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Case Report

Operating Room Fire During Total Knee Arthroplasty Tibial Impaction: A Case Report and Review of the Literature

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ABSTRACT

A fire in the operating room is a rare but potentially deadly occurrence. We present an operating room fire during an elective total knee arthroplasty with an unclear ignition source. Flames were visualized originating from the excess bone cement while impacting the tibial component. The electrocautery device was not in use during impaction and was in a plastic sheath at the head of the bed. To our knowledge, this is the first reported case of an operating room fire involving bone cement not caused by an electrocautery device.

Introduction

Operating room (OR) fires are a relatively rare but potentially deadly hazard, and they continue to occur despite the development of training and safety checks for OR personnel [1,2].

For a fire to begin, a critical triad is required: ignition source, fuel source, and oxidizer. The most common ignition source is the electrocautery device [3,4]. Other reported ignition sources include fiber-optic cables, lasers, and light sources [3,5]. The most common fuel sources are surgical drapes, preoperative solutions such as alcohol-based skin preparations and acetone, and even the patient's hair and skin [3,5,6]. Most surgery-related fires occur under monitored anesthesia care, are ignited by electrocautery devices, and typically occur during head and neck surgeries, likely due to increased oxygen concentration near the airway [4,5].

We present a case of an OR fire during a primary total knee arthroplasty (TKA), with bone cement as the likely fuel source and a spark from the mallet as the proposed ignition source.

Case history

The patient was informed that details about the case would be submitted for publication, and written permission was obtained. A 77-year-old male with a history of type 2 diabetes mellitus and bladder malignancy, body mass index of 30 kg/m^2, with right knee end-stage osteoarthritis was seen in clinic and elected to undergo a primary right TKA after failing nonoperative management (Fig. 1a and b). The procedure was done under neuraxial anesthesia with an adductor canal block, without a tourniquet. Sterile preparation of the right lower extremity was performed with a 2% chlorhexidine gluconate solution. After draping, a second prep was done with additional chlorhexidine gluconate solution prior to applying iodine-impregnated drapes to the right knee. The electrocautery device was placed at the head of the bed sitting in a hard plastic sheath inside a plastic pouch.

The procedure continued uneventfully with standard bone cuts and balancing for a cruciate substituting EMPOWR 3D TKA implant (DJO, Lewisville, TX) until cementing. Two batches (40 mg each) of DJO Cobalt high-viscosity cement (DJO, Lewisville, TX) were mixed for the recommended 30 seconds with a subsequent 2-minute setup time. The monomer was not preheated, and the cement was not mixed in a vacuum. The cement was then manually compressed by the surgeon into the irrigated and dried proximal tibia. Cement was also applied to the tibial baseplate. The tibial component was impacted into the bone with a mallet and the primary impactor. Excess cement was scraped away with a Freer elevator, and the tibial component was impacted using a mallet and the secondary impactor. Additional cement was extruded after secondary impaction, and flames were visualized from the posterolateral portion of the tibial component. There was an attempt to

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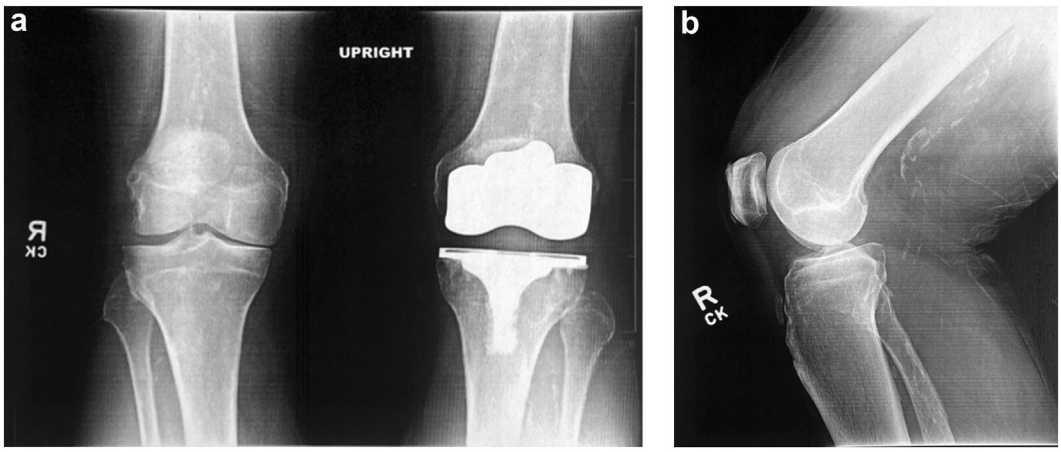

Figure 1. Preoperative radiographic imaging of the bilateral knees. (a) Anteroposterior view. (b) Lateral view.

extinguish the fire using a damp laparotomy sponge, but this was unsuccessful. The flaming cement was then scraped off with a Freer elevator and thrown onto the OR floor where it was smothered by OR personnel. The surgical site was then irrigated copiously with normal saline, and the posterior knee was inspected. There were no signs of visible tissue damage such as excessive bleeding or tissue discoloration in the posterolateral tibia where the cement had been on fire. This whole incident took less than a minute, after which the femoral component was implanted using the same batch of cement. A trial insert was placed while the cement cured. The electrocautery remained at the head of the bed in the plastic sheath during this entire incident.

