

**Impact of Non-Invasive Ventilation on the outcome  
of the extubated chronic hypercapnic patients in the  
Respiratory Intensive Care Unit at Ain Shams  
University specialized Hospital**

*Thesis*

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Degree in Chest Diseases*

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# *Abbreviations*

<b>%</b>	Percent
<b>≥</b>	More than or equal to
<b>&lt;</b>	Less than
<b>&gt;</b>	More than
<b>≤</b>	Less than or equal to
<b>°C</b>	degree Celsius
<b>ABG</b>	Arterial blood gas analysis
<b>AE</b>	Acute Exacerbation
<b>AHRF</b>	Acute hypercapnic respiratory failure
<b>ALS</b>	Amyotrophic lateral sclerosis
<b>APRV</b>	Airway pressure–release ventilation
<b>ARDS</b>	Acute Respiratory Distress Syndrome
<b>ARF</b>	Acute respiratory failure
<b>ASD</b>	Atrial septal defect
<b>ATS</b>	American Thoracic Society
<b>BiPAP</b>	Bi-level positive airway pressure
<b>BMI</b>	Body mass index
<b>bpm</b>	Breath per minute
<b>CaO<sub>2</sub></b>	Arterial oxygen content
<b>CBC</b>	Complete blood count
<b>CcO<sub>2</sub></b>	Capillary oxygen content
<b>CHRF</b>	Chronic hypercapnic respiratory failure
<b>cm</b>	Centimeter
<b>CNS</b>	Central nervous system
<b>CO<sub>2</sub></b>	Carbon dioxide
<b>COPD</b>	Chronic Obstructive Pulmonary Disease
<b>CPAP</b>	Continuous positive airway pressure
<b>CvO<sub>2</sub></b>	Mixed venous oxygen content
<b>CWD</b>	Chest wall diseases
<b>DILD</b>	Diffuse interstitial lung diseases
<b>dL</b>	Deciliter
<b>e.g</b>	Example given
<b>ECG</b>	Electrocardiography
<b>ePEEP</b>	Extrinsic positive end-expiratory pressure

<b>ERS</b>	European respiratory society
<b>ETT</b>	Endotracheal Tube
<b>fR</b>	Respiratory frequency
<b>FEV1</b>	Forced expiratory volume in 1st second
<b>Fig</b>	Figure
<b>FiO2</b>	Fraction of inspired oxygen
<b>FRC</b>	Functional residual capacity
<b>FVC</b>	Forced vital capacity
<b>g</b>	Gram
<b>H2O</b>	Water
<b>Hb</b>	Hemoglobin
<b>HCO3</b>	Bicarbonate
<b>Hg</b>	Mercury
<b>HRF</b>	Hypercapnic respiratory failure
<b>i.e</b>	id est (that is)
<b>I/E</b>	Inspiratory–expiratory ratio
<b>ICU</b>	Intensive Care Unit
<b>ILD</b>	Interstitial lung disease
<b>IMV</b>	Intermittent mandatory ventilation
<b>iPEEP</b>	Intrinsic positive end-expiratory pressure
<b>K</b>	Constant
<b>Kg</b>	Kilogram
<b>L</b>	Liter
<b>m2</b>	Meter square
<b>min.</b>	Minute
<b>MIP</b>	Maximal inspiratory pressure
<b>ml</b>	Milliliter
<b>mm</b>	millimeter
<b>MRSA</b>	Methicillin Resistant Staphylococcus aureus
<b>MV</b>	Mechanical Ventilation, Minute ventilation
<b>NAVA</b>	Neurally adjusted ventilatory assist
<b>NIV</b>	Non-invasive ventilation
<b>NMD</b>	Neuro-muscular disorders
<b>NSIP</b>	Non-specific interstitial pneumonia
<b>O2</b>	Oxygen
<b>OHS</b>	Obesity hypoventilation syndrome
<b>OSAHS</b>	Obstructive sleep apnea hypopnea syndrome

