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Noninvasive Mechanical Ventilation of Critically Ill Patients in ICUs in Mainland China: A Cross-Sectional Study

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1. Abstract

Although noninvasive mechanical ventilation (NIV) has been very common used for ICU patients, limited information exists about the epidemiological information of NIV in mainland China. This is a cross-sectional study in which patients with NIV were observed in September, 2012 from 15 ICUs. Epidemiological data and clinical outcomes were assessed among those who NIV succeed and those who did not. A total of 104 NIV patients were enrolled. Acute respiratory distress syndrome (ARDS), acute exacerbation of chronic obstructive pulmonary disease (AECOPD), cardiogenic pulmonary edema were the first three causes of NIV, accounted for 32.7%, 20.2% and 18.3%, respectively. Bi-level positive pressure ventilation model accounted for 87.5% of NIV used. The APACHEII score of the NIV failure group was significantly

higher than success group (14.5 ± 6.2 vs. 18.2 ± 7.4, p = 0.023). PaCO2 and PaO2/FiO2 were significantly lower than that of success group, (29.5[24.7-40.6] vs. 36.0[30.3-47.5], p=0.012) and (189.7[127.2-245.1] vs. 221.2[178.5-295.5], p=0.02). Multivariate regression analysis revealed that sequential NIV (OR=6.271 [1.238-31.769], P=0.0027), analgesia (OR=3.433 [1.291-9.128], P=0.013) and PaO2/FiO2 (OR=1.007 [1.002-1.013], P=0.012) were protective factors for successful NIV. In summary, The proportion of NIV in ICU patients in mainland China was low. And ARDS was the main NIV cause and analgesia was a protective factor for successful NIV.

2. Introduction

Noninvasive mechanical ventilation (NIV) is one of the important treatments for critical patients with respiratory failure, which improves respiratory failure patient's oxygenation, reduces tracheal intubation risk and mechanical ventilation related complications by increasing pulmonary volume and reducing respiratory work [1,2]. NIV becomes the first choice for patients with acute exacerbation of chronic obstructive pulmonary disease (AECOPD), cardiogenic pulmonary edema, and sequential ventilation after extubation [3,4], as well as an important means to correct mild hypothermia in patients with acute respiratory distress syndrome (ARDS) [5,6].

The use of NIV varies depending on the hospital, region and country, and time. A prospective observational study in France showed that the proportion of NIV in mechanical ventilation increased from 35% in 1997 to 52% (p <0.0001) in the 70 ICUs involved in the study [7,8]. In other European countries and North America, the proportion of NIV is relatively low [8]. Numerous studies have also shown that the proportion of NIV in different ICUs were also different (<5% to> 45%) [7,9,10]. And the effects and prognosis of NIV are differently from the ICU designed ventilation regimen, used experience, and respiratory therapists [11]. Du Bin et al. showed that the proportion of NIV accounted for 12% of ICU patients in their prospective observational cohort study of twenty-two ICUs in mainland China [12]. However they did not further describe the epidemiological characteristics of ICUs patients with NIV in China.

So far, there is no investigation on the clinical information of ICUs patients with NIV in China. Therefore, our study investigated for the epidemiological data of NIV patients in general demographics, causes of ventilation, ventilator parameters and success rate, which is crucial to provide basic reference for future epidemiological studies and design further clinical study.

3. Methods

3.1. Study Design

The study was a 1-month (September, 2012) prospective, observational study to describe the epidemiological data of critical ill adult patients with NIV in 15 participating Chinese ICUs. Our 15 participating ICUs were distributed in 11 cities of 6 provinces in China. Thirteen ICUs (80%) were in university-affiliated hospitals. All participating units were general ICUs. There were an average of 34 (20-39) beds in each ICU, accounting for 1.9% (1.7-2.2) of all hospital beds (Table 1). The protocol was approved by the Institutional Ethics Committee of Zhongda Hospital affiliated to Southeast University (the core center, Approval No. 2012ZD11KY09.0). Informed consent was waived due to the observational nature of the study.

