

Conventional Vs Non Invasive Ventilation In Acute Respiratory Failure.

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Abstract: Treatment of patients with acute respiratory failure (ARF) often involves mechanical ventilation via endotracheal intubation. Non-invasive positive pressure ventilation (NIV) using Bi-level positive airway pressure (BiPAP) can be a safe and effective means of improving gas exchange. The aim of the present study is to: 1) Assess non-invasive positive pressure ventilation (BiPAP) as an alternative way for ventilation in ARF, and to 2) Determine factors that can predict the successful use of BiPAP. Thirty patients with acute respiratory failure (both type I and II) were enrolled in the study and divided into two groups. Group I included 10 patients who were subjected to invasive mechanical ventilation. Group II included 20 patients were subjected to NIV using BiPAP. Both groups were compared regarding the following parameters: *arterial blood gases (ABG)* on admission, 30 minutes after beginning of mechanical ventilation, 1 ½ hour then once daily. *Complications* namely ventilator associated pneumonia (VAP), skin necrosis and CO₂ narcosis; *static compliance and resistance* were measured at day one and day two. Compared to group I, group II patients were associated with similar improvement in ABGs data at 30 minutes and at discontinuation of ventilation (Table 1). Group II patients showed significantly lower incidence in VAP (20% vs 80%), shorter duration of mechanical ventilation (3±3 vs 6±5 days, P = 0.006), with shorter length of hospital stay (5.8±3.6 vs 8.9±2.7 days, P= 0.011) when compared to group I. Skin necrosis (50%) and CO₂ narcosis (20%) occurred in group II only. Group II patients showed significant difference change in compliance and change in resistance from day I to day II when compared to group I. (Table 2) On univariate basis, parameters were analyzed to choose those who were associated with outcome in concern (successful NIV). The following parameters were identified: Level of consciousness, pH (7.3±0.03 vs 7.26±0.1, P=0.009) PCO₂ (69.16±13.14 vs 100.97±12.04) on admission, 1 ½ hour after NIV, pH (7.37±0.03 vs 7.31±0.17, P = 0.005), PCO₂ (53.98±8.95 vs 77.47±5.22, P = 0.0001) in whom NIV succeeded and failed respectively. Then multivariate analysis utilizing two different techniques namely (multivariate logistic regression and discriminate analysis) was used. The variable identified was PCO₂ after 1½ hour in the two models with specificity 100%. In patients with acute respiratory failure, non-invasive ventilation was as effective as conventional ventilation in improving gas exchange, associated with fewer serious complications and shorter stay in intensive care. One and half hour trial with NIV can predict success with BiPAP, as shown by an improvement in pH and PCO₂ and overall clinical picture. PCO₂ after 1½ hour could be the sole predictor of successful NIV with 100% specificity.

Key words: Non invasive ventilation (NIV), Invasive ventilation (INV), Bi-level positive airway pressure (BIPAP)

Table 1:

Variable	½ An hour			Discontinuation of Ventilation		
	Invasive N=10	Non-invasive N=20	P-value	Invasive N=10	Non-invasive N=16	P-value
pH	7.31±0.02	7.33±0.03	0.207	7.42±0.04	7.42±0.03	0.799
PCO ₂	65.55±12.68	65.71±13.29	0.975	51.34±7.22	50.21±5.99	0.672
PO ₂	93.8±6.41	95.04±28.77	0.895	67.25±9.13	68.96±11.38	0.692
SO ₂	95.50±0.97	94.00±5.81	0.428	92.38±2.51	93.5±2.78	0.311
PO ₂ /FIO ₂	184.92±19.96	198.94±14.04	0.500	321.27±43.89	327.83±57.35	0.760

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Table 2:

	Invasive		P-value	Non-Invasive		P-value
	Day I	Day II		Day I	Day II	
Compliance	38.92±11.59	48.55±7.63	0.0001	49.85±8.48	66.93±8.04	0.0001
Resistance	16.140±6.27	11.00±2.49	0.0001	9.75±3.61	3.12±1.40	0.0001

INTRODUCTION

Patients presenting to the intensive care with acute respiratory failure (ARF): either severe hypoxaemic (type I) or hypercapnic (type II) respiratory failure frequently require some form of assisted ventilation. In the past, intubation and invasive mechanical ventilation via endotracheal intubation was the treatment of choice (Meduri, 1996). Treatment is directed toward correcting the pathophysiology of ARF, reducing work of breathing and ameliorating Dyspnea. Noninvasive ventilation (NIV) has emerged as another modality of assisted ventilation. It includes various techniques of augmenting alveolar ventilation without an endotracheal airway. NIV has been used successfully to treat acute respiratory failure in postoperative patients, in those with pulmonary edema, COPD and obstructive sleep apnea. It has also been used to facilitate weaning (Brochard, *et al.*, 1995). However, NIV appears to be particularly effective in patients with an exacerbation of COPD, who are alert and cooperative. Up to our knowledge the comparison of both ventilatory techniques was not assessed in the context of acute respiratory failure. The aim of the present study was to:

- * Assess the use of non-invasive ventilation (using BiPAP) as an alternative way for ventilation in acute respiratory failure.
- * Determine factors that can predict the successful use of BIPAP.
- * Evaluate factors hindering success of BIPAP.

