

## CASE REPORT

## Trauma

# An unusual case of high-voltage electrical injury involving fractal wood burning

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**Abstract**

A 26-year-old female was brought to the emergency department after an apparent electrocution. She was unresponsive, pulseless, and found to be in ventricular fibrillation upon arrival. The patient achieved return of spontaneous circulation after defibrillation. Further examination showed partial to full thickness burns to both hands, right chest wall, and buttocks. She was stabilized and then transferred to a regional burn center for additional care.

Further history revealed the patient had learned how to create art with Lichtenberg figures using a high-voltage transformer extracted from a home microwave oven and a wooden canvas, a process called fractal wood burning. There are countless online video tutorials that describe how to replicate this process; however, the dangers of this practice are frequently omitted and have now become a growing public health concern.

This article hopes to expand on the previous single publication, discuss the exceedingly high mortality rate, motivate emergency medicine providers and other clinicians to publish cases related to fractal wood burning-related injuries, and promote public awareness of this perilous practice.

**KEYWORDS**

cardiac arrhythmias, defibrillation, electrical burn, electrical injury, electrocution, high voltage, ventricular fibrillation

## 1 | INTRODUCTION

This is an unusual case of high-voltage electrical injury from pyrography via fractal wood burning, which has become an increasingly popular practice in recent years. Non-occupational high-voltage electrical injuries are more common than occupational ones and typically occur from electrified railways, high-voltage transmission towers (power poles), substation transformer units, and lightning strikes.<sup>1</sup> The mortality rate varies from the differing type of high-voltage injury but has been reported to average between 5% and 15%.<sup>1,2</sup> There have been 34 cases of fractal wood burning-related injuries reported in local news

articles since 2016 resulting in 24 deaths, revealing a stunningly high mortality rate of ~71%. There are currently no public health resources available in the United States alerting clinicians to the dangers of fractal wood burning nor warning of the hazards to the general public.

## 2 | CASE PRESENTATION

A previously healthy 26-year-old female was brought to the emergency department (ED) after an electrical injury. The patient was at home making art with pyrography via a process called fractal wood burning. A friend heard the patient groaning and walked in to find her clutching an electrical device in both hands, which appeared to be "arcing." The

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friend was able to pull the patient away from the device, at which time she was reportedly awake and alert. En route to the ED via the friend's private vehicle, the patient abruptly became unresponsive about 2 minutes before arrival. At initial assessment by ED staff, the patient was unresponsive and pulseless, and cardiopulmonary resuscitation was immediately started. She was intubated and given 1 mg of epinephrine via intraosseous infusion. The initial rhythm on the cardiac monitor showed ventricular fibrillation and the patient achieved return of spontaneous circulation after initial defibrillation at 200 Joules (J). Further examination revealed total body surface area burns of 1%, composed of patchy partial thickness burns to her buttocks in addition to full thickness burns to the right chest wall, palmar side of the right hand including multiple digits, and palmar side of the left hand including the tip of the index finger with exposed bone.

Initial pertinent labs showed creatine kinase 321 U/L (43–179 U/L), lactic acid 15.2 mmol/L (0.4–1.3 mmol/L), creatinine 1.5 mg/dL (0.5–1.3 mg/dL) with unknown baseline, aspartate aminotransferase 131 U/L (10–37 U/L), and alanine aminotransferase 121 U/L (30–65 U/L). Urine drug screen (UDS) was positive for amphetamine and methamphetamine. Urinalysis showed 1+ blood with 3 red blood cells. Troponin level was <0.02 ng/mL (0.0–0.06 ng/mL). The remaining comprehensive metabolic panel and complete blood count were grossly normal. Postintubation arterial blood gas showed pH 6.90, PaO<sub>2</sub> 232 mmHg, PaCO<sub>2</sub> 67 mmHg, and HCO<sub>3</sub><sup>-</sup> 13 mmol/L on 50% FiO<sub>2</sub> on mechanical ventilator. Postresuscitation electrocardiogram was sinus tachycardia with non-specific t-wave changes in the anterior leads. She was given an intravenous bolus of 1L of lactated ringers and the respiratory rate and tidal volume were increased on the ventilator with repeat arterial blood gas showing resolution of hypercapnia (PaCO<sub>2</sub> 40 mmHg) and improved pH (7.23) and lactic acid level (7.8 mmol/L) before transfer to a regional burn center.

She required ray amputation to the left index finger and had autografts placed to her left hand and right chest wall. Her creatine kinase level peaked at 480 U/L, lactic acid level normalized and transaminases and creatinine levels trended back within normal limits before discharge. She was extubated within 24 hours and other than an initial mild cognitive impairment comprising short-term memory and attention challenges was neurologically intact. She spent 10 days in the hospital after graft placements and received physical and occupational therapy. She was then discharged from the hospital and has since returned to her neurocognitive baseline.

