	84.16 ± 11.75	0.32
SaO_2/FiO_2, mean ± SD	362.69 ± 53.27	368.79 ± 61.38	0.74
PaO_2/FiO_2, mean ± SD	383.55 ± 67.03	380.11 ± 75.03	0.88
pCO_2 (mmHg), mean ± SD	31.64 ± 4.25	33.74 ± 5.95	0.23
pH, mean ± SD	7.45 ± 0.03	7.45 ± 0.03	0.96
WOB score, median [Q1, Q3]	1 (1,2)	1 (1,2)	0.31
Reasons of reintubation within 7 days, n (%)			
Pulmonary cause	1 (7.14)	7 (16.28)	0.66
Pneumonia	1 (7.14)	3 (6.98)	0.99
Aspiration	0 (0)	2 (4.65)	0.99
Secretion obstruction	1 (7.14)	3 (6.98)	0.99
Pulmonary edema	0 (0)	2 (4.65)	0.99
Extra-pulmonary cause	0 (0)	3 (6.98)	0.57
Sepsis	0 (0)	3 (6.98)	0.57
Metabolic acidosis from other causes	0 (0)	1 (2.33)	0.99

Abbreviations: bpm, beats per minute; cmH_2O, centimeter of water; FiO_2, fraction of inspired oxygen; HR, heart rate; MAP, mean arterial pressure; mmHg, millimeters of mercury; n, number of patients; NIV, non-invasive ventilation; PaO_2, partial pressure of oxygen; pCO_2, partial pressure of carbon dioxide; pH, positive potential of the hydrogen ions; Q1, 25% quartile; Q3, 75% quartile; rpm, respirations per minute; RR, respiratory rate; SaO_2, saturation of oxygen in arterial blood; SD, standard deviation; WOB score, work of breathing score
#, the higher score, the more discomfort; *, significant

Table 3 shows factors associated with helmet NIV intolerance using univariate and multivariate regression analyses. In the univariate analysis, age, renal impairment, heart rate, PaO_2/FiO_2 ratio, and comfort score had a p-value < 0.2. After multicollinearity was checked, factors with a p-value < 0.2 were included in the multivariate analysis. The analysis revealed that heart rate was significantly associated with helmet NIV intolerance (p < 0.05).

DISCUSSION

This study demonstrated that the use of helmet NIV during the postextubation period in patients at high risk of postextubation respiratory failure was associated with a higher rate of NIV intolerance. However, no significant difference in extubation success was observed. Even after adjusting for well-protocolized pressure support and PEEP settings in the NIV mode, patients in the intolerance group experienced discomfort, which may be due to the device itself and the median duration of use of 4 h.

We hypothesized that helmet NIV might offer better tolerability due to reduced air leakage and more effective ventilation, which is consistent with many guidelines that recommend helmet NIV over face mask NIV when patients experience intolerance to face mask NIV[18,20]. This study showed a higher rate of helmet NIV intolerance. These findings are inconsistent with those of other studies[16,17]. These discrepancies may be due to differences in study populations, as this study focused on the postextubation period. Conversely, other studies have been conducted on patients with hypoxemic respiratory failure to prevent intubation[17,19].

Helmet NIV intolerance was more prevalent among patients with malignancy, those with a lower initial heart rate before helmet NIV use, and those with higher baseline PaO_2/FiO_2 ratios. Therefore, caution should be exercised when using helmet NIV after extubation for patients with malignancy. However, scientific data supporting the association between lower initial heart rate and high PaO_2/FiO_2 ratios and intolerance are lacking. Although a statistical difference was observed, no clinical difference was observed due to the lack of differences between the etiologies of respiratory failure and gas exchange parameters during the device use. This study focused on the postextubation period,

Table 3 Factors associated with helmet NIV intolerance using univariate and multivariate logistic regression analyses

