Reduced Operating Room Fire Hazard Using Intelligent Supplemental Oxygen Delivery

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Introduction: Fires in the operating room are a major hazard [1]. Mehta et al. reported that 1.9% of all operating room adverse events that resulted in closed insurance claims were caused by fires with electrocautery as the ignition source for 90% of these fires. Most (85%) of electrocautery fires occurred during head, neck, or upper chest procedures (high-fire-risk procedures) [2]. Delivered O2 served as the oxidizer in 95% of electrocautery-induced OR fires and 84% of these occurred when oxygen was given with an open delivery system (nasal cannula or mask) [2]. A significant hazard for fire exists with a 26% or greater oxygen concentration [3]. Using standard oxygen flowmeters, O2 flows continuously into the patient’s nostrils even during exhalation resulting in wasted O2 that flows between the surgical drapes and into the room greatly increasing the amount of fire promoting oxidizer in the operating room.

We have developed an intelligent oxygen flowmeter that reduces the volume of open source O2 delivered by carefully limiting O2 flow to periods during the early phase of inhalation, stopping O2 flow completely during expiration and limiting the rate and duration of oxygen flow during the pause phase of breathing. In our tests, the novel system achieves superior oxygen delivery while using only 60% less oxygen thereby reducing the amount of possible oxidizer by 60% and as much as 90% as respiration rate decreases. The prototype determines respiration rate (RR) and inspiratory effort by measuring intranasal pressure through a cannula port. The system uses measured RR to adjust the O2 volume delivered during each inspiration.

Methods: We used a 3-D printed model of the human airways placed under simulated surgical drapes to compare delivery modes. The model was connected to a test lung that was configured to breathe spontaneously at various rates and volumes. Oxygen was delivered through a nasal cannula at 2 and 4 L/min. Oxygen was given at flow rates of 2 and 4 L/min using both conventional (constant flow) and controlled (pulsed inspired) mode. We analyzed the oxygen concentration at specific places on the face of the model under the drapes (red circles on figure) and interpolated to build a concentration map on the face.

Results: Across all settings and flow rates, the average oxygen concentration under the drapes using pulsed flow r was 38% lower than when using continuous flow oxygen. The average oxygen concentration under the drapes using the pulsed oxygen was 25.0% while it was 40.6% using constant flow. The maximum observed oxygen concentration was 83.27% when using constant flow of 2 l/min and was 35.36% using pulsed flow. We measured the oxygen concentration in the lung simulator to assess oxygenation. Pulsed oxygen resulted in 88% higher average oxygen concentration in the lung. The plot below shows a map of oxygen concentration under surgical drapes on a 3-D printed model of
the face at 4 breaths per minute and 2 L/min oxygen flow. The left side of the plot corresponds to pulsed flow delivery and the right plot corresponds to conventional (constant) flow. Note that oxygen delivery to the simulated lung was higher using pulsed flow for every simulated setting.

**Discussion:** Using intelligent control of oxygen flow allows for a reduction in oxygen waste and hazard while increasing the amount of oxygen inhaled by the patient. Intelligent pulsed oxygen delivery may keep oxygen levels below the 26% threshold for significant fire hazard.

**References:**

