Rollins Medical Solutions, Inc.

Titrated Oxygen Therapy is Safer: Evidence Based Recommendations

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Oxygen as a medication – Brief History

From discovery, charlatan use, to evidenced base therapy

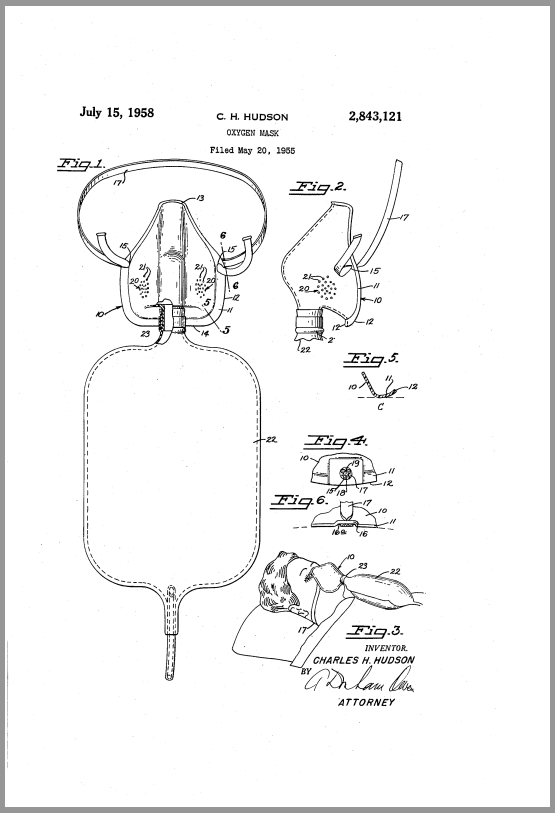
Oxygen- otherwise known as dioxygen – chemical formula 0_2 was Oxygen was discovered independently by Carl Wilhelm Scheele, in Uppsala, in 1773 but credited to Joseph Priestley (pictured on the front page) from Wiltshire England in 1774, as Priestley published the discovery first. The name oxygen was coined in 1777 by Antoine Lavoisier. By the mid to late 1800s oxygen was touted as therapy for everything from anemia to tuberculosis though it was only given several minutes three to four time per day. Oxygen therapy came into its own real science beginning in the early 1900's when CD Haldane reported on the use of oxygen in the treatment of chemical gas injuries to the lungs during World War I.

Over the ensuing years oxygen was administered via hoods, tents, rubber masks etc. A paradigm shift occurred when C.H. Hudson developed the non-rebreather oxygen mask in 1955 (patented in 1958) and heralded in the high concentration oxygen devices. In the1960's reusable material was transitioned to disposable plastics. Today nearly every patient interface with an oxygen delivery device is made from disposable plastic. Other inventions followed as well with the advent of plastic nebulizer devices for medication delivery though there has not been significant innovation to combine O_2 delivery devices with medication delivery devices. This is an issue with patients requiring high oxygen concentrations and at the same time requiring inhaled medication. Additional innovations have occurred with high flow nasal oxygen therapy though these devices are inefficient and expensive.

Early in the development of oxygen therapy was the lack of assessing accurately the effectiveness of O_2. Clinical signs and symptoms were crude and non-specific – for example resolution of cyanosis. A mindset or "philosophy" of oxygen therapy developed into the notion of supporting the patient's minute ventilation. That mindset is still prevalent to some degree today. What was lacking was an easy, non-invasive assessment of oxygen delivery at the tissue or cellular level. The first measurement available was the arterial blood gases though invasive, not entirely easy and not inexpensive but gave excellent insight to tissue oxygenation. Now pulse oximetry has supplemented ABG measurement and is instrumental in the assessment and management of patients with respiratory failure. What has been lacking is an oxygen delivery device capable of harnessing the full potential of the pulse oximetry.

A review of the capabilities of present oxygen masks are rooted in part in anecdotal experience as they have been used for such a long period of time. One such example is the purported oxygen concentration delivered with a non rebreather mask. The standard response from many authorities is 100% though no reference is ever sited. Only one such reference is noted from a poster presentation from a 2003 AARC meeting indicating that the FiO_2 is approximately 56% (http://www.rcjournal.com/abstracts/2003/?id=OF-03-257).

Today standard available oxygen masks comprise the following: simple mask, aerosol mask, venti-mask, partial and non-rebreather masks. Patients experiencing acute respiratory failure often require multiple different masks as O_2 therapy is escalated and deescalated. This process is inefficient and at times unsafe when proper O_2 therapy is not readily available and patients receive too little or too much O_2.



Titrated Oxygen: The Evidence

A rigorous analysis of oxygen therapy as it relates to type of devices or appropriate levels of oxygen in treatment has been lacking in the medical literature for many years. Over the past decade more attention has been paid to this issue. A review of the evidence follows.

(Pictured: patent for CH Hudson's non re-breather mask 1958)

Titrated Oxygen in the pre-hospital setting

(Emergency Medical Services)

In my medical training in the 1980's there were isolated and well documented clinical conditions when too high of oxygen (FiO_2) could cause severe life threatening issues. One such condition was pulmonary fibrosis caused by high oxygen administration in patients receiving the chemotherapy drug Bleomycin. Other conditions were the patients with high pCO_2 levels – administering high concentrations of oxygen might worsen the elevated pCO_2 and result in the patient requiring intubation and ventilator support – but there were no real studies to refer to for guidance until recently. To date the majority of studies have centered on patients with acute exacerbations of COPD (AECOPD) that were treated by EMS personnel.