Patients:

Our study included 30 patients admitted to the Critical Care Department of Cairo University Hospitals during a 2 years period (October 2002 to October 2004), with respiratory failure (both type I and type II) who needed mechanical ventilatory support.

Inclusion Criteria:

- Patients with acute exacerbations of chronic obstructive pulmonary disease and hypercapnic respiratory failure,
- Patients with acute pulmonary edema (cardiogenic & non- cardiogenic).
- Severe Dyspnea at rest, respiratory rate ≥ 30 bpm,
- PaCO₂ > 50 mmHg, with PH < 7.30 in hypercapnic respiratory failure,
- Arterial hypoxemia PaO₂ ≤ 65 mmHg, with SaO₂ $\leq 90\%$,
- Active contraction of the accessory respiratory muscles or paradoxical abdominal motion.

Exclusion Criteria:

- Facial surgery, trauma or deformity.
- Cardiac or respiratory arrest.
- Inability to cooperate.
- Presence of upper airway obstruction.
- Hypotension (systolic BP <90 mmHg).
- Uncontrolled arrhythmia.
- Severe upper gastrointestinal bleeding.
- Inability to clear respiratory secretions with high risk for aspiration and
- Other non-respiratory organ failure: e.g. Severe encephalopathy (e.g. GCS < 10)

Patients were randomly assigned to receive either conventional mechanical ventilation with endotracheal intubation (**Group I**) or non-invasive ventilation through a face mask (**Group II**).

Group I:

Included 10 Patients who were subjected to endotracheal intubation and mechanically Ventilated. Out of the 10 cases, 8 were males, with a mean age of 60.6±8.37 years. They included 9 patients with type II (hypercapnic) respiratory failure and 1 patient with type I (hypoxemic) respiratory failure.

Group II:

Included 20 patients who were subjected to NIV.

Out of the 20 cases, 12 (60%) were males and 8 (40%) were females, with a mean age of 58.70 ± 7.20 years. They included 17 patients (85%) with type II (hypercapnic) respiratory failure and 3 patients (15%) with type I (hypoxemic) respiratory failure.

Study Design:

All included patients were subjected to the following:

1. Detailed medical history: History of COPD, smoking, previous ICU admission with respiratory failure due to acute exacerbation of COPD and history of causes leading to acute pulmonary edema.
2. Clinical examination: Signs of acute respiratory failure: Dyspnea, respiratory rate > 30 bpm, cyanosis, flapping tremors, contraction of accessory muscles of respiration, paradoxical abdominal movement and CO_2 narcosis.
3. Plain chest x-ray, anteroposterior films.
4. Twelve lead electrocardiogram.
5. Central venous line via internal jugular vein or subclavian vein.
6. Arterial cannulation for frequent arterial blood gases sampling was carried out through radial artery.
7. Routine lab investigations including: Complete blood count, Random blood sugar, serum Na & K, serum creatinine, liver enzymes, serum albumin, coagulation profile, total & direct bilirubin.
8. Scoring system to assess the level of consciousness (LOC) as follows: 1, normal; 2, presence of flapping tremors; 3, confusion; and 4, stupor or coma.
9. The acute physiology and chronic health evaluation (APACHE III) score was calculated for each patient on admission.
10. The simplified acute physiologic score (SAPS II) was calculated on admission. This score takes into account 13 variables (age, heart rate, systolic blood pressure, body temperature, respiratory rate or need for ventilatory support, urinary output, white-cell count, hematocrit, Glasgow coma score, and serum glucose, potassium, sodium, bicarbonate, and urea nitrogen concentrations). A range of 0 to 4 is assigned for each variable (range of possible scores, 0 to 60).

Patients in both groups received the standard medical therapy

Ventilation Protocols:

Conventional Ventilation (group I):

Patients assigned to conventional-ventilation underwent intubation with cuffed endotracheal tubes (internal diameter: 7.5 to 8.5 mm). The initial ventilator setting was in the volume-control mode (CMV), with a delivered tidal volume of 8-10 ml per kilogram of body weight and a respiratory rate of 8-12 breaths per minute, a positive end-expiratory pressure of 5 cm of water, and an FIO_2 of 1. Positive end-expiratory pressure (PEEP) was increased in increments of 2 to 3 cm of water, until the FIO_2 requirement was 0.6 or less. All the patients initially received intravenous sedation and muscle relaxant. The head of the bed was kept elevated at an angle of 45 degrees to minimize the risk of aspiration.

