Case Report

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Wire-reinforced endotracheal tube fire during tracheostomy -A case report-

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Every operation could have a fire emergency, especially in the case of a tracheostomy. When a flammable gas meets a source of heat, the danger of fire is remarkable. A tracheal tube filled with a high concentration of oxygen is also a great risk factor for fire. Intra-tracheal tube fire is a rare, yet critical emergency with catastrophic consequences. Thus, numerous precautions are taken during a tracheostomy like, use of a special tube to prevent laser damage, ballooning of the tube with normal saline instead of air, and dilution of FiO_2 with helium or nitrogen. Since the first recorded cases on tube fires, most of the fires were initiated in the balloon and the tip. In the present case report, however, we came across a fire incidence, which originated from the wire. (Korean J Anesthesiol 2012; 63: 157-160)

Key Words: Airway management, Burns, Complications, Tracheostomy.

In the case of certain operations, especially in tracheostomies and in the oral region, there could be an occasional risk of fire [1]. When flammable gas leaks and comes into contact with a heat source, the risk of fire becomes very large; and not only the gas itself, but also the entire tube and presence of high concentration of oxygen can further increase the risk of fire [2,3].

Intra-tracheal tube fire is a rare, yet critical emergency with catastrophic consequences. Since it mostly occurs in operations near the trachea, many efforts have been carried out to prevent such situations. A few examples are using special blocked tubes in laser surgery, filling the tubes with normal saline instead of air, diluting the FiO_2 with helium or nitrogen, or leaking a certain amount of nitrogen around the endotracheal tube [4]. However, in a tracheostomy, reinforced tubes or tubes already in possession are employed. In addition, even in specifically produced tubes for lasers, the balloon can be directly exposed to the laser or heat source. Most of the cases until now had fires initiating in the balloon or in the tip of the tube [2,3]. However, in the present case report, we are reporting an incidence of fire, which initiated in an area where the reinforced wire was wound around the end of the balloon.

Case Report

A 54-year-old male patient with a height of 170 cm and weight of 77 kg visited a private hospital due to a headache and weakness in left muscle that started the day before his hospital visit. During the examination, the patient showed decreased

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consciousness, and internal hemorrhaging in the cerebral ventricle was observed in the CT scan, hence he was transferred to our hospital. When he arrived at the emergency room, the patient was semi-conscious and had difficulty in breathing, and his Glassgow coma scale (GCS) showed severe head trauma with a total score of 8 or lower. The head CT scan revealed worsened stage of hemorrhage in the cerebral ventricle, so he was immediately intubated and transferred to the ICU.

A day after entering the ICU, the hemorrhaging in the patient was still worsened according to the CT scan and he was in a semi-comatose state; therefore, an extra ventricular drainage (EVD) was done to decrease the pressure in the brain and hematoma aspiration was also carried out. In addition, an emergency tracheostomy was done at the same time since long term mechanical ventilation was expected. There were no premedications given to the patient. Preoperative vitals were a blood pressure of 150/80 mmHg, a heart rate of 100/min, a respiration rate of 24/min, a body temperature of 38°C, and a SpO_2 of 97%. After administering 0.2 mg of glycopyrrolate, anesthesia was induced with 125 mg of thiopental sodium. After complete loss of consciousness, muscle relaxation was achieved with 8 mg of vecuronium. Alfentanil at a concentration of 1.0 mg was administered to minimize hemodynamic changes when replacing the tube and at the same time anesthesia was maintained with O_2 supply of 1 L/min, air supply of 2 L/min, and 2.0 vol% of sevoflurane. Considering the difficulty in maintaining airway characteristics in head surgery, the previously intubated polyvinylchloride (PVC) plain tube was replaced with a reinforced tube. The patient's vitals immediately after intubation were blood pressure of 130/70 mmHg, a heart rate of 95/min, and a SpO_2 of 98%. Starting from the EVD, the operation proceeded smoothly and the tracheostomy was done in 2 hours and 30 minutes. Ten minutes after starting the tracheostomy, the FiO_2 increased to 1.0. While adjusting for bleeding around the tracheal cartilage with monopolar coagulation before inserting the tracheostomy tube, a fire of about 15 cm in size suddenly started perpendicular to the direction of the trachea. The supply of sevoflurane and 100% O_2 was immediately stopped after the initiation of fire and manual ventilation was done at a FiO_2 of 0.2. Normal saline was used to extinguish the fire and soon the condition was brought under control. The endotracheal tube (reinforced tube) was taken out, tracheostomy tube was intubated to maintain manual ventilation, and SpO_2 was again increased to 98%. Vitals before and after the tracheostomy were stable except for the temporary decrease in SpO_2. The condition of the tube after extubation was as follows: the part directly above the cuff had holes due to melting from the heat; the coil inside the tube had melted, and there was overall charring (Fig. 1). The operation was completed without occurrence of any further incident, and since the patient was still in a semi-coma state, he was transferred to the ICU while maintaining bag ventilation through the tracheostomy tube. In the ABGA conducted directly after being transferred to the ICU, the pH was 7.406; the pCO_2 was 33.6 mmHg; the pO_2 was 121 mmHg; the HCO_3 was 20.7 mmHg, and oxygen saturation was 97.8%. There were no observable changes in the chest x-rays both, before and after the operation (Fig. 2) and no irregularities were observed in the bronchial endoscopy. The patient showed no improvement in consciousness during continuous mechanical ventilation; therefore, 5 days after the surgery, the patient was transferred to another hospital as per the wishes of the guardian. There were no irregularities in the chest x-ray images and clinical symptoms after being monitored for 4 months post-surgery (Fig. 2).

