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Fire in the Surgical Center

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Abstract: Almeida CED, Curi EF, Brezinscki R, Freiras RC – Fire in the Surgical Center.

Background and objectives: There are several factors in operating rooms that increase the risk of fire. Besides being an oxygen-enriched environment, it contains combustible materials and equipment with available ignition sources. Although fires in operating rooms are a relatively rare event, the consequences are potentially serious and mostly avoidable. We present a case report of a fire occurring in the surgical drape during a blepharoplasty in which oxygen was supplemented by nasal catheter.

Case Report: Female patient, 52-years old, without comorbidities, admitted to hospital for a bilateral blepharoplasty. After monitoring and venoclysis, the patient underwent intravenous sedation and additional oxygen given via spectacle-type catheter at a flow rate of 4 L.min^{-1}, followed by local anesthesia in the eyelids. During surgery, the use of electric scalpel provoked combustion in the surgical drapes and burns on the patient's face.

Conclusions: Anesthesiologists play an important role preventing fire in operating rooms, as they can recognize possible ignition sources and rationally administer the oxygen, especially in open systems. The first step toward prevention is to be constantly aware of potential fire.

Keywords: Anesthesia; Electrosurgery; Fire Prevention and Protection; Operating Rooms; Safety Management.

INTRODUCTION

The introduction of new nonflammable inhalational anesthetic agents reduced the anesthesiologist's concern about the risk of fire in operating room. However, the development of ignition equipment such as electric scalpels, lasers, defibrillators and endoscopes associated to an oxygen-enriched environment kept the risk of fire as a constant possibility.

The United States estimates 100 fire occurrences in operating rooms per year. However, it is difficult to determine the real incidence, as the literature only describes the cases in which the patients were injured or in which there were deaths. Although infrequent, it is a potentially severe situation that must be usually avoided [1].

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We report a case of fire occurring in the surgical drape during a blepharoplasty performed under local anesthesia associated to intravenous sedation with oxygen given via a spectacle-type nasal catheter.

CASE REPORT

This is a case of a fifty -year-old female patient without comorbidities undergoing bilateral blepharoplasty monitored by pulse oximetry, electrocardioscopy and automatic noninvasive arterial pressure. After venoclysis, the patient underwent intravenous sedation with midazolam 5 mg and fentanyl 50 μg. The patient was given supplemental oxygen through spectacle-type catheter at a flow rate of 4 L.min^{-1}. Antisepsis with topical chlorhexidine was performed and the surgical drape with openings was positioned. As the opening totally exposed the patient's face, the surgeon used a compression garment to restrict the lower limit of the surgical drape.

The surgeon used infiltration of 1% lidocaine with vasoconstrictor in the eyelids. In order to promote hemostasis, the surgeon used a monopolar electric scalpel. After approximately 10 minutes of procedure, it was necessary to increase the scalpel's power to obtain an appropriate hemostasis. After cautery operation, the compression garment caught fire and the flames spread through the oxygen catheter and the patient's face. The oxygen flow meter was turned off, the surgical drapes were removed, the combustion region was irrigated with physiological solution and the fire was extinguished. The patient had first degree burns in the lips, nostrils and in the zygomatic region.

DISCUSSION

In order to start a fire, three elements must be present: heat or an ignition source, a fuel source, and oxygen (oxidant). These three elements constitute the so-called “fire triad”. These agents must be present at the same time and place in order to start a fire. As all operating rooms are oxygen-enriched environments, and contains flammable materials and ignition sources, prevention is based on reducing and separating these agents.

The most frequent ignition source involved is the electric scalpel used in about 85% of the surgeries. The instrument is related to 100% of fires associated to anesthesia monitoring [2]. There should be a safe distance from the oxygen source, and surgeons should use the lowest possible power. If the surgical site is close to the oxygen catheter, it is recommended to interrupt the oxygen flow when using the scalpel.

In the case described, the ignition source was the electric scalpel. The use of the monopolar system may have facilitated the incident, as a higher power is necessary for electrocoagulation in this system – when compared to a bipolar one [3,4].

Laser is another common ignition source. There are reports of combustion of the endotracheal tube with potential risk to the airways in otolaryngology surgeries. The tubes made of polyvinyl chloride (PVC) or silicone are flammable even when the oxygen concentrations are lower than 26%; therefore, they are not appropriate to be used together with lasers [5]. There are laser-resistant endotracheal tubes available on the market, but under certain circumstances they can start to ignite. The fraction inspired oxygen (FiO_2) should be limited to 30% or less, and nitrous oxide should not be used.

The popularization of minimal invasive surgeries introduced to surgical centers new sources of light for the fibroscopic equipment, but the fiber-optic light can generate enough heat to start combustion [6].

Antisepsis should introduce potential fire hazard [7]. Most of the available preparations are alcohol-based agents. Chlorhexidine based in 70% alcohol ignites at 900ºC. However, in a 100% oxygen environment, the ignition point starts between 30°C to 70°C. The electrosurgical equipment can reach high temperatures and produce heat capable of initiating combustion in almost all alcohol-based antiseptics, even with a 20% alcohol concentration [8]. Vapor caused by alcohol evaporation due to the skin heat can facilitate combustion. Risks increase when the antiseptic spreads throughout the surgical drapes and accumulates in the patient’s hair, back, skinfold and in the surroundings of the surgical drape. Special attention should be given to the required drying time. If the patient is draped before complete drying, vapor can be channeled to the surgical site, favoring combustion [9]. The presence of hair can delay antiseptics’ drying time. The effective drying time can be higher than what is described by the manufacturer in some products, taking five minutes in some cases [10]. Dye, ether and acetone are also dangerous agents found in operating rooms.