Factors	Univariate analysis		Multivariate analysis	
	Crude Odds ratio (95% CI)	P-value	Adjusted Odds ratio (95% CI)	P-value
Gender: Male	1.72 (0.49 - 5.97)	0.39	1.35 (0.20 - 9.28)	0.76
Age (years)	1.04 (1.00 - 1.08)	0.06	1.06 (0.98 - 1.14)	0.13
BMI (kg/m^2)	1.02 (0.91 - 1.14)	0.76	1.01 (0.86 - 1.20)	0.88
Renal impairment	0.29 (0.07 - 1.17)	0.08	0.05 (0 - 1.14)	0.06
Charlson comorbidity index	1.07 (0.88 - 1.30)	0.51	0.91 (0.61 - 1.36)	0.63
APACHE II	0.98 (0.79 - 1.21)	0.87	1.33 (0.77 - 2.30)	0.31
SOFA score	0.96 (0.73 - 1.26)	0.76	1.18 (0.58 - 2.37)	0.64
HR (bpm)	0.93 (0.89 - 0.98)	0.01	0.93 (0.87 - 0.99)	0.04*
PaO_2/FiO_2	1.01 (1.00 - 1.02)	0.07	1.02 (1.00 - 1.03)	0.07
Pulmonary causes of respiratory failure	0.92 (0.24 - 3.49)	0.90	1.03 (0.04 - 24.47)	0.98
Extra-pulmonary causes of respiratory failure	0.65 (0.19 - 2.20)	0.49	0.66 (0.05 - 9.56)	0.76
Comfort score	1.31 (0.98 - 1.75)	0.06	1.41 (0.92 - 2.17)	0.11

Abbreviations: APACHE II, acute physiology and chronic health evaluation II; BMI, body mass index; bpm, beats per minute; CI, confidence interval; FiO_2, fraction of inspired oxygen; HR, heart rate; kg/m^2, kilogram per square meter; PaO_2, partial pressure of oxygen; SOFA, sequential organ failure assessment
*, significant

which may explain the higher PaO_2/FiO_2 ratios in this study than in other studies. Even in a study that focused on the treatment of postoperative hypoxemia, the PaO_2/FiO_2 ratios were lower than those in our study[16].

Multivariate analysis revealed a positive association between lower heart rate and helmet NIV intolerance. To the best of our knowledge, this is the first study to report on hemodynamic and gas exchange parameters during helmet NIV use. Although this correlation was statistically significant, it may not be clinically significant because the observed lower heart rate was not low enough to cause hemodynamic instability. However, caution should be exercised when using helmet NIV in patients with a low initial heart rate. A low heart rate might be due to medications administered, which are not included in the data collection. Further studies are needed to explore and validate this correlation.

This study has some limitations. This was a retrospective cohort study conducted at a single center, raising the possibility that it might be underpowered, limiting the generalizability of the findings to other healthcare settings. Despite these limitations, this is the first study to identify factors associated with helmet NIV intolerance in the postextubation period among high-risk patients. Improving helmet use among the Thai population requires. Moreover, the prevalence of chronic obstructive pulmonary disease is slightly higher in the intolerance group, but the difference is not statistically significant. Further studies are needed to confirm this finding. Enhancing the learning curve and educating the medical team are crucial to increasing the use of helmet NIV, improving outcomes, and reducing the rate of intolerance[21].

CONCLUSION

Noninvasive respiratory support, particularly the use of helmet NIV during the postextubation period in high-risk patients,was associated with a high rate of NIV intolerance. However, no differences in extubation success were observed. Patients with malignancy, lower initial heart rates, and higher PaO_2/FiO_2 ratio were more likely to experience helmet NIV intolerance.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENT

The authors would like to acknowledge the participants for their information.

DATA AVAILABILITY STATEMENT

All data generated or analyzed during this study are included in this published article. The authors will consider any reasonable requests for additional data case-by-case basis.

REFERENCES

1. Boscolo A, Pettenuzzo T, Sella N, Zatta M, Salvagno M, Tassone M, et al. Noninvasive respiratory support after extubation: a systematic review and network meta-analysis. Eur Respir Rev 2023;32(168):220196.
2. Munshi L, Mancebo J, Brochard LJ. Noninvasive respiratory support for adults with acute respiratory failure. N Engl J Med 2022;387(18):1688-98.
3. Rochwerg B, Brochard L, Elliott MW, Hess D, Hill NS, Nava S, et al. Official ERS/ATS clinical practice guidelines: noninvasive ventilation for acute respiratory failure. Eur Respir J 2017;50(2):1602426.
4. Fernando SM, Tran A, Sadeghirad B, Burns KEA, Fan E, Brodie D, et al. Noninvasive respiratory support following extubation in critically ill adults: a systematic review and network meta-analysis. Intensive Care Med 2022; 48(2):137-47.
5. Nava S, Gregoretti C, Fanfulla F, Squadrone E, Grassi M, Carlucci A, et al. Noninvasive ventilation to prevent respiratory failure after extubation in high-risk patients. Crit Care Med 2005;33(11):2465-70.

