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# Clinical Concepts of High-Flow Oxygenation Therapy

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## ABSTRACT

Respiratory failure and hypercarbic hypoxia is one of the challenging problems in critically ill patients. Non-invasive positive pressure ventilation (NIPPV) is one of the conventional methods of respiratory support in these conditions. High-flow oxygen therapy (HFOT) has been recognized as an effective method of noninvasive ventilatory support. A variety of devices are available for use in the HFOT set to provide maximum flow rate and humidity. Physiological benefits of using HFOT include reducing dehydration of airway mucosa, improving clearance of respiratory tract secretions, increased tidal volume, reducing alveolar atelectasis and decreased respiratory rate. While NIPPV increases anatomical dead space, HFOT decreases dead space. HFOT is effective for the treatment of mild to moderate hyper carbic hypoxemic respiratory failure. It has been used in respiratory disorders after surgery, acute heart failure, management of respiratory failure in the intensive care unit and during bronchoscopy. HFOT has been used as a primary treatment strategy in patients during the Covid-19 era.

It had a significant effect on the patient's morale and decrease respiratory effort. It seems that we need more precise evidence to determine the basic criteria for prescribing HFOT during daily exercise.

**Keywords**: High-flow oxygenation therapy, Respiratory failure, Acute respiratory distress syndrome, SARS-CoV-2

**Abbreviations:** HFOT: High-Flow Oxygenation Therapy; $O_2$: Oxygen; $FiO_2$: Fraction Inspiration of Oxygen; $CO_2$: Carbon Dioxide; NIPPV: Non-Invasive Positive Pressure Ventilation; VT: Tidal Volume; CPAP: Continuous Positive Airway Pressure; PEEP: Positive End Expiratory Pressure; ARDS: Acute Respiratory Distress Syndrome; SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus 2; ICU: Intensive Care Unit

Ventilation means the absorption of oxygen and the removal of carbon dioxide, which is necessary for the life of humans. Sometimes this vital activity is disturbed for various reasons. Consequently, its management should enhance tissue oxygenation with the aim of improving metabolism and contributing to respiratory effort during various support modalities [1,2].

Respiratory problems and ventilation impairment are common in the peri-operative period, patients with co-morbidities and lung diseases and; ventilation support is one of the principles of resuscitation and treatment in critically ill patients [1,3,4].

There are various methods for patients' respiratory support. Some of these methods are accompanied by artificial or mechanical ventilation, and some methods are based on increasing the percentage of respiratory oxygen. Hypoxia and hypoxemia is solved by increasing fraction inspiration of oxygen ($FiO_2$) in most cases but; there are also patients who do not suffer from a decrease in blood oxygen lonely, and they have carbon dioxide retention. In these cases, it is necessary to think about the removal of carbon dioxide ($Co_2$), and since the pressure of carbon dioxide is related to the amount of minute ventilation of the alveoli, it is necessary to somehow increase the effective ventilation of the alveoli [1,5,6].

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Minute ventilation is manipulated through invasive or noninvasive respiratory support to ensure adequate alveolar ventilation. Invasive oxygen delivery methods are performed based on tracheal intubation, and non-invasive traditional methods include nasal cannula, simple facial mask or facial mask plus reservoir bag, and non-invasive positive pressure ventilation (NIPPV) [1,6,7].

NIPPV is the conventional method of respiratory support in many patients because it increases tidal volume (VT) and guarantees adequate alveolar ventilation but, many patients do not tolerate mask of non-invasive ventilation and; the use of high-flow oxygen therapy (HFOT) is an effective treatment option. HFOT can have advantages over NIPPV; While NIPPV interfaces increase anatomical dead space, HFOT actually decreases dead space [8-10].

Administering supplemental oxygen to the patient is divided into two main types; Low-flow oxygenation and high-flow oxygenation methods. Oxygen is usually administered through low-flow systems such as a nasal cannula or a simple face mask and; the amount of oxygen required is based on a percentage of the patient's minute ventilation, ranging from 1 to 6 L/min. An alternative method is high-flow oxygen administration [1,8,9]. This prescription can be done through a venturia mask or special intranasal cannula (nasal prong) as HFOT [1,10,11].

HFOT concepts are increasingly accepted as a non-invasive form of respiratory support because patients usually cannot tolerate continuous positive airway pressure (CPAP) or NIPPV for long periods because of the compressive effects of the mask on the face and insufficient warming and humidification of inspired gas.

The innovation of ventilation systems developed for adults that reliably deliver warmed, humidified mixed air/oxygen at high flows through the prong has led to increased use of HFOT [7,9,12].

While there is controversy regarding the indication and method of HFOT uses and its impact on patient outcomes, some published reports suggest that HFOT can be a useful strategy in ventilation management. HFOT is a method in which a warmed, humidified gases is delivered to the beginning of the respiratory tract through a nasal prong with a high flow rate [1,2,13,14]. In HFOT, a mixture of air and oxygen with inspired oxygen concentrations of up to 100% and a maximum adjustable flow of up to 60 L/min is warmed and humidified by passing through an active humidifier and delivered through a circuit to the beginning of the airways [1,15,16].

