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Comparative Study between Invasive and Non-invasive Mechanical Ventilation in Management of Patients with Mild Acute Respiratory Distress Syndrome

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Abstract: Background: Acute respiratory distress syndrome (ARDS) is a major cause of acute respiratory failure and it is associated with high mortality and morbidity. **Aim of the Work: T**o evaluate whether using noninvasive mechanical ventilation can achieve a good improvement in patients with mild (ARDS) compared to those treated with endotracheal intubation and invasive mechanical ventilation. **Patients and Methods:** This prospective randomized control clinical trial was conducted on 40 males (66.6 %) and 20 females (33.3%) admitted to ICU units of Abu-Qir specialized hospital for Six months. Group 1 included 18 males (60%) and 12 females (40%), and group 2 included 22 males (73.3%) and 8 females (26.7%). **Results:** There was a significant difference between the two groups according to the outcome with success rate of (93.3 %) for group 1 versus success rate of (73.3%) for group 2 with (p =0.038). In group (1) the PH ranged from (7.01-7.56) and in group (2) the PH ranged from (7.20-7.59) and the only significant difference between the two groups was during the zero hour. There were 8 cases who failed to improve in group 2, four of them had metabolic acidosis with PH ≤7.30 and other 2 cases had compensated metabolic acidosis. Also in our current study we found that younger ages have higher response to treatment and success rate in both groups compared to older ages, as the mean age for patients who failed to improve in group 1 was 69 which was higher than those who improved in the same group where the mean age was 56, also the mean age of patients who failed to improve in group 2 was 66 which was higher than the mean age (45) of patients who improved in the same group. Till the present day it is well established that invasive mechanical ventilation remains the standard treatment option in management of ARDS especially in moderate to severe cases, however, non-invasive mechanical ventilation may play a significant role in management of selected mild cases in addition to avoidance of endotracheal intubation with its usual problems and risks. **Conclusion:** Noninvasive mechanical ventilation can be a treatment option for patients with mild (ARDS) and may even be the first choice of treatment provided that patients are closely monitored for signs of improvement during the first few hours. However, patients with mild (ARDS) who are older or with metabolic acidosis respond much less to (NIV). No doubt that further studies are needed for more evaluation with larger sample size and longer follow up.
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Key words: mechanical ventilation, mild Acute respiratory distress syndrome

1. Introduction

Acute respiratory distress syndrome (ARDS) is a major cause of acute respiratory failure and it is associated with high mortality and morbidity [(1)].

A range of physical methods for the general treatment of respiratory diseases is available. Among these methods, noninvasive ventilation (NIV) is a widely accepted treatment that has been used for diseases suchchronic obstructive pulmonary disease exacerbation and cardiogenic pulmonary edema for more than 2 decades [(2)].

The advantages of NIV include not requiring for endotracheal intubation, which lowers the risk of ventilator-associated pneumonia, a shorter intensive care unit (ICU) length of stay, and decreased hospitalization costs [(3)].

However, the use of (NIV) for the treatment of (ARDS) is somewhat controversial. A meta-analysis to assess the percentage of (ARDS) patients who were treated with (NIV) and required endotracheal intubation between 1995 and 2009, as well as the mortality rate of these patients is conducted by Agarwal and co-workers who found that approximately 50% of the (ARDS) patients treated with (NIV) were spared from endotracheal intubation. Therefore, (NIV) can be used in selected patients, especially those presenting mild to moderate (ARDS) [(4)].

However, some studies have indicated that once (NIV) fails, the prognosis becomes worse. Thus, the timing of subsequent invasive ventilation (IV) may be critical [5].

Aim of the Work

The aim of the present study is to evaluate whether using noninvasive mechanical ventilation can achieve a good improvement in patients with mild (ARDS) compared to those treated with endotracheal intubation and invasive mechanical ventilation.

2. Patients and Methods

A prospective Randomized control clinical trial was conducted on a total of 60 patients admitted to ICU units of Abu-Qir specialized hospital for Six months. The study included patients either admitted to critical care department of Abu-Qir specialized hospital with mild acute respiratory distress syndrome ARDS or developed it during the stay, the patients were randomly allocated into two groups [group1 and group 2].