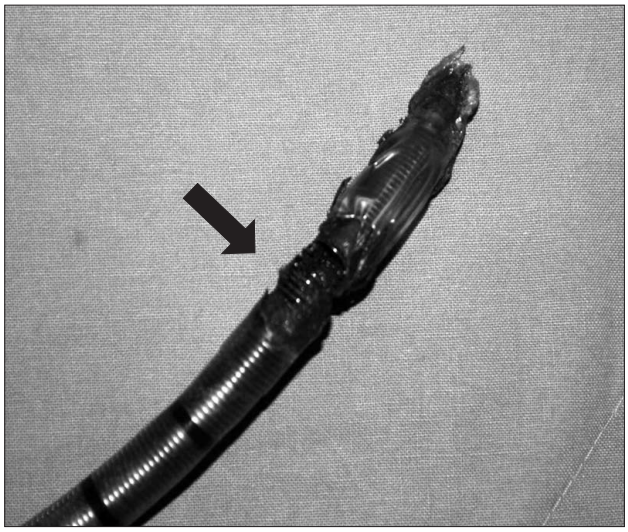

Fig. 1. The burnt wire-reinforced endotracheal tube and the ignition point (arrow).

Discussion

Intra-tracheal tube fire is rare and yet a critical emergency that can cause fatal complications. Despite numerous studies on the cause and prevention of fire, there have been upcoming reports from time to time including this recent occurrence. Of course, when a fire occurs, the type of operation and the cause for the fire are different. It can occur during operations using lasers, in tracheostomies, and there exists reported incidents for double-lumen tubes [5].

The three important factors that contribute to the occurrence of intra-tracheal fires are oxygen, fuel, and heat. The high concentration of oxygen is the main cause of fire [6], but there are reports of fires occurring at 50% oxygen concentrations and can even occur in 25% oxygen environments, which is similar to the atmosphere [4]. Therefore, caution is needed especially

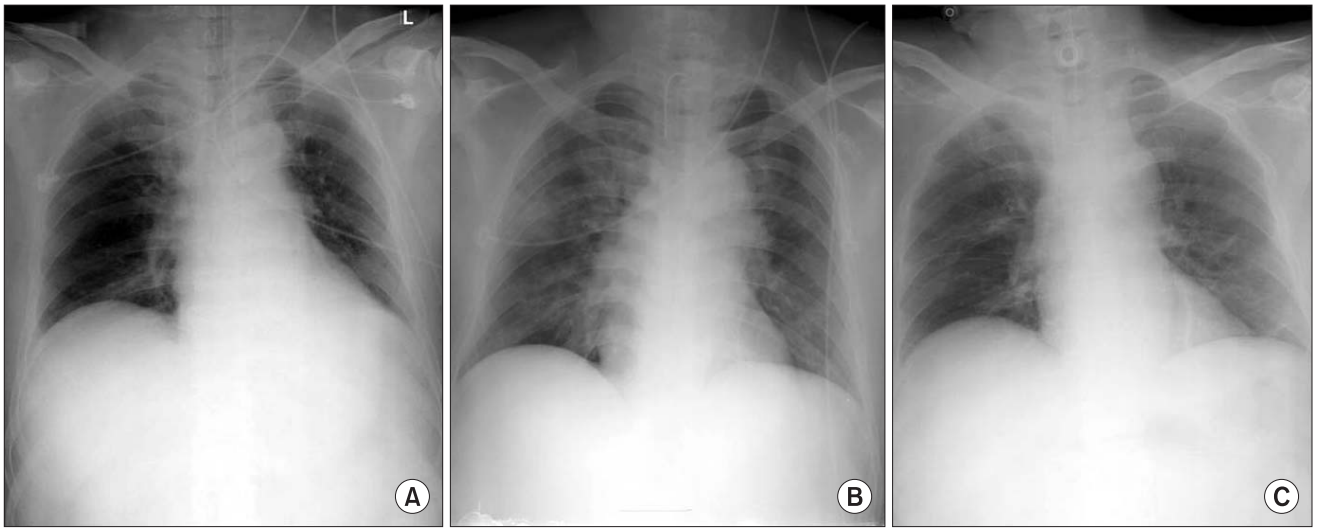

Fig. 2. (A) Preoperative, (B) Postoperative, and (C) Follow up chest X-rays reveal unremarkable findings.

