Anesthesia Quality Institute®
American Society of Anesthesiologists®

Learning From Others: A Case Report from the Anesthesia Incident Reporting System

Case 2020-08

65-year-old female presented for right total knee replacement. The patient had a history of HTN, OSA, obesity and DM. BMI=35. Pre-op labs were unremarkable.

The case was done under spinal anesthesia with adductor canal block. The intraoperative course was unremarkable.

In PACU, oxygen was applied at 8 liters/minute via FM to maintain O2 sat >92%. No apneic episodes were noted. Additionally, the anesthesia provider ordered supplemental oxygen to be administered via FM with incentive spirometry on the surgical ward until 19:30 p.m. due to presumed atelectasis.

The patient was discharged to the surgical ward at 13:07 p.m. and was maintained on 4 liters/minute nasal cannula throughout the night.

At 04:30 a.m. on POD#1 the patient was noted to be awake and alert and was given PO Oxycodone for 4/10 pain. At 6:20 a.m. a code blue was called when the patient was found unresponsive.

CPR was initiated. The anesthesia team had difficulty intubating the patient. A video laryngoscope was used and a 7.0 ETT was placed after two attempts. Gel defibrillation pads were applied to the chest and a shock of 200 joules was applied for v-fib without incident. Ten minutes later another shock was required for v-fib at 300 joules.

Upon application of the second shock an electrical arc ensued igniting a fire which immediately engulfed the patient spreading cephalad to the Ambu®-bag. The fire was extinguished using a combination of smothering, water, and eventually a fire extinguisher.

Resuscitation efforts were continued but were unsuccessful. The patient expired at 6:43 a.m.

After effects:

- *Five staff members were treated in the ED for smoke inhalation*
- *One RN suffered second-degree burns to the arm*
- *Bed, sheets, and video laryngoscope cord were burned*
- *Staff involved in the case were emotionally traumatized*

Fires resulting from defibrillation are a well-described phenomenon during an attempted resuscitation. In fact, the ECRI Institute has twice published reports about them in 1994 and 2005 (*Health Devices* 23:307-9; *Health Devices* 34:423-5). Unfortunately as this AIRS case report illustrates, fires like these continue to occur and therefore a review of the mechanism and strategies to prevent them are timely.

As with OR fires, defibrillation fires require an ignition source, a fuel, and an oxidizer such as an oxygen enriched environment. In this case, the fire was ignited due to the arcing that occurred as a result of poor contact of the gel defibrillation pads with the patient's skin. After the fact, a crease in the defibrillation pad was noted with burn markings clearly visible in this crease. Other causes of poor contact with the patient can also lead to arc formation; an insufficient or excessive amount of conductive gel, use of the wrong gel (e.g., ultrasound gel), application of paddles over irregular surfaces (e.g., bony prominences, wires, ECG electrodes), or misapplication of paddles (e.g., the metal surface of the paddle not completely on the pad, a fold in the pad, a pad smaller than the paddle's metal surface, a dry pad) (*Health Devices* 23:307-9). In patients with a large amount of chest hair, it is recommended that the patient be shaved prior to application of the gel pad. In most resuscitation scenarios this is likely not practical. A slightly less time-consuming alternative has been suggested. Apply the adhesive gel pad to the hirsute surface and remove rapidly and reapply a second set of gel pads (e.g., "wax job").

The most common fuels in these scenarios are alcohol preps, bed linens or clothing, and body hair. The presence of fine vellus hair has been implicated in promoting a particularly curious physical phenomenon described as surface-fire flame propagation (SFFP). In an oxygen-enriched environment, the fire ignites each small hair or fabric fiber which in turn ignites the adjacent fiber until the flame front meets an edge and either establishes a flame or burns out (*Health Devices* 23:307-309). A very graphic illustration of this can be seen in a demonstration conducted in the 1960s by the British Royal Air Force at the Institute of Aviation Medicine (asamonitor.pub/2YWqKWv).

Finally, the most important element required to produce a fire in this setting is an oxygen-enriched environment. In this case there were two sources of oxygen that contributed to the enriched oxygen environment. When the code team initially started ventilating the patient, the Root Cause Analysis revealed that the team removed the nasal cannula from the patient and tucked it under the patient without shutting off the oxygen flow at 4 liters/minute. Secondly, when it came time to defibrillate the patient, the Ambu®-bag was disconnected from the endotracheal tube and placed next to the patient's shoulder. High flow oxygen continued to flow out of the reservoir end of the Ambu®-bag onto the patient's torso.

Given that oxygen is slightly denser than nitrogen (*Plast Reconstr Surg* 1995;95:978-84), in a tightly enclosed space with little disruption of air flow, an oxygen rich layer of gas can accumulate over the patient's chest. Should the Ambu®-bag or mechanical ventilator in fact be disconnected from the endotracheal tube during defibrillation? A study by Robertshaw and McAnulty examined various oxygen concentrations around a patient during a simulated cardiopulmonary resuscitation (*Anaesthesia* 1998;53,634-7). The authors concluded that there was no significant increase in the oxygen concentration surrounding the patient when the endotracheal tube was left connected. Conversely, they did find a high concentration of "pooled" oxygen around the patient when the Ambu®-bag was disconnected and left nearby but oxygen was left flowing at high rates. Removal of the oxygen source >1 meter from the site of defibrillation however did not result in areas of high oxygen concentrations around the patient.

While it has become routine for perioperative staff to receive regular fire safety education, this practice is less common for critical care staff and those responding to codes on the floor. The following preventative strategies should be reviewed with these team members as well as with our own anesthesia colleagues who routinely respond to codes:

- Review the "Fire Triad": oxidizer, igniter, fuel
- Remove nearby fuels (clothing, linens, towels) prior to defibrillation
- Prevent arcing by ensuring good contact of defibrillation pads with the patient
- Prevent creating an oxygen-rich environment
  - Remove all sources of oxygen (>1 meter)
  - Do *NOT* disconnect Ambu®-bag from ETT during shock (*Resuscitation* 2015;95:100-47; *Resuscitation* 2010;81 Suppl 1:e71-85)
  - If disconnected, remove Ambu®-bag >1 meter away
  - Direct bag reservoir away from the patient's body
- "All clear" check should include free flow O_2 and pad contact.

While a rare event, defibrillation fires can be particularly gruesome and devastating to both the patient and to the providers. Elevated awareness of this phenomenon and education on how to prevent such fires should be a routine part of ACLS certification. ■

ASA is interested in collecting vaping-specific data to formulate recommendations for anesthesiologists taking care of these types of patients. The AIRS database is now capable of receiving data for this purpose. Please enter any available information at **www.aqiairs.org**.

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Review of unusual patient care experiences is a cornerstone of medical education. Each month, the AQI-AIRS Steering Committee abstracts a patient history submitted to the Anesthesia Incident Reporting System (AIRS) and authors a discussion of the safety and human factors challenges involved. Real-life case histories often include multiple clinical decisions, only some of which can be discussed in the space available. Absence of commentary should not be construed as agreement with the clinical decisions described. Feedback regarding this article can be sent by email to **airs@asahq.org**. Report incidents at **www.aqiairs.org**.