Patients included in the study had ages more than 18 years old, diagnosis of early (mild) ARDS requires all of the following: Timing: Within 1 week of a known clinical insult or new or worsening respiratory symptoms. Oxygenation: Mild: PaO2/FiO2 <300 and >200 with positive end expiratory pressure (PEEP) or continuous positive airway pressure (CPAP) ≥5 cmH2OChest imaging: Bilateral infiltrates seen on frontal chest radiograph – not fully explained by effusions, lobar/lung collage, or nodules. Origin of edema: Respiratory failure not fully explained by cardiac failure or fluid overload confirmed by echocardiography.

While Pregnant female, immunosuppressant patients, severe chronic liver disease (class B, C child-paugh score) and renal impairment (creatinine clearance less than 50 ml/ min), moderate and severe ARDS (Po2/Fio2 <200), hypotension and shock state (BP less than 90/60 mmHg), no other requirement for emergency intubation and APACHE II score more than 20 were excluded from the study.

Patients were divided into two groups: Group 1: (control group) patients who were diagnosed with mild ARDS received the main lines of the treatment in the form of treatment of the underlying cause, ventilatory management using endotracheal intubation and invasive mechanical ventilation with protective lung strategy. Group 2: (group ventilated using noninvasive ventilation CPAP mode (patients who were diagnosed with mild ARDS received the main lines of the treatment in the form of treatment of the underlying cause, ventilatory management using noninvasive ventilation at CPAP mode delivering ventilation to the patient via CPAP mask.

Informed consent was taken from patient legal guardianship.

Study procedure:

Patients who were diagnosed with mild ARDS with the following criteria:

Acute onset, bilateral infiltration of both lungs not fully explained by cardiac failure or volume overload, Po2/Fio2 <300 and >200; were included in this prospective randomized clinical trial and was grouped into two groups, group 1 and group 2.

Group 1(control group): patients who was diagnosed with mild ARDS received the main lines of the treatment in the form of treatment of the underlying cause, ventilatory management using endotracheal intubation and invasive mechanical ventilation with protective lung strategy.

Group 2: patients who were diagnosed with mild ARDS received the main lines of the treatment in the form of treatment of the underlying cause, ventilatory management using noninvasive ventilation at CPAP mode delivering ventilation to the patient via CPAP mask. the duration of using NIV on patients of group 2 continued for 3 hours during which ABG (regarding ph,pco2,Hco3), heart rate, hypoxemic index, and respiratory rate was closely monitored and recorded hourly on basis of (zero,1st,2nd and 3rd hour). If there is an indication for endotracheal intubation during the 1st 3 hours or failure to improve by the end of that period so shifting to intubation and invasive ventilation was done.

If good improvement is recorded during the 1st 3 hours of NIV regarding hypoxemic index, respiratory parameters and hemodynamics, so the NIV was continued till successful weaning from noninvasive ventilation after achievement of good success.

Signs of good success was in the form of improvement of respiratory rate of <24 breaths/min, heart rate <110 beats/min, compensated pH >7.35, and SpO_2 >90% on FiO_2 <4 l/min [6].

Criteria of weaning from noninvasive mechanical ventilation are arterial pH ≥ 7.35, hypoxemic index above 300, respiratory rate ≤ 25 / min, heart rate ≤ 110 / min, systolic blood pressure ≥ 90 mmHg and no signs of respiratory distress like agitation, diaphoresis or anxiety, and the weaning was done with stepwise reduction protocol [7].

Criteria for intubation of patients using noninvasive ventilation: [8]. Respiratory arrest, Loss of consciousness with respiratory pauses, Psychomotor agitation requiring sedation, Heart rate less than 50 bpm with loss of alertness, Hemodynamic instability with systolic blood pressure less than 70mmHg, Signs of failure to improve in group 2: [8]. Respiratory rate greater than 35 breaths/minute, pH less than 7.25 and decreased from onset, PaO2 less than 45 mm Hg despite oxygen, Increase in encephalopathy or decreased level of consciousness.