The case report form was initially developed by one investigator (L Liu), and then cycled among all participating ICUs for feedback until reached a final version. Every participating ICU assigned a study coordinator, who was responsible for patient screening, enrollment, and data collection. Any questions about the case report were answered by the phone or E-mail. Only the investigator and research coordinators at each unit were familiar with the exact purpose for minimize practice changes in response to observation. The date of finished case reports were submitted through network platform. Another coordinator was assigned to audit the submitted date and sent queries to the source hospital for resolution.

3.2. Study Population

All new patients with NIV admitted to participating ICUs during the study period (August 31st to September 30st, 2012) were screened for eligibility. Exclusion criteria were age less than 18 years, received NIV before admission and NIV less than one hour.

Date Collection

The enrollment period of the study was one month, from August 31 to September 30, 2012. For every enrolled patient, demographic data, severity of illness, causes of NIV, types of interface, state of consciousness, model and parameters of NIV, blood gas analysis at the beginning of NIV, causes of failure of NIV, and patient outcome were recorded. Severity of illness, including Acute Physiology and Chronic Health Evaluation (APACHE) □, was assessed based on the worst variables recorded during the first 24 hrs of ICU admission. Failure of NIV was defined for needing tracheal intubation or death during NIV.

3.3. Outcome Measures

All enrolled patients were followed until one of the following situations occurred, whichever happened earlier: discharge from ICU, or death in the current ICU admission. The primary outcome was all-cause NIV failure. Patients who were still need NIV on September 30 were followed until discharge or death.

3.4. Statistical Analysis

Statistical analysis was performed with SPSS 15.0. Normal distribution variables were expressed as mean ± SD, non-normal distribution variables used the median (interquartile range). Continuous

variables were compared with the use of the one way ANOVA or Mann–Whitney test. The Chi-square or exact Fisher's test was used to comparisons of proportions. Binary logistic regression analysis was used to evaluate the independent risk factors for the failure of NIV. All comparisons were unpaired, and all tests of significance were two-tailed. P<0.05 was considered as statistically significant.

4. Results

3.1. Patient Enrollment

There were 1,814 admissions in 15 ICUs during the study period. A total of 104 patients (accounting for 18.7% of the total number of mechanical ventilation, and 5.7% of ICU admissions) were enrolled in the final analysis. Reasons for exclusion included age ≤18 yrs (n=23), before admission to ICU who have received NIV (n=54), only invasive mechanical ventilation (n=451), no mechanical ventilation and NIV ＜1hr (n=1205) (Figure 1).

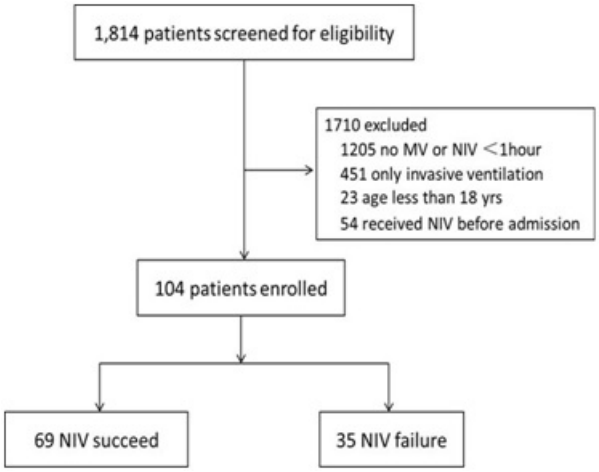

Figure 1: Flow diagram of patient screening and enrollment.

4.2. General Information

Among the 104 NIV patients, 71 (68.3%) were male, and mean age was 70.5 [57.0-77.3] yrs. APACHEII score was 15.0 [10.0-19.3]. ARDS (32.7%), congestive heart failure (20.2%), AECOPD (18.3%), and sequential NIV (16.3%) were the main causes of NIV. Face mask interface (75%) was the most common way to deliver from NIV.