Several materials found in the operating room are potential fuels. Patients are frequently close to materials containing fabric or paper. Even the nonflammable synthetic surgical drapes resistant to flames can ignite in an oxygen-enriched atmosphere [11].

When oxygen concentration exceeds 21% or its partial pressure is higher than 160 mm Hg, the area can be considered an oxygen-enriched environment. An oxygen concentration of 26% to 28% is necessary to increase the combustion rate. Therefore, the International Electrotechnical Commission (IEC 1977) does not suggest additional precaution in environments with oxygen concentration 4% higher than ambient air (24.9%) [12].

Most of fire cases in operating rooms are related to procedures involving anesthetics and the use of open systems to provide oxygen, such as nasal catheter and facial masks [13].

Air renewal rate of operating rooms can easily spread the oxygen that is not used, provided by catheters and masks. However, the proximity of the surgical site to the nasal region creates an environment favorable for combustion.

A recent study demonstrates oxygen concentration in several landmarks on the face of the volunteer receiving oxygen through nasal catheter at flow rates of 2, 4 and 6 $L.min^{-1}$. Surgical drape was positioned to simulate a neck node biopsy. At 2 $L.min^{-1}$ only one corner of the lips (left one) presented concentration higher than 24.9%. At 4 $L.min^{-1}$, both lips’ corners, the jaw symphysis and the hyoid bone presented critical concentration. All the critical landmarks were less than 10 cm away from the catheter outlet. However, at 6 $L.min^{-1}$, all landmarks presented a concentration higher than 24.9%, except for the glabella and the septal nucleus of the right eye [12].

Many reports mention the accumulation of oxygen under the surgical drapes or compression garments, creating the so-called oxygen-enriched tent [10]. Another important contributing factor to oxygen concentration is density. Oxygen is heavier than ambient air and it tends to accumulate in lower regions. The use of exhaust systems located under the surgical drapes minimizes the risks of combustion.

In the case reported, the use of a compression garment to reduce the opening of the surgical drapes has probably produced an oxygen-enriched area.

Nasopharyngeal catheter can be used instead of the spectacle-type nasal catheter. Oxygen supplementation at 3 $L.min^{-1}$ via nasopharyngeal catheter has proven to reduce oxygen concentration at landmarks close to the patient’s neck and face, if compared to the traditional technique [14]. An alternative is to deliver sub-100% oxygen with nasal catheter via flowmeter of the anesthesia machine or by blenders [15].

Oxygen delivery in procedures requiring anesthesia, or sedation in surgeries performed close to the head and the neck regions should be carefully considered. Facial occlusion by surgical drapes associated to anxiety usually makes necessary to increase sedation, becoming imperative the use of oxygen [16]. The use of the smallest possible fraction of oxygen, of low flows and of exhaust systems minimizes the risks of combustion.

When combustion starts, it is important to take precocious measures to avoid the “fire triad”. The first step is to interrupt the oxygen flow through the respiratory system. Then, all combustible materials such as compression garments, gauzes and surgical drapes should be removed from the patient's surroundings. It may be necessary to irrigate the surgical drapes or fabrics with serum or water. Although many surgical centers use fire sprinklers, in most of the cases they are ineffective in operating rooms, as the fire sprinklers are rarely positioned on the surgical table [1].

Fire in the surgical center usually produces a great quantity of smoke and toxic products due to synthetic material burn. Combustion may produce carbon monoxide, ammonia and cyanide. In addition to fire control techniques, evacuation procedures should be modeled.

All personnel should be familiar with fire extinguishers location and use. Fire extinguishers have three different classes: Class A: used in solid fuels, such as fabric, plastic, paper and wood; Class B: used in flammable liquids and grease, and Class C: used in energized materials.

There are fire extinguishers composed with water, carbon dioxide, foam, and powder. Water fire extinguishers are not suitable for fuels and electrical equipment (Classes B and C) due to the risk of spreading flammable liquid and causing electrocution.

The carbon dioxide (CO_2) extinguishers can be used for Classes A, B and C fire. However, its residue can damage electrical devices. These extinguishers contain liquid CO_2 under pressure. The mechanisms involve cooling (expanding) and eliminating the oxidant from the surrounding area, as it is heavier than the oxygen.

There are chemical or mechanical foam extinguishers. Both use water for smothering and cooling; therefore, they are useful for Classes A and B fire. They are not recommended for Class C fire, due to electric shock risk. Unlike other extinguishers, they should be used upside down, with the ejector positioned in the bottom.

Basically, the powder fire extinguishers consist of sodium bicarbonate (95%) and act as smothers. This type is recommended for Class B fire. They are not much effective in Class A fire, and although powder is not a good conductor, the powder fire extinguishers should be used with caution in Class C fire.

The carbon dioxide extinguishers are the safest option to be used in the operating room, as the carbon dioxide dissipates quickly and is not toxic. Additionally, the lever and the handle limit the shooting time by the operator, minimizing the risks of cold thermal injury. Water fire extinguishers may be an alternative to be used in magnetic nuclear resonance rooms due to the possibility of being manufactured in non magnetic material at low cost [17].

Surgeons and the personnel involved must be aware of the material composition, the appropriate distance from the oxygen source, the appropriate use of antiseptics, as well as the ignition sources.

Anesthesiologists play an important role in fire prevention in operating rooms, as they can recognize possible ignition sources and rationally administer the oxygen, especially in head and neck surgeries with oxygen delivery in open systems. Most of retrospective combustion reports presented obvious risks of fire. Therefore, the first step toward prevention is to be constantly aware of potential fire.

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