3. Results

In group 1 age of patients ranged from (38-78) years (mean 56.33 ± 11.29), and in group 2 the age of patients ranged from (20-74) years (mean 50.83 ± 13.76). There was no significant difference between the ages of the patients of the two groups as in table (1).

Relation between age and outcome in both groups. There was no significant difference in age between patients who improved (mean55.43 ± 11.14) and those who failed to improve (mean 69.0 ± 0.0) in group (1), however, there was a significant difference in age between patients who improved (mean 44.86 ± 10.64) and those who failed to improve (mean 67.25 ± 4.95) in group 2 ($p<0.001$). table (2).

Comparison between the two studied groups according to the PH and Pco2, and comparison between the different periods according to the PH and Pco2, and there was a significant difference between the two groups according to the PH during the zero hour which was higher in group 2 (=0.044), and there were significant differences between the two groups according to the Pco2 during the zero ($p<0.001$), 1st ($p<0.001$), 2nd ($p<0.001$) and 3rd ($p =0.005$) hour which were higher in group 2. table (3)

Table (1): Comparison between the two studied groups according to demographic data

	Group I (n = 30)		Group II (n = 30)		Test of Sig.	p
	No.	%	No.	%		
Sex						
Male	18	60.0	22	73.3	χ^2=	0.273
Female	12	40.0	8	26.7	1.200	
Age (years)						
Min. – Max.	38.0 – 78.0		20.0 – 74.0		t=	0.096
Mean ± SD.	56.33 ± 11.29		50.83 ± 13.76		1.693	

Table (2): Relation between outcome and age in each group

Age (years)	Outcome		t	p
	Failure	Success		
Group I (n = 30)	**(n = 2)**	**(n = 28)**		
Min. – Max.	69.0 – 69.0	38.0 – 78.0	1.694	0.101
Mean ± SD.	69.0 ± 0.0	55.43 ± 11.14		
Group II (n = 30)	**(n = 8)**	**(n = 22)**		
Min. – Max.	59.0 – 74.0	20.0 – 60.0	5.684*	<0.001*
Mean ± SD.	67.25 ± 4.95	44.86 ± 10.64		

Table (3): Comparison between the two studied groups according to PH and PCO_2

		Group I (n = 30)	Group II (n = 30)	t	p
PH	**Zero hour**				
	Min. – Max.	7.01 – 7.54	7.20 – 7.59	2.061*	0.044*
	Mean ± SD.	7.36 ± 0.13	7.42 ± 0.09		
	1st hour				
	Min. – Max.	7.04 – 7.54	7.22 – 7.59	1.817	0.074
	Mean ± SD.	7.37 ± 0.12	7.42 ± 0.09		
	2nd hour				
	Min. – Max.	7.10 – 7.55	7.21 – 7.55	1.299	0.199
	Mean ± SD.	7.38 ± 0.11	7.42 ± 0.09		
	3rd hour				
	Min. – Max.	7.16 – 7.56	7.20 – 7.55	0.121	0.904
	Mean ± SD.	7.40 ±0.09	7.41 ± 0.10		
PCO_2	**Zero hour**				
	Min. – Max.	15.0 – 39.0	21.0 – 50.90	4.201*	<0.001*
	Mean ± SD.	27.99 ± 5.46	35.25 ± 7.73		
	1st hour				
	Min. – Max.	15.0 – 36.0	20.0 – 49.30	4.598*	<0.001*
	Mean ± SD.	27.11 ± 4.66	34.11 ± 6.93		
	2nd hour				
	Min. – Max.	17.0 – 37.0	22.0 – 49.10	4.261*	<0.001*
	Mean ± SD.	26.93 ± 4.05	32.81 ± 6.39		
	3rd hour				
	Min. – Max.	17.0 – 35.0	20.0 – 48.80	2.949*	0.005*
	Mean ± SD.	27.40 ± 4.22	31.65 ± 6.67		

Comparison between the two studied groups according to the HCO3 and the SPO2 and comparison between the different periods according to the HCO3 and the SPO2, And there were significant differences between the two groups according to the HCO3 during zero (p<0.001), 1st (p=0.001), 2nd (p=0.006) hour which were higher in the group 2. There was only significant difference between the 2 groups according to the SPO2 during zero hour (p=0.28) which were higher in group 2. table (4).