6. Ornico SR, Lobo SM, Sanches HS, Deberaldini M, Tofoli LT, Vidal AM, et al. Noninvasive ventilation immediately after extubation improves weaning outcome after acute respiratory failure: a randomized controlled trial. Crit Care 2013;17(2):R39.
7. Ferrer M, Sellares J, Valencia M, Carrillo A, Gonzalez G, Badia JR, et al. Non-invasive ventilation after extubation in hypercapnic patients with chronic respiratory disorders: randomised controlled trial. Lancet 2009; 374(9695):1082-8.
8. Ferrer M, Valencia M, Nicolas JM, Bernadich O, Badia JR, Torres A. Early noninvasive ventilation averts extubation failure in patients at risk: a randomized trial. Am J Respir Crit Care Med 2006;173(2):164-70.
9. El-Solh AA, Aquilina A, Pineda L, Dhanvantri V, Grant B, Bouquin P. Noninvasive ventilation for prevention of post-extubation respiratory failure in obese patients. Eur Respir J 2006; 28(3):588-95.
10. Thille AW, Boissier F, Ben-Ghezala H, Razazi K, Mekontso-Dessap A, Brun-Buisson C, et al. Easily identified at-risk patients for extubation failure may benefit from noninvasive ventilation: a prospective before-after study. Crit Care 2016;20:48.
11. Grieco DL, Menga LS, Cesarano M, Rosa T, Spadaro S, Bitondo MM, et al. Effect of helmet noninvasive ventilation vs high-flow nasal oxygen on days free of respiratory support in patients with COVID-19 and moderate to severe hypoxemic respiratory failure: the HENIVOT randomized clinical trial. JAMA 2021;325(17):1731-43.
12. Chaudhuri D, Jinah R, Burns KEA, Angriman F, Ferreyro BL, Munshi L, et al. Helmet noninvasive ventilation compared to facemask noninvasive ventilation and high-flow nasal cannula in acute respiratory failure: a systematic review and meta-analysis. Eur Respir J 2022;59(3): 2101269.
13. Liu Q, Gao Y, Chen R, Cheng Z. Noninvasive ventilation with helmet versus control strategy in patients with acute respiratory failure: a systematic review and meta-analysis of controlled studies. Crit Care 2016;20(1):265.
14. Chiumello D, Pelosi P, Carlesso E, Severgnini P, Aspesi M, Gamberoni C, et al. Noninvasive positive pressure ventilation delivered by helmet vs. standard face mask. Intensive Care Med 2003;29(10):1671-9.
15. Jirawat N, Kongpolprom N. Comparison of extubation success between prophylactic helmet NIV and facemask NIV in high-risk postextubation patients; a randomized controlled trial. Eur Respir J 2023;62 Suppl 67: OA3188.
16. Squadrone V, Coha M, Cerutti E, Schellino MM, Biolino P, Occella P, et al. Continuous positive airway pressure for treatment of postoperative hypoxemia: a randomized controlled trial. JAMA 2005;293(5):589-95.
17. Principi T, Pantanetti S, Catani F, Elisei D, Gabbanelli V, Pelaia P, et al. Noninvasive continuous positive airway pressure delivered by helmet in hematological malignancy patients with hypoxemic acute respiratory failure. Intensive Care Med 2004;30(1):147-50.
18. Coppadoro A, Zago E, Pavan F, Foti G, Bellani G. The use of head helmets to deliver noninvasive ventilatory support: a comprehensive review of technical aspects and clinical findings. Crit Care 2021;25(1): 327.
19. Rocco M, Dell'Utri D, Morelli A, Spadetta G, Conti G, Antonelli M, et al. Noninvasive ventilation by helmet or face mask in immunocompromised patients: a case-control study. Chest 2004;126(5):1508-15.
20. Esquinas Rodriguez AM, Papadakos PJ, Carron M, Cosentini R, Chiumello D. Clinical review: helmet and non-invasive mechanical ventilation in critically ill patients. Crit Care 2013;17(2):223.
21. Amirfarzan H, Cereda M, Gaulton TG, Leissner KB, Cortegiani A, Schumann R, et al. Use of helmet CPAP in COVID-19 - a practical review. Pulmonology 2021;27(5):413-22.