87 (83.7%) NIV patients were wide awake, and 16 (15.4%) were drowsiness. 30 (29.1%) underwent sedative therapy, among whom dexmedetomidine and propofol were the most common sedation drugs, accounting for 66.7% and 60.0% separately. 30 (29.1%) NIV patients received analgesic treatment, 24 (80%) of whom received morphine, and the others (20%) were remifentanil (Table 2).

4.3. Ventilator Modes and Blood Gas Analysis

Bi-level positive airway pressure (BiPAP) (87.5%) was the most popular mode for NIV patients, followed by CPAP (10.6%). The median tidal volume was 7.5 [6.4-8.9] ml/kg.pbw, the airway peak pressure was 17.0 [12.0-20.0] cmH2O. The first blood gas analysis was done at the beginning of NIV. The value of PH was 7.4 [7.3-7.5], HCO3 was 22.8 [18.6-27.7] mmol/L, PaO2/FiO2 was 211.5 [164.9-277.0] mmHg, Lactic acid was 1.6 [1.0-2.2]. PaO2/FiO2 was significantly lower in NIV succeed subgroup (189.7 [127.2-245.1] vs. 221.2 [178.5-295.5], p = 0.02), and also PaCO2 (29.5 [24.7-40.6] vs. 36.0 [30.3-47.5], p = 0.012) (Table 3).

Table 1: Characteristics of Participating Centers

Characteristic	Participating ICU Centers(n=20)
Type of hospital, n (%)	
University affiliated	16 [80]
Public	4 [20]
Hospital grade, n (%)	
Tertiary hospital	17 [85]
Secondary hospital	3 [15]
Number of hospital beds	
Total	42198
Median (IQR)	1825 [1043-2311]
Type of ICU, n (%)	
General	19 [95]
Surgical	1 [5]
Number of ICU beds	
Total	550
Median (IQR)	28 [19-37]
Nurses : ICU beds (IQR)	2.3:1 [2.0:1-2.5:1]
Doctors : ICU beds (IQR)	1.6:1 [1.1:1-2.0:1]

ICU, intensive care unit; IQR, interquartile range

4.4. NIV for ARDS

Total 34 patients (32.7%) with ARDS received NIV, among which 14 patients were mild ARDS, 12 were moderate ARDS and 8 were severe ARDS. PaO2was significant decreased in mild, moderate and severe ARDS (103.9mmHg [92.2-114.6], 76.8 mmHg [75.6-82.2] and 64.6 mmHg [60.0-69.0], P=0.000), and also PaO2/FiO2 was significant decreased (255.8mmHg [227.3-282.8], 170.5mmHg [148.1-190.4] and 78.7mmHg [60.8-94.0], P=0.000). 19 (55.9%) NIV patients with ARDS successful weaned from NIV. Hypoxemia was the main causes of NIV failure, accounting for 73.3% (Table 4).

4.5. Independent Risk Factors for NIV

Univariate regression analysis showed that sequential NIV (OR=4.952 [1.043-23.523], P=0.044), analgesia (OR=2.872 [1.148 -7.183], P=0.024) and PaO2/FiO2 (OR=1.007 [0.970-1.011], P=0.008) were protective factors for NIV, while lactate (OR=0.555 [0.344-0.895], P=0.016) was the independent risk factor. Further multivariate regression analysis revealed sequential NIV (OR=6.271 [1.238-31.769], P=0.0027), analgesia (OR=3.433 [1.291-9.128], P=0.013) and PaO2/FiO2 (OR=1.007 [1.002-1.013], P=0.012) were protective factors (Table 5).

Table 2: General Information of Critically Ill Patients with NIV in Chinese ICUs.