Comparison between the two studied groups and between the different periods according to the hypoxemic index, and there were significant differences between the two groups in zero (p=0.048) which was higher in group 2 and in 3rd (p=0.001) hour which was higher in group1. table (5),

Table (4): Comparison between the two studied groups according to HCO_3 and SPO2 %

		Group I (n = 30)	Group II (n = 30)	t	p
HCO_3	**Zero hour** Min. – Max. Mean ± SD.	 9.50 – 25.90 17.65 ± 3.83	 12.10 – 33.60 22.64 ± 5.33	4.167*	<0.001*
	1st hour Min. – Max. Mean ± SD.	 10.10 – 26.0 18.41 ± 3.57	 12.0 – 33.50 22.38 ± 5.20	3.447*	0.001*
	2nd hour Min. – Max. Mean ± SD.	 11.20 – 26.50 19.35 ± 3.38	 11.90 – 35.20 22.75 ± 5.53	2.870*	0.006*
	3rd hour Min. – Max. Mean ± SD.	 10.90 –27.0 20.32 ± 3.36	 11.50 – 35.0 22.76 ± 5.79	2.00	0.051
SPO2 %	**Zero hour** Min. – Max. Mean ± SD.	 90.0 – 97.0 94.03 ± 1.50	 89.0 – 98.0 95.04 ± 1.94	2.253*	0.028*
	1st hour Min. – Max. Mean ± SD.	 92.0 – 98.0 95.27 ± 1.53	 90.0 – 98.0 95.64 ± 1.82	0.859	0.394
	2nd hour Min. – Max. Mean ± SD.	 91.0 – 98.0 96.13 ± 1.70	 90.0 – 98.0 95.83 ± 1.91	0.643	0.523
	3rd hour Min. – Max. Mean ± SD.	 91.0 – 99.0 96.77 ± 1.83	 90.0 – 99.0 96.05 ± 2.24	1.357	0.180

Table (5): Comparison between the two studied groups according to hypoxemic index (HI)

Hypoxemic index	Group I (n = 30)	Group II (n = 30)	t	p
Zero hour Min. – Max. Mean ± SD.	 201.0 – 290.0 235.1 ± 19.52	 206.0 – 293.0 248.4 ± 30.25	2.023*	0.048*
1st hour Min. – Max. Mean ± SD.	 220.0 – 301.0 262.1 ± 15.19	 216.0 – 301.0 262.0 ± 24.11	0.026	0.980
2nd hour Min. – Max. Mean ± SD.	 226.0 – 310.0 285.0 ± 17.59	 210.0 – 310.0 277.8 ± 23.06	1.353	0.181
3rd hour Min. – Max. Mean ± SD.	 239.0 – 366.0 325.3 ± 30.24	 200.0 – 326.0 295.1 ± 34.35	3.610*	0.001*

Comparison between the two studied groups according to the blood pressure, and there was no significant difference between the two groups. table (6),

Comparison between the two studied groups according the heart rate (HR) and respiratory rate (RR), and there were significant differences between the two groups according to the (HR) in the zero hour (p=0.018) and 3rd hour (p=0.021) which was higher in group 1 during the zero hour and higher in group 2 in the 3rd hour, however there was only significant difference between the two groups according to the

(RR) during the zero hour ($p < 0.001$) which were higher in group 1. table (7).