When spontaneous breathing reappeared, the ventilator settings were changed to spontaneous ventilation (CPAP) with pressure support 14 to 20 cm of water, adjusted to achieve a spontaneous tidal volume of 8 to 10 ml per kilogram, a respiratory rate of fewer than 25 breaths per minute, and the disappearance of accessory-muscle activity.

All patients were weaned from the ventilator by reducing the level of pressure support by 4 cm of water and reducing level of CPAP at two-hour intervals, as tolerated.

Patients Were Extubated If They Achieve the Following:

- Continuous positive airway pressure (CPAP) zero,
- Pressure-support level of 8 cm of water,
- FIO_2 of 0.5 or less, and a PaO_2 greater than 75 mm Hg and
- Maintenance of respiratory rate lower than 25 breaths per minute.

Non-invasive Ventilation (Group II):

Patients assigned to non-invasive ventilation were connected to the GALELIO GOLD ventilator^(USA) with conventional tubing to a clear, full-face mask with an inflatable soft-cushion seal. The mask was secured with

straps to avoid an excessive air leakage, and the head of the bed was kept elevated at a 45-degree angle.

In all cases, a cream was applied over the nasal bridge. After the mask had been secured, pressure support was increased to achieve predetermined values:

- An exhaled tidal volume of 8 to 10 ml per kilogram,
- A respiratory rate of less than 25 breaths per minute,
- $\text{SaO}_2 > 90$ mmHg and
- The disappearance of accessory-muscle activity (as evaluated by palpation of the sternocleidomastoid muscle) and patient comfort.

* Patients who were randomly assigned to receive noninvasive ventilation, the criteria for switching them to endotracheal intubation and conventional ventilation were:

- The failure to maintain a PaO_2 above 65 mmHg with FiO_2 of at least 0.6.
- Failure to increase $\text{pH} > 7.3$, decrease PCO_2 at least 10mmHg.
- The development of conditions necessitating endotracheal intubation to protect the airways (coma or seizure disorder) or to manage copious tracheal secretions.
- Hemodynamic or electrocardiographic instability or
- Patient discomfort or intolerance of the face mask.

Weaning from NIV was by gradual reduction in pressures as follows: P-high then Pressure support and CPAP.

- Monitoring Of Ventilatory Mechanics:

The Following Mechanics Were Monitored:

Static Compliance (Cstat):

- It is calculated by the following equation:

$$\frac{\text{Exhaled Tidal Volume}}{\text{Plateau pressure- (Applied PEEP +Auto PEEP)}}$$

Normal range = (60-100) ml/cmH₂O. It is normally higher in COPD patients with emphysema and lower in restrictive lung disease.

Airway Resistance:

- It is calculated by the following equation:

$$\frac{\text{Peak Pressure (PIP) - Plateau pressure (P}_{\text{Plat}})}{\text{Peak Flow}}$$

Normal range = (3-11) cmH₂O/l/sec

RESULTS AND DISCUSSIONS

Results:

There was no statistically significant difference between both groups regarding age, gender, type of respiratory failure, Hemodynamic parameters and scoring systems (Table 1).

Comparison Of Severity Of Illness On Admission In Both Groups:

Comparing group I to group II showed no statistically significant difference as regards admission score of APACHE III (75.2±10.9 vs. 68.2±8.9, P value 0.219). Comparing group I to group II there was no statistically significant difference as regards admission score of SAPS II (21.7±10.8 vs. 15.1±5.5, P value 0.068).

Significant correlation has been observed between impaired level of consciousness and failure of trial of non-invasive ventilation (TABLE 2).

Table 1: Clinical characteristics of included patients:

ADMISSION		Invasive N=10 Gp I	Non-invasive N=20 Gp II	P-value
Age (years)		60.6±8.3	58.7±7.2	N.S
Gender	Male	8 (80%)	12 (60%)	N.S
	Female	2 (20%)	8 (40%)	N.S
DM		2 (20%)	11 (55%)	N.S
Systemic HTN		2 (20%)	12 (60%)	N.S
Pulmonary HTN		3 (30%)	6 (30%)	N.S
Pulmonary Edema		1 (10%)	3 (15%)	N.S
HEMODYNAMIC PARAMETERS	HR	94.0±35.8	106.8±14.2	0.466
	RR	29.0±15.9	31.9±2.4	0.328
	TEMP	37.9±0.6	37.6±0.6	0.204
	SBP	126.0±29.5	131.5±30.1	0.554
	DBP	74.0±15.0	82.5±16.5	0.112
APACHE III		75.2±10.9	68.2±8.9	0.219
SAPS II		21.7±10.8	15.1±5.5	0.068

Table 2: Level of consciousness

Level of consciousness	Score	Success	Failure	Total
Normal	1	4	None	4
Flapping tremors	2	12	1	13
Confusion	3	None	3	3
Total		16	4	20

Distribution Of Type Of Respiratory Failure In Both Groups:

Each of the two groups included both types of respiratory failure (Type I and Type II). Comparison of number of patients with Type II respiratory failure in group I showed no difference of statistical significance when compared to group II (90% vs. 17(85%), P-value NS (FIGURE 1).