	Total (n=104)	**NIV succeed (n=69)**	**NIV failure (n=35)**	**p**
Age	70.5[57.0-77.3]	70.0[57.0-77.0]	72.0[59.0-77.5]	0.839
Male sex	71(68.3%)	46(66.7%)	25(71.4%)	0.622
APACHEII	15.0[10.0-19.3]	14.5±6.2	18.2±7.4	0.023
Reasons for NIV				
ARDS	34(32.7%)	20(29.0%)	14(40.0%)	0.258
Cardiogenic Pulmonary Edema	21(20.2%)	14(20.3%)	7(20.0%)	0.972
AECOPD	19(18.3%)	15(21.7%)	4(11.4%)	0.284
Sequential NIV	17(16.3%)	15(21.7%)	2(5.7%)	0.049
Refused Intubation	4(3.8%)	0	4(11.4%)	0.011
Postoperative Respiratory Support	3(2.9%)	2(2.9%)	1(2.9%)	1.000
Sepsis	2(1.9%)	1(1.4%)	1(2.9%)	1.000
Other	4(3.8%)	2(2.9%)	2(5.7%)	0.597
Interface types				
Face mask	78(75.0%)	50(72.5%)	18(51.4%)	
Nasal mask	12(11.5%)	7(10.1%)	5(14.3%)	
Nasal-mouth mask	14(13.5%)	12(11.5%)	2(5.7%)	
State of consciousness				
Awake	103(99.0%)	69(100.0%)	34(97.1%)	0.337
Sedative drugs	30(29.1%)	17(24.6%)	13(37.1%)	0.333
Propofol	18(60.0%)	11(64.7%)	7(53.8%)	
Dexmedetomidine	2(6.7%)	1(5.9%)	1(7.7%)	
Midazolam	20(66.7%)	10(58.8%)	10(76.9%)	
Analgesic drugs	30(29.1%)	14(20.3%)	16(47.8%)	0.021
Morphine	24(80.0%)	10(71.4%)	14(87.5%)	
Remifentanil	6(20.0%)	3(21.4%)	3(18.8%)	
ICU death	23(22.1%)	0	23(65.7%)	

Table 3: Ventilator parameters and Blood gas analysis of NIV patients

	Total (n=104)	NIV succeed (n=69)	NIV failure (n=35)	p
NIV mode n(%)				
BIPAP	91(87.5%)	59(85.5%)	32(91.4%)	0.224
Plow (cmH2O)	5.5[5.0-6.0]	5.0[5.0-6.0]	6.0[5.0-8.0]	
Phigh ((cmH2O)	12.0[10.0-13.0]	12.0[10.0-13.0]	12.0[10.0-12.5]	
FiO_2 (%)	40.0[40.0-50.0]	40.0[40.0-50.0]	50.0[40.0-60.0]	
CPAP	11(10.6%)	9(13.0%)	2(5.7%)	0.114
PEEP (cmH2O)	6.0[5.0-8.0]	5.0[5.0-8.0]	6.0[6.0-6.0]	
FiO_2 (%)	40.0[35.0-45.0]	40.0[35.0-40.0]	100.0[100.0-100.0]	
Other modes	2(1.9%)	1(1.4%)	1(2.9%)	
Ventilator parameters				
Vt(ml/kg.pbw)	7.5[6.4-8.9]	7.7[6.5-9.2]	7.2[6.4-8.6]	0.284
F	22.0[19.0-26.8]	21.5[18.8-26.0]	22.0[19.0-27.8]	0.449
Ti(s)	1.0[1.0-1.2]	1.0[1.0-1.2]	1.0 [1.0-1.1]	0.433
Ppeak(cmH2O)	17.0[13.0-20.0]	16.0[12.0-20.0]	18.0[16.0-20.0]	0.147