Table (6): Comparison between the two studied groups according to blood pressure

	Blood pressure	Group I (n = 30)	Group II (n = 30)	t	p
Systolic	**Zero hour** Min. – Max. Mean ± SD.	 100.0 – 160.0 119.7 ± 16.50	 100.0 – 160.0 125.0 ± 17.76	1.205	0.233
	1st hour Min. – Max. Mean ± SD.	 90.0 – 140.0 113.7 ± 15.86	 100.0 – 150.0 119.0 ± 16.05	1.295	0.201
	2nd hour Min. – Max. Mean ± SD.	 90.0 – 130.0 110.7 ± 11.72	 90.0 – 150.0 113.7 ± 14.50	0.881	0.382
	3rd hour Min. – Max. Mean ± SD.	 80.0 – 120.0 106.7 ± 9.59	 80.0 – 140.0 109.7 ± 14.74	0.935	0.354
Diastolic	**Zero hour** Min. – Max. Mean ± SD.	 60.0 – 100.0 77.67 ± 12.23	 60.0 – 100.0 80.33 ± 12.17	0.847	0.401
	1st hour Min. – Max. Mean ± SD.	 60.0 – 90.0 74.0 ± 11.63	 60.0 – 100.0 77.33 ± 9.80	1.201	0.235
	2nd hour Min. – Max. Mean ± SD.	 60.0 – 90.0 73.33 ± 10.61	 60.0 – 90.0 73.67 ± 8.90	0.132	0.896
	3rd hour Min. – Max. Mean ± SD.	 50.0 – 90.0 70.33 ± 8.50	 50.0 – 100.0 71.67 ± 10.53	0.540	0.592

t: Student t-test
p: p value for comparing between the studied groups

Table (7): Comparison between the two studied groups according to vital sings "clinical"

	Vital sings "clinical"	Group I (n = 30)	Group II (n = 30)	t	p
HR	**Zero hour** Min. – Max. Mean ± SD.	 100.0 – 125.0 111.9 ± 5.22	 90.0 – 120.0 107.8 ± 7.59	2.439*	0.018*
	1st hour Min. – Max. Mean ± SD.	 85.0 – 125.0 103.8 ± 7.65	 89.0 – 119.0 105.6 ± 8.76	0.848	0.400
	2nd hour Min. – Max. Mean ± SD.	 87.0 – 121.0 97.67 ± 7.80	 83.0 – 121.0 102.5 ± 10.85	1.981	0.053
	3rd hour Min. – Max. Mean ± SD.	 83.0 – 122.0 93.27 ± 8.64	 83.0 – 120.0 99.73 ± 12.06	2.388*	0.021*
RR	**Zero hour** Min. – Max. Mean ± SD.	 28.0 – 35.0 30.33 ± 2.26	 25.0 – 30.0 27.50 ± 1.43	5.792*	<0.001*
	1st hour Min. – Max. Mean ± SD.	 23.0 – 33.0 26.43 ± 2.13	 24.0 – 32.0 26.43 ± 1.92	0.00	1.000
	2nd hour Min. – Max. Mean ± SD.	 20.0 – 34.0 24.10 ± 3.04	 22.0 – 33.0 25.27 ± 2.92	1.514	0.135
	3rd hour Min. – Max. Mean ± SD.	 18.0 – 35.0 22.20 ± 4.19	 20.0 – 35.0 24.03 ± 4.16	1.700	0.094

t: Student t-test
p: p value for comparing between the studied groups
*: Statistically significant at $p \leq 0.05$

Comparison between the two groups according to the outcome and there was a significant difference between the two groups according to the outcome with success rate of (93.3 %) for group 1 versus success rate of (73.3%) for group 2 with (p =0.038). table (8).

Causes of failure in the current study:

We have only 2 patients who failed to improve in group 1 due to persistent hypoxia, tachypnea and tachycardia.

Also 8 cases in group 2 failed to improve, 4 of them had progressive metabolic acidosis and 2 patients had refractory hypoxia and tachycardia with compensated metabolic acidosis, one patient had hypotension and one had disturbed level of consciousness.

Table (8): Comparison between the two studied groups according to outcome

Outcome	Group I (n = 30)		Group II (n = 30)		χ^2	p
	No.	%	No.	%		
Failure	2	6.7	8	26.7	4.320*	0.038*
Success	28	93.3	22	73.3		

χ^2: **Chi square test**

p: p value for comparing between the studied groups

*: Statistically significant at $p \leq 0.05$

Discussion

In the current study Sixty adult ICU patients paticipiated, they were divided into 2 groups, group (1) was indicated to receive invasive mechanical ventilation after endotracheal intubation, and group (2) was indicated to receive non- invasive mechanical ventilation to evaluate the use of noninvasive mechanical ventilation in management of patients with mild (ARDS) and we found that success rate in patients managed using noninvasive mechanical ventilation (group2) was (73.3%) compared with success rate of (93.3 %) in (group 1)

Noninvasive ventilation (NIV) is a well-established treatment for acute respiratory failure, especially in patients with hypercapnia and cardiogenic pulmonary edema [(9)].