in tracheostomy since 100% highly concentrated oxygen is typically used, which is characteristic of the operation. For fuel, the intra-tracheal tube itself is the problem since tubes generally consist of PVC material. In tracheostomy, the risk of fire is increased since fire-resistant tubes are not used, unlike in other laser operations. Our present case also employed a reinforced tube, since tracheostomy was done after the neurosurgery, which is believed to be one of the reasons for the fire. Electrocautery is one of the possible heat sources. There are reports of heat occurring in all modes of cutting, coagulation, and blending [4]. Therefore, when doing a tracheostomy, the use of electrocautery is minimized or a bipolar is used, but the bipolar can also cause sparks while coming into contact with tissue; so it cannot be considered as a completely safe alternative. Our case also considered these points and tried to minimize the use of electrocautery during the operation. However, it is believed that the reinforced wire was exposed due to damage to the tube cover during the process of cutting into the mesh. There was immediate occurrence of hemorrhage before inserting the tube, and while urgently trying to control the bleeding, the electrocautery and reinforced wire are believed to have reacted to initiate the fire.

Although there are a number of reports on intra-tracheal tube fires and numerous reports on the review, prevention, and countermeasures of tube fires, currently there are no accurate protocols established regarding this situation. However, when similar cases and reports are put together, there are some common suggestions and advice, which can be organized as follows [2,4,7]: 1) Use a tube of sufficient length so the tip of the tube can reach directly above the carina to minimize the possibility of damaging the balloon during tracheostomy, 2) avoid using flammable gases for anesthesia, 3) fill the balloon with normal saline, 4) maintain the safest minimum level of FiO_2 when using nitrous oxide or helium, 5) remove the by-products of the electrocautery (smoke, burnt tissue) through a sufficient amount of suction before performing the tracheostomy, 6) insert the tube deeply before the tracheostomy, 7) the surrounding area needs to have sufficient hemostasis before proceeding and avoid using electrocautery for the tracheostomy, and 8) when there is hemorrhage after a tracheostomy, carry out ligature of the hemorrhage with the tube and cuff in place, or use bipolar electrocautery.

There are also reports, which state that PEEP ventilation can decrease the risk of fire [8]. Whereas, Rhee et al. [9] reported that by filling the balloon with normal saline and mucous lidocaine, tube fires can be prevented that can occur in laser operations as well as maintain the shape of the balloon and ventilation when there are punctures in the air balloon due to fire and other incidents. Additionally, maintaining the aridness of the operating room to prevent fires and preparing containers and ambu bags with normal saline in case of fire emergencies are also considered as important factors.

The above-mentioned methods may prevent fire emergencies, but necessary countermeasures to combat the occurrence of fire must also be devised. The anesthesiologist needs to first check the state of the patient, quickly separate the pipe streaming anesthetic gas from the tube, and attempt ventilation with atmospheric air. At the same time, there needs to be cooperation amongst the surgeons to extinguish the fire.

Dealing with a tube that has been on fire is another part that should not be ignored. There is controversy regarding immediate extubation after the incidence of a tube fire. In the

past, immediate extubation was recommended considering the chemical risks due to the evolution of toxic substances from the burnt tube and the damage to the trachea [10]. However, Chee and Benumof [11] argue that immediate extubation is not always the best option, considering that the damage from the fire is minimal in most of the cases of fire reported until now; most of the patients undergoing tracheostomies have difficulties in maintaining their airways due to edema, which is the leading cause of morbidity and the increase in the death rate in accidents involving anesthesia is hypoventilation and hypoxia. In our case, immediate extubation and intubation of the endotracheal tube were done, but in post-operative examinations, there were no problems with the trachea itself and there was no chemical damage. It is most important to consider the risk benefit on a case-by-case basis rather than setting a general rule regarding the timing of the extubation.

In conclusion, it is important in tracheostomies to understand that though occurrence of fires are rare, they are still possible along with other risk factors and the surgeons must be attentive in terms of preventing the occurrence of fires. Caution needs to be taken, since tube fires can occur in unexpected areas such as the reinforced wire in our case. In addition, when a tube fire does occur, it is very important to minimize additional damage or burns in the respiratory tract through appropriate and fast responses, and to determine a suitable time for extubation according to the specific situation.

Acknowledgments

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