<b>P</b>	Probability
<b>PaCO<sub>2</sub></b>	Partial arterial carbon dioxide Pressure
<b>PAO<sub>2</sub></b>	Pressure of alveolar oxygen
<b>PaO<sub>2</sub></b>	Partial arterial Oxygen Pressure
<b>Patm</b>	Barometric atmospheric pressure
<b>PAV</b>	Proportional assist ventilation
<b>PC</b>	Personal Computer
<b>PEEP</b>	Positive end-expiratory pressure
<b>PFTs</b>	Pulmonary function tests
<b>pH</b>	Power of Hydrogen
<b>PH<sub>2</sub>O</b>	Water vapor pressure at 37°C
<b>PiO<sub>2</sub></b>	Pressure of inspired oxygen
<b>PO<sub>2</sub></b>	Partial pressure of oxygen
<b>PRVC</b>	Pressure-regulated volume-control ventilation
<b>PSV</b>	Pressure support ventilation
<b>Qs/Qt</b>	The shunt fraction
<b>R</b>	Respiratory exchange ratio
<b>r</b>	Coefficient of correlation
<b>RICU</b>	Respiratory Intensive Care Unit
<b>RQ</b>	Respiratory quotient
<b>RSBI</b>	Rapid shallow breathing index
<b>SaO<sub>2</sub></b>	Arterial oxygen saturation
<b>SBT</b>	Spontaneous breathing trial
<b>SD</b>	Standard deviation
<b>SIMV</b>	Synchronized intermittent mandatory ventilation
<b>t</b>	Student T test
<b>Ti</b>	Inspiratory time
<b>UIP</b>	Usual interstitial pneumonia
<b>V/Q</b>	Ventilation / Perfusion ratio
<b>VA</b>	Alveolar ventilation
<b>VAP</b>	Ventilator Associated Pneumonia
<b>VCO<sub>2</sub></b>	Carbon dioxide production
<b>VSD</b>	Ventricular septal defect
<b>VSV</b>	Volume-support ventilation
<b>VT</b>	Tidal volume
<b>χ<sup>2</sup></b>	Chi-Square test

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# **INTRODUCTION**

Respiratory failure is a syndrome in which the respiratory system fails in one or both of its gas exchange functions: oxygenation and carbon dioxide elimination. In practice, it may be classified as either hypoxemic or hypercapnic (**Lanken P, 1995**).

Respiratory failure may be further classified as either acute or chronic. Although acute respiratory failure is characterized by life-threatening derangements in arterial blood gases and acid-base status, the manifestations of chronic respiratory failure are less dramatic and may not be as readily apparent (**MacSweeney R. et al, 2011**).

The need for mechanical ventilation (MV) is a frequent reason for admission to an intensive care unit (ICU). The principal indications for MV are airway protection and respiratory failure which are considered the most common vital organ failure seen in critically ill patients. Among ICU patients, 40–65% need MV during their ICU stay. Patients receiving MV require a complex, well-organized, and technically sophisticated level of care (**Reddy R and Guntupalli K, 2007**).

Use of Non-invasive ventilation (NIV) may provide a means of reducing the duration of invasive mechanical support for intubated patients with ARF. Unlike for conventional invasive ventilation, NIV is achieved with an oro-nasal, nasal or total face mask connected to a ventilator and does not require an indwelling artificial airway. Through NIV one can (i) administer oxygen, (ii) augment the inhaled volume and (iii) apply extrinsic positive end-expiratory pressure (ePEEP) to counteract intrinsic positive end-expiratory pressure (iPEEP) (**Ambrosino N and Vaghegini G, 2008**).

## **AIM OF THE WORK**

The aim of this work was to study the impact of non-invasive ventilation on the outcome of the extubated chronic hypercapnic patients and comparing it versus conventional Oxygen therapy in the Respiratory Intensive Care Unit at Ain Shams University Specialized Hospital during the period from October 2013 till May 2015.

## **Overview on Respiratory Failure**

### **Definition:-**

Respiratory failure can be defined as a condition in which the respiratory system fails in one or both of its main gas exchanging functions; which are oxygenation of, and carbon dioxide elimination from, mixed venous (pulmonary arterial) blood. Hence, respiratory failure is considered to be a syndrome rather than a single disease (**Lanken P, 1995**).