Blood gas analysis				
PH	7.4[7.3-7.5]	7.41[7.3-7.5]	7.4 [7.3-7.5]	0.901
HCO3(mmol/L)	22.8[18.6-27.7]	23.7[19.8-28.4]	20.0 [15.9-24.2]	0.013
Lac(mmol/L)	1.6[1.0-2.2]	1.5[1.0-2.0]	1.7[1.2-3.0]	0.059
PaO_2(mmHg)	88.5[74.0-120.4]	88.5[74.8-126.6]	90.0 [69.7-105.0]	0.452
PaO_2/FiO2(mmHg)	211.5[164.9-277.0]	221.2[178.5-295.5]	189.7[127.2-245.1]	0.020
$PaCO_2$(mmHg)	35.1[28.1-47.2]	36[30.3-47.5]	29.5[24.7-40.6]	0.012
ARDS	35.5[28.5-39.9]*	37.0[32.4-41.0]	29.3[24.1-38.6]	0.791
Cardiogenic Pulmonary Edema	31.2[28.0-38.0]*	30.7[28.3-37.4]	35.9[28.6-39.0]	0.564
AECOPD	56.2[47.5-71.5]	62.0[56.1-82.6]	28.0[28.0-48.5]	0.014
Sequential NIV	34.8[28.5-44.2]*	34.8[28.4-43.6]	37.9[33.2-42.5]	0.908

* Compared with AECOPD, P＜0.05

NIV, noninvasive ventilation; BIPAP, bi-level positive airway pressure; Plow, low pressure, Phigh, high pressure; FiO2, fraction of inspired oxygen; CPAP, continuous positive airway pressure; PEEP, positive end-expiratory pressure; Vt, tital volume; Ti, inspired time; Ppeak, peak pressure

Table 4: General Information of NIV Patients with ARDS

	Total (n=34)	mild ARDS (n=14)	moderate ARDS (n=12)	severe ARDS (n=8)	P
Age	63.5 [48.3-78.5]	60.5 [45.5-75.8]	65.5 [54.3-74.8]	60.0 [51.0-68,5]	0.406
Male sex	23 (67.6%)	10 (71.4%)	10 (83.3%)	3 (37.5%)	0.097
APACHEII	15.5 [12.0-22.8]	17.5 [14.3-22.8]	14.0 [9.8-17.0]	19.0 [14.3-27.0]	0.149
Ventilator parameters					
Vt(ml/kg.pbw)	7.8 [6.4-9.1]	7.9 [6.7-9.0]	8.0 [6.7-9.0]	6.3 [5.5-9.0]	0.415
F (bpm)	21[18-26]	21 [19-23]	21 [18-25]	26 [19-34]	0.302
Ppeak (cmH2O)	18 [13-22]	17.5 [13.5-20.0]	19.0 [15.5-22.8]	20.0 [11.5-30.0]	0.492
Blood gas analysis					
PH	7.4 [7.3-7.5]	7.4 [7.4-7.5]	7.4 [7.4-7.4]	7.3 [7.3-7.5]	0.343
HCO3(mmol/L)	21.0 [18.8-25.3]	23.6 [19.9-27.0]	20.3 [18.4-21.6]	23.6 [18.5-25.2]	0.353
Lac(mmol/L)	1.9 [1.2-2.7]	1.6 [1.0-2.0]	2.0 [1.3-2.7]	2.7 [1.9-4.4]	0.143
PaO2(mmHg)	82.4 [71.0-101.1]	103.9 [92.2-114.6]	76.8 [75.6-82.2]	64.6 [60.0-69.0]	0.000
PaCO2(mmHg)	35.5 [28.5-39.9]	37.0 [32.2-39.7]	30.4 [28.6-39.8]	35.5 [26.6-49.6]	0.646
PaO2/FiO2(mmHg)	190.8[137.7-231.2]	255.8 [227.3-282.8]	170.5 [148.1-190.4]	78.7[60.8-94.0]	0.000
Successful NIV n(%)	19 (55.9%)	10 (71.4%)	6 (50.0%)	3 (37.5%)	0.261
Reason of NIV failure n(%)					
Hypoxemia	11/15 (73.3%)	2/4 (50%)	4/6 (66.7%)	5/5 (100%)	
Increased secretions	2/15 (13.3%)	1/4 (25%)	1/6 (16.7%)		0
Others	2/15 (13.3%)	1/4 (25%)	1/6 (16.7%)		0