Also there was no significant difference between number of patients with Type I respiratory failure in group I compared to that of group II (1 (10%) vs. 3 (15%), P-value NS (FIGURE 1).

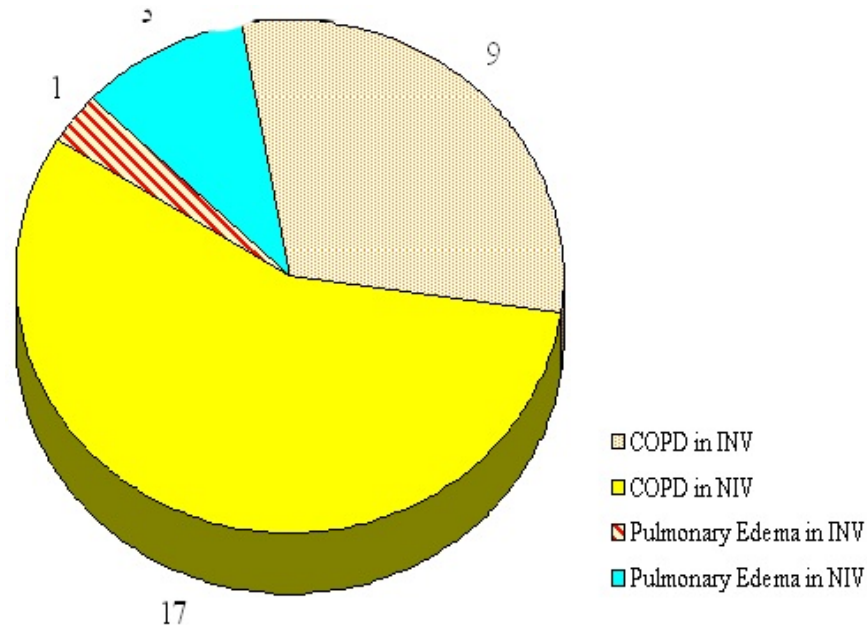


Figure 1: Distribution of type of respiratory failure

Comparison Of Admission Arterial Blood Gases In Both Groups:

Compared to group II the admission arterial blood gases in **group I** showed significantly *more acidotic* pH (7.17±0.08 vs. 7.29±0.03, P-value 0.001), significantly *lower arterial oxygen saturation SaO₂* (55.6±20.88 vs. 67.75±7.31, P-value 0.025) and significantly *higher RR* (35.50±4.97 vs. 32.05±2.39, P-value 0.015) (TABLE 3).

Table 3: Admission Arterial Blood Gases In Both Groups

Variable	InvasiveN=10GpI	Non-invasiveN=20GpII	P-value
pH a	7.17±0.08	7.29±0.034	0.001
PCO ₂ a	87.7±24.8	75.53±18.15	0.135
PO ₂ a	36.74±8.77	43.12±9.25	0.081
SO ₂ a	55.6±20.88	67.75±7.31	0.025
HCO ₃ a	37.90±4.72	37.14±4.17	0.658
PO ₂ /FIO ₂ a	177.48±40.83	205.4±44.13	0.105
RR a	35.50±4.97	32.05±2.39	0.015

Whereas no significant difference was found as regards arterial PCO₂ (87.7±24.8 vs. 75.53±18.15, P-value 0.135), arterial PO₂ (36.74±8.77 vs. 43.12±9.25, P-value 0.08), serum HCO₃ (37.90±4.72 vs. 37.14±4.17, P-value 0.65) and PO₂/FIO₂ ratio (177.48±40.83 vs. 205.4±44.13, P-value 0.105) (Table 3).

Comparison Of Follow Up Arterial Blood Gases Between Both Groups:

Despite the fact that no statistically significant difference was found between both groups in arterial blood gases done half an hour after admission (TABLE 4).

Comparison of arterial blood gases in group I that was done one and half an hour after admission showed the following:

- Significant higher pH (7.41±0.05 vs. 7.36±0.04, P-value 0.017),
- Significant higher PO₂ (118.38±29.69 vs. 96.12±16.94, P-value 0.014),
- Significant higher SaO₂ (98.70±0.48 vs. 95.45±3.69, P-value 0.010), when compared to group II, but no statistically significant difference was found in other measured parameters (Table 4).