After the cement had cured, the posterior knee tissue was inspected once more prior to insertion of the final polyethylene insert and again found to be without visible damage. There was no blackening of tissue or bleeding in the area. The final polyethylene insert was placed, and the arthrotomy and skin were closed. The fire was disclosed to the patient's family as well as to the patient himself in the recovery unit, and all questions were answered to their satisfaction. The patient was discharged home on postoperative day 2 on apixaban for deep venous thrombosis prophylaxis due to his history of malignancy. At his 2-week follow-up visit, his wound was healing well, and he continued to progress uneventfully. As of 15 months postoperatively, he was doing well with good mobility and minimal pain (Fig. 2a and b).

Discussion

This case emphasizes the need to reduce fire risks in all 3 aspects: ignition source, fuel source, and oxidizer. We suspect that the ignition source could have been a spark from the mallet hitting the secondary impactor that ignited the bone cement as it was curing. To our knowledge, this is the first reported case of an OR fire involving bone cement which was not caused by an electrocautery device. Sibia et al. reported a case in which an electrocautery device was used to resect residual lateral meniscus tissue while the cement was curing and ignited a fire in the operative field [7]. The authors recommend resecting all soft tissue prior to cementing and avoiding the use of electrocautery during the cementing process [7].

Bone cement (polymethyl methacrylate [PMMA]) is made by mixing a liquid monomer with a powdered copolymer. Due to the high volatility and flammability of PMMA, it should be used in well-ventilated areas as the vapor is denser than air and can easily concentrate [7]. PMMA can spontaneously combust at 421°C while vapors can ignite at just 10.5°C with an ignition source [8]. Since the electrocautery device can create up to 1200°C of heat, the use of the electrocautery device should be avoided during the cement curing process [7,9].

In a recent survey of 172 orthopaedic surgeons, 14 surgical fires were reported, with the most common fuel source being bone

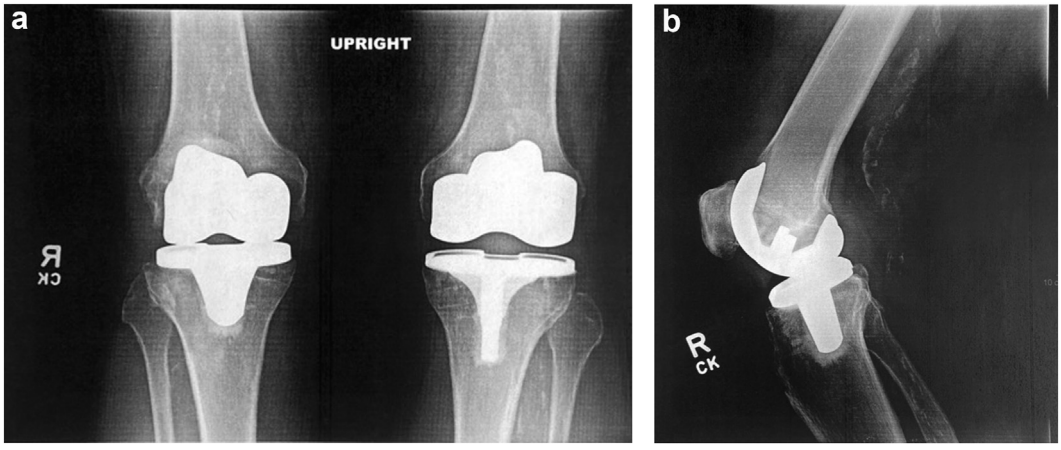

Figure 2. Postoperative radiographic imaging of the bilateral knees. (a) Anteroposterior view. (b) Lateral view.

cement [10]. In 1 case, a metal saw was the source of ignition [10]. Bone cement is also commonly used in craniofacial reconstruction, which increases the risk of fire as the fuel source and oxidizer are in closer proximity [4,5,11].

The key to preventing OR fires is awareness of how fires begin. In the same survey mentioned previously, 42.4% of respondents answered they are never concerned about a fire in the OR, and 34.3% answered that they believed discussing fire risk during the surgical time-out is irrelevant to orthopaedic procedures. Of all respondents, 55.3% reported that they did not even know where the OR fire extinguisher was located [10]. Therefore, surgeon education regarding flammable surgical materials and greater vigilance towards these risks are an important part of prevention. Fire risk can be reduced by avoiding large oxygen concentrations underneath the surgical drapes in patients who are not intubated, allowing alcohol-based skin preparation solutions to dry for 5 minutes longer than the 2 to 3-minute drying time recommended by the manufacturer, and avoiding the use of electrocautery during implant cementation [12].

Addressing risks that lead to fires can also help prevent potential litigation. In a study of 139 cases of litigation of surgical fires and operative burns, 25 cases were related to an orthopaedic procedure, the most out of any procedure type listed [10,13]. Of these cases, less than half were decided in the defendant's favor, and the median reported plaintiff payout was $215,000 [13].

Summary

This case report of an OR fire during TKA implant cementation highlights the importance of being aware of unexpected ignition sources and trying to reduce fire risk. To help prevent fires, we recommend reducing or avoiding the accumulation of excess bone cement and ensuring adequate ventilation so that vapors are not allowed to concentrate. OR fires are a potentially deadly hazard, and it is important to consider all ignition sources to reduce risk.

Conflict of interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: A. C.-Rosenblum receives material or financial support from Journal of Bone and Joint Surgery and Elsevier; is in the editorial or governing board of *Arthroplasty Today* and *Journal of Arthroplasty*; and is a board member in American Association of Hip and Knee Surgeons and Ruth Jackson Orthopaedic Society.

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Informed patient consent

The author(s) confirm that informed consent has been obtained from the involved patient(s) or if appropriate from the parent, guardian, power of attorney of the involved patient(s); and, they have given approval for this information to be published in this case report (series).

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