Table 5: Univariate and multivariate regression analysis of the success of NIV in ICU

	Univariate regression analysis		multivariate regression analysis	
	95% CI Exp (B)	P value	95% CI Exp (B)	P value
Age	0.998[0.970-1.026]	0.889		
Gender	1.168[0.462-2.954]	0.744		
Height	0.961[0.907-1.019]	0.187		
Ideal body weight	0.973[0.923-1.026]	0.312		
Actual body weight	0.967[0.930-1.007]	0.101		

APACHEII		0.945[0.887-1.007]	0.081		
Reasons for NIV					
	AECOPD	0.533[0.155-1.834]	0.318		
	ARDS	0.386[0.041-3.610]	0.404		
	Cardiogenic Pulmonary Edema	1.317[0.471-3.686]	0.600		
	Sequential NIV	4.952[1.043-23.523]	0.044	6.271[1.238-31.769]	0.027
	Sepsis	0.611[0.037-10.104]	0.731		
Interface types					
	Face mask	0.846[0.246-2.913]	0.791		
	Nasal mask	0.878[0.336-2.289]	0.789		
	Nasal-mouth mask	4.041[0.465-35.127]	0.206		
	Sedation	1.651[0.664-4.107]	0.281		
	Analgesia	2.872[1.148-7.183]	0.024	3.433[1.291-9.128]	0.013
Blood gas analysis					
	PH	0.999[0.993-1.005]	0.761		
	HCO3	1.061[0.993-1.134]	0.080		
	Lac	0.555[0.344-0.895]	0.016		
	PaO2	1.010[0.998-1.022]	0.117		
	PaCO2	1.024[0.991-1.058]	0.157		
	PaO2/FiO2	1.007[1.002-1.011]	0.008	1.007[1.002-1.013]	0.012

APACHEII, acute physiology and chronic health evaluationII; NIV, noninvasive ventilation; ARDS, acute respiratory distress syndrome; ICU, intensive care unit; AECOPD, acute exacerbation of chronic obstructive pulmonary disease;

4.6. Outcome and Prognosis

Sixty-nine (66.3%) of patients had successfully withdrawn from NIV, 23 (22.2%) failed and needed intubation and 12 (11.5%) were died when undergoing NIV. At last 23 NIV patients died in ICU in our study period.

Further analysis according to the reasons of NIV, the successful NIV rate of ARDS was 58.8%, the congestive heart failure was 66.7%, the AECOPD was 78.9%, and the successful NIV rate of sequential NIV after extubation was 88.2% (Table 2).

Among 35 patients who failed NIV, 22 (62.9%) patients were due to hypoxemia, followed by airway secretions (8.6%), cardiac arrest (8.6 %), respiratory function increased (5.7%) and coma (5.7%).

5. Discussion

Our study represents the first prospective, observational study to describe clinical information of ICU patients with NIV in Mainland China, helping to increase understanding of NIV status in Chinese ICUs.

In the present study, NIV rate to ICU hospitalization was similar to that of Esteban et al. (4%) in 2004, but significantly lower than that of Esteban et al. (14%), which was conducted in 927 ICUs from 40 countries in 2010 [13]. And the proportion was also lower than that of Du Bin's study (5.7% vs. 12%), the first study to define patient characteristics of ICU patients of 22 ICUs in Mainland China. Our study period might be the reason for the low proportion, for AECOPD and cardiogenic pulmonary edema were the main reason for NIV, occurring frequently in autumn and winter, especially during the seasonal exchange [14,15]. In addition, the lower utilization rate of NIV in our study maybe was related to the inclusion criteria, lack of NIV knowledge, insufficient respiratory therapist training, and inadequate equipment [9,12]. In addition, according to the results of our study, BiPAP was the most common model of ICU noninvasive mechanical ventilation in China, which was similar to the ratio of 82 acute care hospitals in United States by Maheshwari et al [9].

