Airway Fire During Jet Ventilation for Laser Excision of Vocal Cord Papillomata

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Supraglottic jet ventilation (SJV) has been shown effective in providing both adequate oxygenation and ventilation for patients undergoing laser surgery.[1] Pitfalls associated with use of SJV are abdominal distension, abnormal forced movements of the vocal cords, and airway desiccation, all of which are easily avoided by proper technique.[2] One purported major advantage of SJV in addition to a good operative field, is the elimination of extraneous combustible material such as an endotracheal tube from the airway.

This report illustrates a potentially dangerous situation associated with SJV and a CO_2 laser. An errant laser ignited combustible material (a surgical glove) outside the oropharynx. The resultant burning vapors were entrained by the jet into the airway. The burning oxygen-enriched mixture was spread by exhalation around the laryngoscope and caused facial burns despite the fact that the patients face was covered with soaking wet draping.

Case Report:

A 35 year-old male presented for laser ablation of recurrent laryngeal papillomata. Nine months previously he had undergone an uncomplicated anesthetic with endotracheal intubation for ablation of these papillomata at another hospital. History and physical exam were unremarkable other than a 20 pack-year smoking history, a bushy moustache, and a weight of 129 kg. After oral diazepam premedication , he was taken to the operating room and monitored with Standard ASA recommended monitors (blood pressure cuff , pulse oximeter, ECG, end-tidal CO_2, and temperature). Anesthesia was induced with thiopental and fentanyl. Vecuronium was given to provide relaxation. Mask ventilation with O_2, N_2O, and isoflurane was without problems. When the response to a peripheral nerve stimulator disappeared a anesthesia appeared to be adequate the surgeon inserted an adult Dedo laryngoscope. Jet ventilation was instituted with oxygen via a 13 gauge cannula inserted in the left light-carrier channel of the Dedo laryngoscope. A thumb-controlled valve and 50 psi oxygen from the piped-in system powered the jet.

The patient's face and the perioral area were covered with soaking wet towels to the extent that only the barrel of the Dedo laryngoscope was visible. Anesthesia was maintained with thiopental and fentanyl during jet ventilation. There were no problems, although arterial oxygen saturation (SaO_2) dipped briefly into the high 80% range during episodes of apnea requested by the surgeons to eliminate movement of the vocal cords. Spot checks of end-tidal CO_2 during jetting were in the 30-40 mm Hg range.

Near the end of the surgical procedure, the surgeon yelled "Fire" and bright blue and orange flames accompanied by a muffled roar were observed coming out

of and around the laryngoscope. Jet ventilation was stopped, the towels removed, and the patient's blazing moustache extinguished with the wet towels. The surgeon, was in a great deal of pain, and noted that two of the fingers on his right hand had had the latex glove burned completely away. (Figure 1). The Dedo was removed and bag-and-mask ventilation was commenced until a rigid bronchoscope could be inserted. No carbonaceous material was found in the trachea, and except for the evidence of lasering, the glottis was normal. Muscle relaxation was reversed and the patient awakened. Recovery from anesthesia was otherwise not remarkable.

The patient suffered a second degree burn to his right upper lip which was treated with Silvadine and healed over the next two weeks without further incident. (Figure 2) Although the patient's nasal hairs were burned indicating the presence of airway fire there were no laryngeal or other internal or external injuries. The surgeon suffered second degree burns of the right index and middle fingers

Discussion:

SJV is a useful technique for removing CO_2 and oxygenating patients during laser ablation of laryngeal papillomata and other masses of glottic and subglottic regions. SJV, as with any technical skill, is not without problems. Desiccation of the airway can occur. The surgeon must periodically irrigate the tissues. Excellent coordination between surgeon and anesthesiologist is necessary to maintain a patent airway during surgery. The availability of short acting muscle relaxants, hypnotics and opiates have overcome our inability accurately to deliver volatile anesthetics via jet ventilation (plus our inability to scavenge waste them).

This patient experienced an unusual complication of SJV. An errant laser strike on the surgeon's latex glove ignited the glove, producing enough hot volatile fuel to be entrained by the jet ventilator. Combustion of the latex accelerated dramatically in the oxygen-enriched atmosphere of the airway. The expanding gaseous products of combustion were exhaled via either the patient's nose or his mouth and in turn ignited his mustache despite the drapes. It would be difficult to say to what degree the patients mustache contributed to his facial burns, or whether combustion alone under the drapes would have been adequate to cause the degree of injury sustained.

All recommended precautions against direct laser strike injury were taken. The airway contained no extraneous flammable material and the patients face was shielded from direct laser strike by soaking wet drapes. This incident occurred despite those precautions. The presence of high concentrations of O_2 in the airway clearly contributed to this incident. In this patient, the jet used pure dry O_2 utilizing the venturi effect to entrain room air. At the end of inspiration the SJV ceases to maintain the venturi effect and no longer entrains room air to dilute the oxygen.

When the venturi effect is no longer contributing to ventilation the jet is said to be "stalled." The oxygen injected via the jet ventilator during late in inspiration collects in the pharynx and some is passively exhaled via the laryngoscope. However, the majority of oxygen enriched exhalation occurs through the mouth and nose under the drapes.

The Venturi effect cannot reliably be counted upon to entrain enough room are to prevent hazardous accumulations of O_2 or N_2O. In this case the wet drapes provided a reservoir for gases containing elevated oxygen concentration. Dilution of O_2 with N_2O would not have provided any additional margin of safety because nitrous oxide supports combustion more readily than oxygen and because equivalent amounts of fuel will produce more thermal energy when consumed in an excess supply of N_2O than in O_2.[3]

This incident does not mean that SJV should be abandoned in favor of more traditional methods of ventilation. Use of SJV eliminates the presence of a flammable polyvinyl chloride (PVC) endotracheal tube.[4] In this patient an errant laser strike igniting a combustible endotracheal tube may have caused complications more serious than a burned mustache and lip. Ignition of a PVC endotracheal tube in the presence of combustion supporting gases such as O_2 and N_2O could produce injury from the inhalation of HCN, Phosgene, HCl and Cl_2 in addition to thermal injury.[5,6,7]

So-called laser endotracheal tubes are not without problems. Often laser tubes are bulky relative to the inside diameter causing high airway resistance and may be prone plugging with secretions. Unless the tubes are made of flexible metal and have fluid filled cuffs they do not provide complete protection from ignition.

SJV has clear advantages over endotracheal intubation for certain laser procedures. Nevertheless, SJV does have its disadvantages, and the anesthesiologist must always remain alert to the risk of fire despite apparent absence of combustible material placed in the airway. The risk of fire is always present when increased O_2 concentrations and high energy sources (laser and electrocautery) are present in close proximity. With care this risk can be minimized.

It has been shown by Sosis[8] that N_2 insufflation decreases the flammability of PVC. N_2 would also decrease the combustion rate of other material including tissue, hair and drapes. In the modern operating room anesthesia is almost always delivered using A.S.A. recommended monitoring devices. In the time of almost universal availability of pulse oximetry, air or nitrogen could be blended with oxygen to decrease the risk of combustion.

One goal in SJV should be to ventilate with the lowest oxygen concentration consistent with patient safety. 100% O_2 is not always necessary to maintain adequate SaO_2. O_2 concentration should be decreased whenever possible by blending with N_2 or air to reduce the possibility of unwanted combustion. A suitable SaO_2 should be determined individually by pre-operative SaO_2 measurement if the patient is stable. For patients with ischemic cardiovascular or cerebrovascular disease, acceptable SaO_2 levels would have to take into account limited cardiac and circulatory reserve.

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