Conversely, the use of NIV for hypoxemic respiratory failure, including the acute respiratory distress syndrome (ARDS), is still controversial [(4)].

Group (1) included 18 males and 12 females and group (2) 22 males and 8 females.

In group (1) the age of patients ranged from (38-78) years with (mean 56 ± 11), and in group (2) the age of patients ranged from (20-74) with (mean 50 ± 13). There was no significant difference between the ages of the two groups. However, in the current study we found that younger ages have higher response to treatment and success rate in both groups compared to older ages, as the mean age for patients who failed to improve in group 1 was 69 which was higher than those who improved in the same group where the mean age was 55, also the mean age of patients who failed to improve in group 2 was 67which was higher than the mean age (44) of patients who improved in the same group. table (5).

El-Haddad H et al. [(10)] studied the effect of age on the outcome of patients with ARDS and found that higher ages in patients with ARDS are related to worse outcome.

Factors associated with age that may explain worse outcomes include a reduction in respiratory function due to decline in chest wall compliance, respiratory muscle strength, and diminished response to hypoxia and hypercapnia. Other factors include comorbid illnesses, increased risk of pulmonary infections and delayed tissue repair following an inflammatory injury [(11)].

In the current study, group (1), the PH ranged from (7.01-7.56) and in group (2) the PH ranged from (7.20-7.59) and the only significant difference between the two groups was during the zero hour (the hour of admission before applying mechanical ventilation).

There were 8 cases who failed to improve in group 2, four of them had metabolic acidosis with PH ≤7.30 and other 2 cases had compensated metabolic acidosis.

Mas et al. [(12)] explored the signs that predict failure of using of noninvasive ventilation in acute respiratory failure and ARDS; and considered that metabolic acidosis especially with PH≤7.25 may be a predictive sign of failure in patients treated with noninvasive mechanical ventilation, and this agree with data found in the present study.

Also according to **Duan et al.** [(13)] acidosis and PH <7.35 is considered a predictive sign of failure of noninvasive mechanical ventilation in patients with hypoxemia, similarly we found in the present study that acidosis is a predictive sign of failure of (NIV).

In the current study only 2 of 30 patients of (group 1) failed to improve during the 1st 3 hours and

their condition got worse and needed more aggressive ventilator support and sedation, while 28 got improved with success rate 93.3%, whereas in the (group 2) 8 of 30 patients failed to improve and success was recorded in 22 patients with success rate of73.3 %.

According to a controlled cohort study of **Irfan et al. [14].** Twenty ARDS patients were assessed for the efficacy of non-invasive positive pressure ventilation in ARDS. The twenty patients were divided into two groups: a "standard medical therapy group" and a "NIV group". Of the 20 patients, the mean APACHE II score was 18.7 and the mean PaO2/FiO2 ratio was 106.6 mmHg, in that study Seven ARDS patients deceased (35% mortality), three from the NIV group and four from the standard therapy group; noninvasive mechanical ventilation was successful in four of the seven patients (57%), and the other three required intubations for need of high O2 requirement, change in mental status or intolerants of NIV.

The difference between the two studies is that in current study the success rate was higher 73.3 % versus 54 % in that study, and this is because in current study the tested population were chosen to be mild cases of ARDS with PaO2/FiO2 ratio ≥200, also we excluded patients with APACHE II score > 20 unlike their study where patients with moderate to severe ARDS were included withmean PaO2/FiO2 ratio 106 and the mean APACHE II score 18.7, also in the current study number of patients was 30 in each group versus only 10 patients in the other study.

In a study **Rocker et al. [15]** done at a university hospital in 1999 on 10 patients involving patients with cases of mild ARDS, the median APACHE II score was 16, the mortality rate was 30%, the NIV success rate was 66% and the mean ventilation time was 64 hours.