There are various devices to provide high flow of humidified oxygen and air for administration through nasal cannula. These devices consist of intranasal tube with wide-bore prongs connected to an oxygen flow meter with an air-oxygen gas mixer, gas analyzer and Oxygen sources. The heating and humidification blender heats the gases to a temperature between 33ºC and 43ºC and creates a humidity of 95 to 100 % [2,17,18]. The size of the opening of the nasal cannula can be different according to the comfort and choice of the patient. Some patients prefer standard cannula and some prefer large holes to reduce the output pressure. An interface is available for use with tracheostomy tubes [1,2,16].

Physiological benefits of using HFOT include reducing dehydration of airway mucosa, improving clearance of respiratory tract secretions, increased tidal volume, reducing alveolar atelectasis and decreased respiratory rate. The use of High- flow gas wash outs CO2 from the breathing system, reduces anatomical dead space and acts as a reservoir of oxygen ($O_2$) in the body until $FIO_2$ is more than air room $O_2$ concentration [4,6,8,16].

Although HFOT is an open system, high flow through the cannula creates resistance to expiratory flow and increases airway pressure, exerting physiologic properties similar to CPAP or Positive End Expiratory Pressure (PEEP) and makes an increased end-expiratory volume. This condition may have a beneficial effect on alveolar recruitment [2,16,18].

Park [9,10] measured pressure of nasopharyngeal space in patients. Nasopharyngeal pressure increased during HFOT about 2.7 ± 1.04 $CmH_2O$ with the closed mouth and 1.2 ± 0.76 $CmH_2O$ with the open mouth during HFOT with a 35 L/min flow rate.[8, 9] Mouth opening or closing significantly affects pharyngeal positive pressure. It is almost accepted that HFOT causes an increase in pharyngeal pressure of about 3-5 $cmH_2O$ so, it causes an increase in lung volumes. Studies has been shown that using HFOT increases the end-expiratory lung volume, but its effect on the improvement of oxygenation is uncertain [8-10,18-20].

HFOT has been used in the peri- intubation and post extubation period of abdominal and cardiac surgery, post-surgical respiration impairment, acute heart failure and pulmonary edema, Acute Respiratory Distress Syndrome (ARDS), management of respiratory failure in the intensive care unit, Lung cancer, Pneumonia, Bronchiectasis, chest trauma and ribs fracture, Obstructive sleep apnea, difficult airway management, and during bronchoscopy.

Some studies show that HFOT reduces the need for endotracheal intubation and invasive mechanical ventilation in patients with hypoxemic acute respiratory failure, but has no effect on overall mortality [6-9].

HFOT is increasingly used as part of the basic care management of respiratory failure in the emergency department. In a study, Dr. Raisi and colleagues investigated the effects of HFO in patients with asthma exacerbation and concluded that this method could be considered as an effective strategy in the treatment of acute asthma attacks in the selected patients [12].

Clinical evidence shows that HFOT is an effective method for the early treatment of patients with hypoxemic respiratory failure without paying attention to underlying diseases [1,2,18,20]. We used HFOT as an early treatment strategy in patients during the Covid-19 era. It seemed that HFOT had no effect on the need for intubation and the outcome of the patients, but it reduced the duration of the patient's stay in the Intensive care unit (ICU). It also had significant impact on patient morale and decrease breathing effort. HFOT had a positive effect on extubating time and it reduced the need for re-intubation. We concluded that HFOT in patients whom suffer from severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), improves oxygenation, reduces respiratory rate and dyspnea, and helps patients to be discharged faster, resulting in a shorter ICU stay. This oxygen administration strategy is more economical, especially during the Covid-19 pandemic and the shortage of beds in intensive care units, because mechanical ventilation is not required and oxygen therapy can be started soon in different hospital departments.

In summary, high-flow oxygen administration is known as an effective non-invasive ventilation method and is considered as a simple and reliable alternative to ventilation support in critically ill patients [1]. Various devices are available for use in the HFOT set which deliver maximum flow rates and humidification. As HFOT administration becomes increasingly feasible, we anticipate growth in its use in a wide variety of clinical conditions and envision that the traditional method of oxygen administration may become a thing of the past. High flow oxygen therapy is recommended for people who have respiratory distress and still have low oxygen levels despite using traditional oxygen therapy. HFOT is effective for the treatment of mild to moderate hyper carbic hypoxemic respiratory failure.

We need more accurate evidence to determine basic criteria for HFOT administration during treatment, such as criteria for starting, stopping, using sedation, and determining non-responsiveness in order to intubate the patient and start aggressive ventilation.

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## CONFLICTS OF INTEREST

There are no conflicts of interest.

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