In clinical practice, respiratory failure is defined as an arterial oxygen tension (PaO<sub>2</sub>) value of less than 60 mm Hg while breathing room air with or without an arterial carbon dioxide tension (PaCO<sub>2</sub>) of more than 50 mm Hg. These values are measured using arterial blood gases analysis (**MacSweeney R. et al, 2011**).

### **Classification of respiratory failure:-**

Respiratory failure can be classified using different classifications.

#### **1- According to PaO<sub>2</sub> and PaCO<sub>2</sub> levels:-**

##### **■ Type 1 (hypoxemic) respiratory failure:**

It is characterized by an arterial oxygen tension (PaO<sub>2</sub>) lower than 60 mm Hg with a normal or sometimes low arterial carbon dioxide tension (PaCO<sub>2</sub>). This is considered the most common type of respiratory failure, and it can be caused with almost all acute diseases of the lungs, which generally involve fluid filling or collapse of alveolar units. Some examples of conditions associated with type 1 respiratory failure are cardiogenic or non-cardiogenic pulmonary edema, pneumonia, and pulmonary hemorrhage (**Confalonieri M. et al, 1999**).

■ **Type 2 (hypercapnic) respiratory failure:**

In this type, the level of arterial carbon dioxide tension (PaCO<sub>2</sub>) is higher than 50 mm Hg. Hypoxemia is usually common in patients with hypercapnic respiratory failure who are breathing room air. The pH depends on the level of bicarbonate anion, which, in turn, is dependent on the duration over which the hypercapnia has developed. Common etiologies include drug overdose, neuromuscular disease, chest wall abnormalities, and severe airway disorders (eg, asthma and chronic obstructive pulmonary disease [COPD]) (Plant P. et al, 2000).

■ **Type 3 (Peri-Operative) respiratory Failure:**

In this type, the increased atelectasis due to low functional residual capacity (FRC) which is usually caused by abnormal abdominal wall mechanics in the peri-operative period often results in type 1 or type 2 respiratory failure and can be prevented by: selecting anesthetic or operative technique, posture, incentive spirometry, adequate post-operative analgesia, attempts to lower intra- abdominal pressure (Glossop A. et al, 2012).

■ **Type 4 (Shock) respiratory Failure:**

Type 4 describes respiratory failure occurring in patients who are intubated and ventilated during management of shock. The ultimate goal of ventilation of those patients is to stabilize gas exchange and to remove the burden of respiratory muscles, lowering their oxygen consumption (Midelton G. et al, 2002).

**2- According to duration of development:-**

Respiratory failure can be classified on the basis of the duration over which it has developed into either acute or chronic respiratory failure. Although acute respiratory failure is often associated with life-threatening abnormalities in arterial blood gases and

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## ***Review of Literature***

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acid-base balance, the manifestations of chronic respiratory failure are less dramatic and may not be as readily apparent (**MacIntyre N, Huang Y, 2008**).

In case of acute hypercapnic respiratory failure, the condition develops over the period of minutes to hours; therefore, pH is less than 7.3 as there is no time available for renal compensation while in chronic respiratory failure which develops over several days or longer, allowing time for renal compensation and an increase in bicarbonate concentration. Therefore, the pH usually is only slightly decreased (**Brochard L. et al, 1995**).

In contrast to hypercapnic respiratory failure, The differentiation between acute and chronic hypoxemic respiratory failure cannot easily be made using the analysis of arterial blood gases, so, The use of clinical markers of chronic hypoxemia, such as polycythemia or cor pulmonale, suggest a long-standing disorder indicating chronicity (**Esan A. et al, 2010**).

**Table (1): Distinctions between Acute and Chronic Respiratory Failure**

<b>Category</b>	<b>Characteristic</b>
Hypercapnic respiratory failure	$Pa_{CO_2} > 45$ mm Hg
Acute	Develops in minutes to hours
Chronic	Develops over several days or longer
Hypoxemic respiratory failure	$Pa_{O_2} < 55$ mm Hg when $F_{I_{O_2}} \geq 0.60$
Acute	Develops in minutes to hours
Chronic	Develops over several days or longer

(Source: **Grippi A. et al, 2015**)