Table 4: Arterial Blood Gases done at ½ & 1 ½ Hour

Variable	½ An hour			1 ½ an hour		
	InvasiveN=10GpI	Non-invasiveN=20GpII	P-value	InvasiveN=10GpI	Non-invasiveN=20GpII	P-value
pH	7.31±0.02	7.33±0.03	0.207	7.41±0.05	7.36±0.04	0.017
PCO ₂	65.55±12.68	65.71±13.29	0.975	52.85±10.43	58.68±12.67	0.22
PO ₂	93.8±6.41	95.04±28.77	0.895	118.38±29.69	96.12±16.94	0.014
SO ₂	95.50±0.97	94.00±5.81	0.428	98.70±0.48	95.45±3.69	0.01
HCO ₃	37.47±4.05	36.76±3.89	0.646	36.24±2.97	35.73±3.07	0.672
PO ₂ /FIO ₂	184.92±19.96	198.94±14.04	0.5	233.83±63.40	198.98±32.31	0.054
RR	19.50±2.838	27.15±3.03	0.0001	10.0±1.63	22.95±3.44	0.0001

Comparison of arterial blood gases that was done on the second day after admission in group I showed the following:

- Significant higher pH (7.45±0.026 vs. 7.41±0.04, P-value 0.022),
- Significant higher SaO₂ (97.40±0.96 vs. 95.31±2.82, P-value 0.034),
- Significant lower RR (9.90±1.52 vs. 17.62±1.99, P-value 0.0001).

When compared to group II, but no statistically significant difference was found in other measured parameters (TABLE 5).

Table 5: Arterial Blood Gases done on 2nd day & after discontinuation of mechanical ventilation.

Variable	2 nd Day			Discontinuation of Ventilation		
	Invasive N=10GpI	Non-invasiveN=20GpII	P-value	InvasiveN=10GpI	Non-invasiveN=16GpII	P-value
pH	7.45±0.02	7.41±0.045	0.022	7.42±0.04	7.42±0.03	0.799
PCO ₂	46.99±8.21	51.50±7.21	0.154	51.34±7.22	50.21±5.99	0.672
PO ₂	109.15±32.64	93.31±18.05	0.123	67.25±9.13	68.96±11.38	0.692
SO ₂	97.40±0.96	95.31±2.82	0.034	92.38±2.51	93.5±2.78	0.311
HCO ₃	35.48±2.68	35.11±2.32	0.715	35.29±3.58	36.15±3.19	0.53
PO ₂ /FIO ₂	251.0±99.60	245.25±54.73	0.848	321.27±43.89	327.83±57.35	0.76
RR	9.90±1.52	17.62±1.99	0.0001			
VT	725.0±54.00	712.5±69.52	0.633			

Arterial blood gases done after discontinuation of ventilation in group I showed no statistically significant difference compared to that of group II as regards to:

- pH (7.42±0.04 vs. 7.42±0.034, P-value 0.799),
- PCO₂ (51.34±7.22 vs. 50.21±5.99, P-value 0.672),

- PO₂ (67.25±9.13 vs. 68.96±11.38,P-value 0.692),
- SaO₂ (92.38±2.51 vs. 93.5±2.78,P-value 0.311) and
- PO₂/FIO₂ (321.27±43.89 vs. 327.83±57.35, P-value 0.760). (TABLE 5)

Group II patients were further divided into two subgroups:

- Subgroup A (SUCCESS): 16 patients who succeeded with Non-Invasive Ventilation.
- Subgroup B (FAILURE): 4 patients who failed Non-Invasive Ventilation.

Comparison of Admission Arterial Blood Gases between Subgroups “A” And “B”:

Admission pH was significantly higher in subgroup A compared to subgroup B (7.30±0.03 vs 7.26±0.01, P 0.009), PCO₂ was significantly lower in subgroup A compared to subgroup B (69.16±13.14 vs. 100.97±12.04, P 0.0001) (Table 6).

Table 6: Admission Arterial Blood Gases In Both Subgroups

Admission Variables	Subgroup A (SuccessNIV)	Subgroup B (Failure NIV)	P- value
pH a	7.30±0.03	7.26±0.01	0.009
PCO ₂ a	69.16±13.14	100.97±12.04	0.0001
PO ₂ a	42.88±7.93	44.10±15.03	0.821
PO ₂ /FIO ₂ a	204.19±37.89	210.25±71.51	0.813
RR a	31.93±2.35	32.50±2.88	0.686

Comparison Of Follow Up Arterial Blood Gases Between Subgroups “A” And “B”:

Compared to subgroup A the arterial blood gases done half an hour after admission in subgroup B showed significantly more acidotic pH (7.28±0.17 vs. 7.34±0.02,P-value 0.002), and significantly higher PCO₂ (83.40±7.84 vs. 61.28±10.35,P-value 0.001) (Table 7).