### 3 | DISCUSSION

This patient had recently learned from the internet how to create Lichtenberg figures using a high-voltage transformer extracted from a home microwave oven. In this practice, electrical wiring is connected directly from the transformer to a wooden canvas that has been coated in a conductive solution, primarily derived from baking soda (Figure 1). From there, "tree-like" patterns or Lichtenberg figures are burned into the wood creating a truly stunning and unique appearance (Figure 2). Lichtenberg figures are branching electrical discharges that appear on the interior of insulating surfaces, discovered by German physicist



**FIGURE 1** The process of fractal wood burning using a microwave oven transformer<sup>4</sup>



**FIGURE 2** Fractal burning abstract design on wood<sup>5</sup>

Georg Christoph Lichtenberg in 1777.<sup>3</sup> The art of pyrography has existed for thousands of years; however, it has become popularized with the practice of fractal wood burning within the last several years. There are countless online video tutorials that describe how to replicate this process of creating one-of-a-kind artwork. However, discussion of the danger of fractal wood burning appears to be absent in many of these instructional videos, omitting the potential lethal consequences of this risky practice.

Microwave oven transformers operate with alternating current and are commonly used in the process of fractal wood burning as they are generally easy to access. They can generate extremely high voltage ranging between 1000 and 15,000 volts (V), which can create a fatal current of 500 to 2000 milliamps (mA). For perspective, 16 mA is the maximum current a person can grasp and then "let go"<sup>6</sup>; 16–20 mA causes tetany of skeletal muscles,<sup>6</sup> 20–50 mA causes paralysis of respiratory muscles and respiratory arrest, and 50–100 mA is the threshold for ventricular fibrillation.<sup>6</sup>

To date, there is a single medical journal publication remarking on the numerous deaths and injuries caused by fractal wood burning, published in the *Journal of Burn Care and Research* in April 2020 by Harold Campbell et al.<sup>7</sup> Using online news reports dating from July 2016 to January 2020, the researchers located 26 reports of fractal burning-related accidents.<sup>7</sup> Twenty of these victims died and the

remaining 6 suffered considerable injuries.<sup>7</sup> From January 2020 to August 2020 at least 8 more cases have emerged in the United States resulting in 4 deaths and 4 other severely injured patients.<sup>8</sup>

Given the lack of research and reported data surrounding fractal wood burning accidents, the variety of resulting potential injuries that could occur remains unclear. It can be hypothesized that those experiencing electrical injury from fractal wood burning would also be subject to the wide array of consequences expected from any high-voltage electrical injury, which range from superficial burns to multisystem organ failure and death.<sup>6</sup> From the information currently available, most cases of fractal wood burning electrocution are fatal. In the majority of witnessed cases, the electrical injuries occurred while the victim was holding either the microwave oven transformer or the connectors with both hands resulting in severe burns to the hands, which appear to be the most common non-fatal injury.

The mortality rate associated with fractal wood burning cases is exceedingly high. Adding the 4 most recent cases of demise to the 20 cases previously reported from Harold Campbell et al<sup>7</sup> (n = 24 of 34) reveals a mortality rate of ~70.6%, which is much higher than the 5% and 15% mortality rate previously reported from several retrospective studies of high-voltage incidents.<sup>1,2</sup> These data are likely skewed, given the documented cases were discovered from local news articles that may grossly underreport non-fatal injuries and exclude patients who did not seek medical care. Regardless, the mortality rate can be assumed to be significant and is potentially much higher than the risk of death from being struck by lightning, which carries the highest risk of mortality of all electrical sources, ranging between 10% and 30%.<sup>9,10</sup>

Ventricular fibrillation is the most common fatal arrhythmia associated with electrical injuries and can be present in up to 60% of cases with horizontal current flow, in which the electrical current pathway travels across the torso from hand to hand.<sup>11</sup> It is possible that the mechanism of hand-to-hand electrical transmission, in addition to the extremely high-voltage transformers used in fractal wood burning, may contribute to the significantly higher rate of lethal cardiac arrhythmias and thus the higher mortality rate in these cases than what has been reported for any other non-fractal wood burning related electrical injury, regardless of mechanism. In this case study, the patient's urinary drug screen was positive for amphetamine and methamphetamine. Substances such as methamphetamine, phencyclidine, and cocaine have been shown to increase the propensity of cardiac arrhythmias in the setting of electrical weapons use, such as with tasers,<sup>12,13</sup> and may have also contributed to this patient developing ventricular fibrillation. Lastly, delay in onset of malignant cardiac arrhythmias such as ventricular fibrillation, after a high-voltage electrical injury as seen in this case, has been documented although reportedly rare.<sup>14</sup>

#### 4 | CONCLUSION

We report an unusual case of high-voltage electrical injury in a patient who was creating pyrography via fractal wood burning. Given

the apparent dangers of this practice, more published cases are needed in order to obtain a more accurate representation of the true incidence of fractal wood burning-related injuries and the associated mortality and propensity for fatal cardiac arrhythmias as well as further delineation of the variety of injuries possible. Escalated efforts should be made within the public health sector to warn the public of the dangers of fractal burning, and clinicians should be alerted to its significant popularity despite alarming morbidity and mortality.

#### CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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