Figure 1-NON REBREATHER MASK

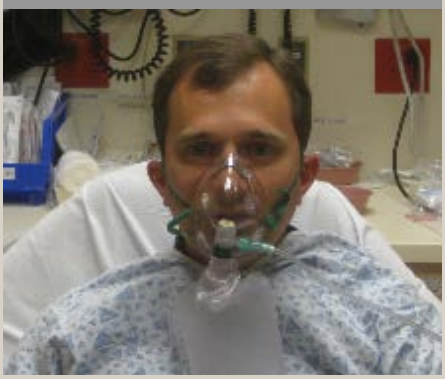


Figure 2- NASAL CANNULA

Effect of excessively high FiO_2

A study in 2002 entitled "The use of oxygen in acute exacerbations of chronic obstructive pulmonary disease: a prospective audit of pre-hospital and hospital emergency management."(Clin Med. 2002 Sep-Oct;2(5):449-51) found in a prospective audit of 101 consecutive episodes of acute exacerbation of COPD demonstrated that oxygen therapy with an FiO_2 in excess of 0.28 is common, potentially deleterious and predominantly initiated in the ambulance. A follow up study from the UK in 2005 (QJM. 2005 Jul;98 (7):499-504. Epub 2005 Jun 13) Initial oxygen management in patients with AECOPD with high concentration oxygen (HCO) caused significant acidosis and inappropriately high PaO_2 and $PaCO_2$, compared to initial low concentration oxygen therapy. There was a significantly increased complication rate during admission in those COPD patients receiving HCO. Identical findings followed in other studies: BMJ. 2010; 341: c5462. Intern Med J. 2011 Aug;41(8):618-22. 10.1111/j.1445-5994. Postgrad Med J. 2012 Dec;88 (1046):684-9. Consensus was a target of 88-92% O_2 saturation was optimal.

In the United States nearly all EMS departments carry only two types of oxygen devices: nasal cannula and a non-rebreather mask. This does not allow for O_2 therapy to be adequately titrated and thus potentially causing an adverse outcome (morbidity or mortality).

High oxygen dosing in cardiac disease

The 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care recommends providers should titrate therapy, based on monitoring of oxyhemoglobin saturation to 94% and that higher values may be detrimental. This is further supported in two review articles, one in published 2009 (Heart 2009;95:198–202) and the other in 2013 (Eur Heart J. 2013;34 (22):1630-1635) indicating most studies suggest that oxygen does not have a beneficial hemodynamic effect and is even harmful. In normal oxygenated patients (SaO2 >90%) with an acute myocardial infarction, oxygen therapy decreased cardiac output and stroke volume and raised systemic vascular resistance. In some studies infarct size actually increased with high O_2 values. This suggests indiscriminate administration of oxygen is unwarranted and titration to a specific value is medically indicated.

Titrated Oxygen in the hospital setting

Studies of hospitalized patients with titrated oxygen therapy has been poorly represented in the medical literature. What does exist primarily comes from the United Kingdom. A study published in 2012 in the JOURNAL OF THE ROYAL SOCIETY OF MEDICINE entitled: “Randomized controlled trial of high concentration oxygen in suspected community-acquired pneumonia” concluded that high concentration oxygen therapy increases the $PtCO_2$ in patients presenting with suspected community-acquired pneumonia. This suggests that the potential increase in $PaCO_2$ with high concentration oxygen therapy is not limited to COPD, but may also occur in other respiratory disorders with abnormal gas exchange (J R Soc Med. May 2012; 105(5): 208–216).

Titrated Oxygen: Summary

Titrated oxygen therapy has been shown to be a “best practice” for patients with pre-hospital AECOPD. This recommendation has been codified in the United Kingdom in a THORAX publication in 2008 (Thorax 2008;63 (Suppl VI):vi1–vi68. doi:10.1136/thx.2008.102947). Quoting:

> “***The essence of this guideline can be summarized simply as a requirement for oxygen to be prescribed according to a target saturation range and for those who administer oxygen therapy to monitor the patient and keep within the target saturation range***.”

In conclusion – given the accumulated evidence to date titrated oxygen should be the standard for all patients with or suspected of having AECOPD in the pre-hospital setting with an O_2 saturation target range of 88-92%. It also seems logically consistent that titrated oxygen therapy should be performed on all patients with AECOPD and strongly considered in patients with community acquired pneumonia who are admitted to the hospital. Additionally, titrated oxygen therapy is best for patient with acute ischemic cardiac disease. ***We conclude that EMS departments and hospitals should maintain an oxygen delivery “system” that allows for titration of FiO_2 and optimally performed with a single device.***

In our research we have also identified a lack of any research on the safety and effectiveness of medication delivery when nebulized medication is given with an oxygen mask not designed for medication delivery. ***We suggest that until such evidence exist the only masks that should be utilized are oxygen masks that are FDA cleared for both oxygen and medication delivery***.

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