Table 7: Arterial Blood Gases done 30 minutes & 1 ½ Hour in Both Subgroups:

Variable	½ An hour			1 ½ an hour		
	Subgroup A (16)	Subgroup B (4)	P-value	Subgroup A (16)	Subgroup B (4)	P-value
pH	7.34±0.02	7.28±0.17	0.002	7.37±0.03	7.31±0.17	0.005
PCO ₂	61.28±10.35	83.40±7.84	0.001	53.98±8.95	77.47±5.22	0.001
PO ₂	95.78±31.87	92.05±12.14	0.823	99.30±14.08	83.37±23.56	0.093
PO ₂ /FIO ₂	202.42±69.36	185.0±24.65	0.426	207.04±23.05	166.75±47.13	0.021
RR	26.93±2.35	28.00±5.41	0.545	22.62±2.44	24.25±6.50	0.413

Table 8b: ABGs follow up in patients who succeeded NIV (group II-Subgroup A)

Variable	Admission(16)	Discontinuation(16)	P- value
pH	7.30±0.03	7.42±0.03	0.0001
PCO ₂	69.16±13.14	50.21±5.99	0.0001
PO ₂	42.88±7.93	68.96±11.38	0.0001
SaO ₂	67.18±8.06	93.50±2.78	0.0001
PO ₂ /FIO ₂	204.19±37.89	327.83±57.35	0.0001

Comparison of arterial blood gases in subgroup A that was done one and half an hour after admission showed the following:

- Significant higher pH (7.37±0.03 vs. 7.31±0.17,P-value 0.005),
- Significant lower PCO₂ (53.98±8.95 vs. 77.47±5.22,P-value 0.0001).
- Significant higher PO₂ (99.30±14.08 vs. 83.375±23.56,P-value 0.093),
- Significant higher PO₂/FIO₂ (207.04±23.05 vs. 166.75±47.13, P-value 0.021). (Table 7)

Table 9: Multivariate Logistic Regression

Observed	Predicted	
	Success	Failure
Success	*100	
Failure	**	0%
Overall		80%

* Properly allocated

** Wrongly allocated

When compared to subgroup B, but no statistically significant difference was found in RR.

Table 10: Discriminate Analysis

Observed	Predicted	
	Success	Failure
Success	*100%	
Failure		* 100%
Overall	100%	

Discontinuation Of Ventilation In Subgroup “A”:

Comparison between arterial blood gases in subgroup A done on admission to arterial blood gases of the same subgroup after discontinuation of mechanical ventilation showed remarkable improvement in all its parameters.

There was statistically significant difference in pH (7.30±0.030 vs. 7.42±0.03, P-value 0.0001), PO₂ (42.883±7.93 vs. 68.96±11.38, P-value 0.0001), PCO₂ (69.16±13.14 vs. 50.21±5.99, P-value 0.0001), SaO₂ (67.18±8.06 vs. 93.50±2.78, P-value 0.0001), PO₂/FIO₂ (204.19±37.89 vs. 327.83±57.35, P-value 0.0001) and HCO₃ (37.32±4.59 vs. 36.15±3.19, P-value 0.534) (Table 8).

Predictors Of Success:

Following univariate analysis of all relevant parameters to success of Non-Invasive Ventilation. Those who were significantly associated with our end point were verified in addition and clinical experience. Multivariate Logistic Regression model with Enter Method was designed utilizing the following parameters: level of consciousness PCO₂ and pH on admission, PCO₂ and pH after 1½ hour of NIV (PCO₂ a, pH a, PCO₂ 1b, pH 1b and LOC) as independent predictors. This model failed to correctly classify patients into success and failure with accepted sensitivity and specificity.

However, using Stepwise approach with Forward Conditional Method to choose best predictor; only PCO₂ after 1 1/2 hour “PCO₂ 1b” could be the sole predictor with 100% specificity (i.e. it could correctly classify all successful cases), yet none of failed cases was correctly classified (Table 9). To confirm the role of “PCO₂ 1b” in prediction of success and failure, another technique has been used namely Stepwise Discriminate Analysis utilizing the same parameters, again “PCO₂ 1b” was the best predictor (Table 8).

* Properly allocated

Comparison of Lung Mechanics During Invasive and Non-invasive Ventilatory Support:

Lung mechanics of group II patients showed a statistically significant improvement at day two compared to day one regarding VT (630.00±110.5 vs. 712.50±69.52, P- value 0.0001), RR (17.62±1.99 vs. 22.30±3.26, P-value 0.0001), static compliance (66.93±8.04 vs. 49.85±8.48, P-value 0.0001) and Resistance (3.12±1.40 vs. 9.75±3.61, P-value 0.0001). Lung mechanics of group I patients showed a statistically significant improvement at day two compared to day one regarding VT (725.00±54.00 vs. 695.00±83.16, P-value 0.0001), RR (9.90±1.52 vs. 10.00±1.63, P-value 0.0001), static compliance (48.55±7.63 vs. 38.92±11.59, P-value 0.0001) and Resistance (11.00±2.49 vs. 16.14±6.27, P-value 0.0001).