And the final conclusion of that in a group of hemodynamically stable patients with ALI (mild ARDS), NIV had a high success rate. NIV should be considered as a treatment option for patients in stable condition in the early phase of ALI/ARDS; similarly, in the current study we found that NIV can be first choice of treatment in mild cases of ARDS, though in the current study the success rate was higher (73.3 %), then the difference of the study conducted by **Rocker et al. [15]** than the current study may be as the mean time of ventilation with NIV was prolonged to 64.5 h whereas in the current study we put a strict citeria for success in the 1st3 hours and beyond this period NIV is stopped and shifting to invasive ventilation is done if success not fulfilled as the delay of intubation may be associated with worse prognosis.

In another study **Antonelli et al**. [16] a Prospective, multiple-center cohort study was done in three European intensive care units to assess if NIV can be first-line intervention for acute respiratory distress syndrome, 479 patients with ARDS were admitted to the intensive care units. Three hundred and thirty-two ARDS patients were already intubated, so 147 were eligible for the study.

Their study found that NIV improved gas exchange and avoided intubation in 79 patients (54%). Avoidance of intubation was associated with less ventilator-associated pneumonia (2% vs. 20%; p <.001) and a lower intensive care unit mortality rate (6% vs. 53%; p <.001) [16].

Also that study found that Intubation was more likely in patients who were older, and a Pao2/Fio2 < or =175 after 1 hr of NIV was independently associated with NIV failure and need for endotracheal intubation [16].

The findings of that study agree with the current study in submitting NIV as a good choice in treatment of ARDS especially in mild cases and predicting its failure with higher ages and hypoxemic index less than 200, however in the current study we have higher success rate (73.3% versus 54%) and this is because we excluded patients with hypoxemic index less than 200.

According to **Domenighetti et al.** [17] an Observational case-control study of non-invasive ventilation in patients with ARDS was done to compare the outcome of NIV-treated patients with diagnostic criteria for primary (pulmonary) ARDS and presenting without distant organ failures at admission, with those of a matched control group treated in the same ICU with endotracheal mechanical ventilation (ETMV), in that study NIV was applied to 12 immunocompetent and collaborative patients who met the above mentioned criteria, NIV failure rate, short-term oxygenation, length of stay, mortality rate and complications were analyzed and compared with a control group of 12 intubated ARDS patients matched for age, PaO2/FiO2 and pH at admission.

In that study only 4 patients of NIV group failed to improve with success rate of (66%) and Compared to the control group, NIV success patients had reduced cumulative time on ventilation (p = 0.001) and length of ICU stay (p = 0.004). The overall ICU mortality rate did not differ significantly between the groups but tended to be higher in the NIV group. [17]

In that study they found that In ARDS patients without organ failures at admission and during the disease course, NIV might be a suitable alternative to invasive ventilation. [17]

However in the current study better results were recorded with success rate of (73%) and this is because only mild cases were included in our study and patients with organ failure were excluded.

Another different study of **Bellani et al.** [18] to assess the impact on NIV on outcome of patients with ARDS compared to invasive ventilation in view of

categorization of ARDS severity based on the PaO2/FiO2 Berlin criteria. Of 2,813 patients with ARDS, 436 (15.5%) were managed with NIV on Days 1 and 2 following fulfillment of diagnostic criteria, and it was found that Classification of ARDS severity based on Pa_{O2}/Fi_{O2} ratio was associated with an increase in intensity of ventilatory support, NIV failure, and intensive care unit (ICU) mortality. NIV failure occurred in 22.2% of mild, 42.3% of moderate, and 47.1% of patients with severe ARDS. And the study concluded that irrespective of severity category, NIV seems to be associated with higher failure rate and ICU mortality in patients with a Pa_{O2}/Fi_{O2} lower than 150 mm Hg.

We can explain the disagreement between both studies regarding failure rate by that they included different categories of ARDS patients mild, moderate and severe so many patients with hypoxemic index less than 200 had high probability of failure, however in the current study only mild cases with better condition were included.

Conclusions

Noninvasive mechanical ventilation can be a treatment option for patients with mild (ARDS) and may even be the first choice of treatment provided that patients are closely monitored for signs of improvement during the first few hours. However, patients with mild (ARDS) who are older or with metabolic acidosis respond much less to (NIV).

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