ARDS was the main cause of NIV patients in our study, but its success rate was significantly lower than AECOPD and congestive heart failure patients. Our study period was not the high incidence time of AECOPD and congestive heart failure, which may be the reason of low proportion of NIV in AECOPD and congestive heart failure. It has been confirmed that NIV is a first-line treatment of AECOPD and congestive heart failure, but there is still controversy in patients with ARDS [16,17]. Some studies have demonstrated that the use of noninvasive ventilators in ALI/ARDS patients can reduce the risk of endotracheal intubation and improve oxygenation [18,19]. However, many other studies and meta-analyzes are contrary to the above results, and even increase the ALI/ARDS mortality [6,16,20-22]. The reason for NIV failure in ARDS may be due to the need for higher levels of PEEP. Because at high PEEP, face mask intolerance and air leak can impede effective oxygen-

ation, then increase NIV failure [23]. Helmet interface-a transparent hood gave another choice for NIV interface, which provided for delivery of higher airway pressure without substantial air leak. Among patients with ARDS, treatment with helmet NIV resulted in a significant reduction of intubation rates, and also a statistically significant reduction in 90-day mortality with helmet NIV. Helium may be another option for noninvasive mechanical ventilation in ARDS patients.

NIV failure may be related to the severity of the disease, oxygenation and other factors. Our study showed a significant higher APACHE II score and lower PaO2/FiO2 in the NIV failed group. This result is similar to Esteban's study. In Esteban's study, patients who failed non-status positive pressure ventilation had significantly higher SAPS II scores than successful patients [13]. NIV failure patients who even if accepted tracheal intubation, the mortality rate of whom would be significantly higher than the direct tracheal intubation [13,24-26]. There are several possible explanations. First, failure of non-invasive positive pressure ventilation could identify patients who are difficult to ventilate or who have a higher severity of illness, as shown in our study. Second, in hypoxemic patients, keep using NIV and thus delaying invasive ventilation may expose the patients to the effects on an increased trans pulmonary pressure namely the sum of the pressure applied to the airway by the ventilator and the pleural pressure generated by the patient's spontaneous effort [27,28]. The pressure may generate high tidal volumes higher than those considered safe for lung. Third, during NIV, the level of PEEP may be not sufficient to recruit consolidated dependent lung areas [29]. Another explanation is that failing NIV is in itself harmful, and that delayed recognition of failure may exacerbate this harm [27].

Analgesia was the protective factor for successful NIV. Almost ICU patients were all undergoing varying degrees of pain, agitation and other discomfort [30], which lead to prolonged ICU stay and increased mortality [31]. The concept of "eCASH" was proposed by the European association for critical care medicine to establish optimal patient comfort, which advocate flexible multimodal analgesia to relieve the pain effectively as the first priority [32]. Because of Patients with NIV experienced mask-related pain and expressed as "I had the feeling that I was trapped" [33], analgesia was necessary for NIV patients to relieve pain and facilitate the successful implementation of the NIV.

The present study had also several limitations. First, the use of a convenience sample of ICUs in our study may have resulted in some bias, as only units with research interests were preferentially chosen. But ICUs in our study were almost university affiliated hospitals, so we think the result can represent the status of Chinese ICU patients with NIV to a certain extent. Second, the time for study period was arbitrarily decided, which may underestimate the NIV proportion of ICU patients.

6. Conclusions

In summary, this prospective, multicenter observational study showed that the characteristics of critically ill patients in ICUs with NIV in Mainland China exhibited a different to those of Western countries. The proportion of NIV in ICU patients was lower. ARDS was the main cause of NIV. And analgesia was a protective factor for NIV. Our findings might be helpful for future collaborative research.

7. Author Contributions

Conceptualization: ZWG, LL; methodology: YY, HBQ; software: LL, ZWG; validation: LL, investigation: ZWG, FJX, MQL, XWM, YRW, GCL, WS, XW, QG, RQZ, HSZ, DA, GLC, YSW, KC, JGL; writing—original draft preparation, ZWG; writing—review and editing, LL; supervision: LL, All authors have read and agreed to the published version of the manuscript.

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