Comparing applied pressures at the two levels (BiPAP) to achieve the preset end points namely RR (<25), VT (8ml/kg) and SaO₂ (>90) in group II patients showed significant lower pressures needed in day two compared to that of day one (5.0±0.8 vs. 6.2±1.2, P-value 0.008) in CPAP and (8.9±0.9 vs. 11.8±1.5, P-value <0.001) in P-High.

Complications:

Incidence of complications was significantly higher in group I compared to group II 8: (80%), vs. 14 (70%).

Ventilator associated pneumonia (VAP) occurred mostly in Gp I compared to Gp II (80% vs. 20%, P value: 0.002).

CO₂ narcosis and skin necrosis occurred only in group II patients who had NIV with incidence of (20% & 50%) respectively.

Length of Hospital Stay:

Among the 28 patients who survived to be discharged from the intensive care unit, the patients in the noninvasive-ventilation group had a shorter duration of mechanical ventilation (3±3 vs. 6±5 days, P=0.006) and a shorter stay in the intensive care unit (5.8±3.6 vs. 8.9±2.7 days, P= 0.011) compared to those in the conventional-ventilation group. Two patients (one in each group) died in the intensive care with Sepsis. The other patients were successfully discharged from the hospital without further complications.

Discussion:

Noninvasive ventilation using bi-level pressure ventilation via nasal mask or full face mask has been shown to improve arterial blood gas data (ABG), decrease length of hospital stay (LOS), complication rates and improve patient survival. A number of studies support the use of bi-level pressure ventilation in patients with acute respiratory failure (Brochard, *et al.*, 1995, Bott, *et al.*, 1993 and Kramer *et al.*, 1995). Adding noninvasive ventilation to standard therapy in patients with acute exacerbations of chronic obstructive pulmonary disease and hypercapnic respiratory failure decreased the need for endotracheal intubation (Bott, *et al.*, 1993, Kramer, *et al.*, 1995, Amed, *et al.*, 1992 and Martin, *et al.*, 1994). Similarly, noninvasive continuous positive airway pressure was effective in patients with cardiogenic pulmonary edema, particularly those with hypercapnia. (Rasanen, *et al.*, 1985 and Lin, *et al.*, 1995).

In our study, patients in the NIV group had a similar initial improvement in gas exchange compared to those who received INV, as seen in ABG data. Improvement in gas exchange in the NIV group was sustained until mechanical ventilation was discontinued, as confirmed by serial blood gas measurements. After 1 ½ hour of mechanical ventilation, 4 patients (20%) in the noninvasive-ventilation group required endotracheal intubation i.e. rate of success was (80%). This is in agreement with Antonelli *et al.*, 1998 who reported that the noninvasive-ventilation group had improvement in gas exchange evaluated within one hour after study entry (initial improvement) and over time (sustained improvement). Ten patients in the noninvasive-ventilation group (31 %) required endotracheal intubation. The use of Bi-level pressure ventilation in other studies was associated with similar rates of endotracheal intubation in the NIV groups, (25.9% with Poponick *et al.*, 26 % with Brochard *et al.*, and 28% with Martin, *et al.*, 1994, poponick, *et al.*, 1994, Brochard, *et al.*, 1994 and Martin, *et al.*, 2000).

The present study showed that the length of hospital stay was significantly lower in patients received NIV in comparison to those who received INV (5.8±3.6 days vs. 8.9±2.7 days, P-value 0.011) respectively. This is in accordance with the findings of other reported studies. Antonelli *et al.*, 1998, pointed out that the patients in the noninvasive-ventilation group had a shorter stay in the intensive care unit (6.6±5 vs. 14±13 days, P= 0.002) than those in the conventional-ventilation group. Successful noninvasive ventilation was associated with shorter stays in the intensive care unit. Similarly, Brochard, *et al.*, 1995 compared non-invasive positive pressure ventilation delivered through face mask with standard treatment, reported that length of hospital stay was significantly reduced by noninvasive ventilation. This difference in length of hospital stay may be explained by the presence of more patients with respiratory acidosis in the conventional-ventilation group, and this may have affected the duration of mechanical ventilation and the outcome in this group. Factors that may have been involved in shortening the duration of mechanical ventilation include the avoidance of sedation, elimination of the extra work of breathing imposed by the endotracheal tube, the lower rate of ventilator-associated pneumonia and earlier removal from ventilation. This result suggests that noninvasive ventilation may be a cost-saving measure.

Other studies had found no difference in length of hospital stay when compared both groups of studies and demonstrated that NIV therapy didn't significantly affect ICU length of hospital stay (5 days vs. 6 days, p = 0.77), NIV versus usual medical care, respectively (Martin, *et al.*, 2000). Wysocki and colleagues, 1995 found no significant effect of NIV on ICU length of hospital stay. Kramer and colleagues, 1995 found that in hypercapnic ARF resulting predominantly from COPD, length of hospital stay was not significantly different in their NIV group and controls. The different observations in these investigations may be partly explained by differences in enrollment criteria.

In our study we found that occurrence of complications was more in group I compared to group II (80% vs 70%). Conventional ventilation group showed more complications especially that related to intubation particularly VAP with statistically significant difference (80% vs 20%, P: 0.002) when compared to non-invasive group. Whilst patients received NIV suffered from complications related to the mask as skin necrosis at pressure points, claustrophobia and gastric distension. This was in agreement with other studies. Other studies had found that noninvasive ventilation, as compared with standard treatment, was associated with fewer complications, many of which are specifically linked with mechanical ventilation and are believed to have an effect on mortality (Meduri, 1995, Bott *et al.*, 1993 and Brochard, *et al.*, 1994).

In the present work, there was a non significant difference in mortality in group I compared to group II (5% vs. 10%, P value= 1.0) respectively. In non-invasive ventilation, it is noteworthy that mortality occurred in a patient in subgroup B, who required endotracheal intubation. Other studies demonstrated that mortality was significantly reduced with the use of non invasive ventilation. The mortality rate in the study conducted by Brochard *et al.*, 1995 appeared to be high in the control group compared to the rates reported by Bott and coworkers. Patients were probably at a more severe stage of disease than those in the study by Bott *et al.*, 1993

as shown by the lower pH values in the patients on admission (Fernandez, *et al.*, 1993).

Martin et al., demonstrated that despite ICU mortality in the usual medical care (UMC) group was greater than that in the NIV group (34% versus 16%, respectively), the difference was not statistically significant ($p = 0.21$). *Wysocki, et al.*, 1995 found no significant effect of NIV on ICU mortality. *Kramer, et al.*, 1995 found that in hypercapnic ARF resulting predominantly from COPD, hospital mortality was not significantly different in their NIV group and controls (4).

In our study A logistic multivariate regression model was used to analyze the relationship between significant variables of the univariate study that were associated with subsequent failure of treatment: severity of acidosis ($p < 0.009$) and degree of hypercapnia ($p < 0.001$), and to calculate a regression equation. Patients who succeeded with NIV had better level of consciousness scores (2.44 ± 0.89 vs. 2.8 ± 1.13 ; $p < 0.05$), lower values for PaCO₂, and higher values for pH. However, APACHE III scores, SAPS II, respiratory rates, and the values for PaO₂ at the beginning of NIV did not differ between patients in whom treatment with NIV was successful and not successful. After ½ h of NIV the patients in whom NIV was successful also had better LOC scores ; they also had higher pH ($p < 0.002$) and greater reductions in PaCO₂ ($p < 0.001$). After 1 ½ hours of treatment the same variables were associated with treatment success on univariate analysis: higher pH ($p < 0.005$) and greater reductions in PaCO₂ ($p < 0.001$). The final regression model included the following: admission pH, PaCO₂, LOC values, pH and PaCO₂ after 1 ½ hour. This model failed to correctly classify patients into success and failure with accepted sensitivity and specificity. However, using Stepwise approach with Forward Conditional Method to choose best predictor; only one variable “PaCO₂ 1 ½ h” could be the sole predictor with 100% specificity (i.e. it could correctly classify all successful cases), yet none of failed cases was correctly classified.

Poponick, et al., 1994 conducted a study aiming at identification of patient characteristics early in the course of acute illness that can predict the successful use of bi-level pressure ventilation. They evaluated clinical data in an attempt to predict which patient could be successfully ventilated with bi-level pressure ventilation. As in other studies, demographic and initial clinical data such as age, APACHE II, and ABG data could not predict success. The improvements in pH and PaCO₂ after a short trial of bi-level pressure ventilation were the best indicators that intubation was not necessary in patients with ARF. There were no significant differences between the success and failure groups in age, gender, GCS, or APACHE II.

Thus successful treatment with bi-level pressure ventilation could not be predicted by pretrial data (including pH and PaCO₂) obtained in the emergency department. However, successful outcome could be determined quickly within a 30-min trial as shown by an improvement in pH and PaCO₂ and overall clinical appearance. On the other hand *Ambrosino et al.*, 1995 retrospectively reviewed their experience with bi-level pressure ventilation in patients with COPD. After an analysis of multiple variables, the baseline pH remained the best predictor of success (sensitivity, 97%; specificity, 71%). However, predicting which patients will be successfully treated with bi-level pressure ventilation in an acute setting remains difficult. Their study demonstrated that a short trial of bi-level pressure ventilation in cooperative patients can aid the physician in deciding whether or not to continue bi-level pressure ventilation as a treatment.

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