

# Lichtenberg Figures and Lightning: Case Reports and Review of the Literature

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*The Lichtenberg figure (LF) is a recognizable skin pattern that is only seen in individuals struck by lightning. LF, also known as a ferning pattern, is a transient finding. It is not a burn, and biopsies of the skin reveal no pathologic changes. We present 3 case reports of patients who presented with LF after being struck by lightning. The explanation of what LF represents remains unknown. Many researchers believe that LFs are fractal patterns and do not correspond to known vascular or neuroanatomic patterns. We present our ideas on possible mechanisms of the pathophysiology of LFs.*

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The Lichtenberg figure (LF), also known as a ferning pattern, is a pathognomonic sign found only in individuals struck by lightning. LF is a recognizable but transient pattern commonly found on the skin. We present 3 case reports with classical findings of LF. We review what is known about this unique clinical finding based on the literature and our observations. In addition, we provide our ideas about possible explanations for this curious clinical phenomenon of LF.

## Case Reports

**Patient 1**—In June 2004, a 24-year-old man was hiking above timberline in Colorado's Rocky Mountains. As he approached the summit (above 14,000 ft), he noticed approaching clouds. At 12:30 PM, he was struck by lightning and lost consciousness for 15 minutes. Other hikers helped him to the town at the base of the mountain. He was taken by ambulance to the hospital. On examination, he had a ruptured left tympanic membrane, corneal abrasion and

erythema of the left eye, and second-degree burns on his thorax and lower limbs. A ferning pattern was present on the left clavicular area and thorax (Figure 1). The LF blanched with pressure. After 2 weeks, the second-degree burns and tympanic membranes were noted to be healing. He fully recovered after 17 months.

**Patient 2**—In early October 2005, a 36-year-old man was standing near his truck during a storm in a small town in Colorado (elevation 8800 ft). At 3:58 PM, the truck was struck by lightning and the patient was hit by a side-flash lightning strike. He suffered transient loss of consciousness and limb weakness. A ferning pattern was present on his chest and axilla (Figure 2). The LF disappeared and he fully recovered by the next day.

**Patient 3**—A 29-year-old woman was standing beside a tree during a lightning storm in southern Colorado. The tree took a direct lightning strike. The patient received both ground voltage and side-flash lightning strikes. She collapsed to the ground but did not lose consciousness. When emergency medical service personnel arrived, they noted the patient had LFs around her neck and under her breasts. These areas had been in contact with metal. She was wearing a gold necklace and her brassiere contained metallic wire. The emergency medical service personnel placed electrodes on her chest to record an electrocardiogram (ECG). On arrival at the hospital, it was noted that she had developed a circular ferning pattern around the electrode (Figure 3). All LFs resolved in 12 hours.

## Comment

LF is one of medicine's enduring mysteries. It refers to a peculiar transient skin pattern that is only seen in individuals struck by lightning. Lichtenberg<sup>1</sup> first described this electrical phenomenon in 1777. When working with static electricity and resin, he noticed the peculiar treelike pattern in dust.<sup>2</sup> In 1976, Golde and Lee<sup>3</sup> applied the name *Lichtenberg figure* to the ferning pattern on the skin of individuals struck by lightning. Nearly 200 years earlier, Parkinson<sup>4</sup> described the ferning pattern in

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**Figure 1.** Lichtenberg figure on the thorax.

a patient struck by lightning.<sup>5</sup> Clinical aspects of LF in lightning injuries are summarized by Cherington et al<sup>2</sup> and ten Duis et al<sup>6</sup>; however, the mechanism and pathophysiology of this lightning-induced occurrence remain unknown.

LFs are specific to individuals struck by lightning, either by a direct strike, a side flash (as from a tree), or ground voltage. This finding is not seen in industrial patients injured by contact with alternating current electricity.

LFs are transient, lasting a few hours to 48 hours. LFs appear as early as 20 minutes to 1 hour after the lightning strike and as late as 3.5 hours after the event. LF can arise in a circular pattern in response to the placement of an ECG electrode (Figure 3).

LFs gradually wane. Suitable lighting may be necessary to see an LF as it fades. When the ferning pattern disappears, there is no residual LF scar. Transient LFs are seen in both surviving patients and deceased lightning victims. LFs may persist for 48 hours postmortem.

The LF pattern occurs in a pink-red color. The “lesion” is not painful, dysesthetic, or pruritic. Although it does blanch when compressed, it does not disappear when a blood pressure cuff is proximally applied. No pathologic changes are found in biopsies of the skin.<sup>7</sup> The skin lesion does not correspond to any major vascular (arterial or venous



**Figure 2.** Lichtenberg figure in the axilla.

trees) or neuroanatomic patterns. ten Duis et al<sup>6</sup> observed that LFs are fractal patterns. A fractal is a mathematical pattern that manifests increasing detail with increasing magnification. Fractals exhibit the property of self-similarity.<sup>6</sup> Component parts resemble the whole.<sup>8</sup> The arterial tree is based on repeated bifurcations, and in this sense has some resemblance to fractals<sup>9</sup>; however, in some ways (eg, asymmetrical branching), the arterial vascular system differs from the fractal structure. In contrast, capillaries more closely approximate fractal structures.<sup>10</sup> The coronary arterial system on the surface of the heart closely approximates a fractal pattern.

At times, LFs seem to originate or end at metallic objects (eg, jewelry) on the skin. LFs are found on the torso and limbs but usually spare the face, hands, and feet.

When a group of people are struck by lightning, several patients in the group may demonstrate LFs. Although LFs on the skin are transient, ferning patterns on other surfaces (ie, wood, grass, resin) are prolonged or permanent.<sup>2</sup>

What causes LF? The pathophysiology of LF remains unknown. The physics of LF are fairly well-understood. Lichtenberg<sup>1</sup> discovered these electrical figures while performing static electricity experiments on a cake of resin. These original LFs were 2-dimensional. More than 200 years later, 3-dimensional LFs can be produced on plastic blocks in laboratories using linear accelerators.<sup>11</sup> The linear accelerator produces accelerated electrons. When an acrylic block is placed in the path of electrons, a space charge is produced and trapped in the electrical insulator. Acrylic block has exceptional dielectric and mechanical properties. As the electrical field increases, the trapped space charge violently exits, accompanied by a bright light and production of a ferning pattern within the block.<sup>11</sup> According to Dwyer,<sup>12</sup> we know that lightning is associated with accelerated electrons.



**Figure 3.** Lichtenberg figure around an electrocardiogram electrode.

Applying what is known so far about LF, we hypothesize that when an individual is struck by lightning, electrons are driven into the epidermis where they accumulate to create a space charge. Because skin is a relatively good insulator, the electrons cannot move freely. They accumulate without moving freely in skin until the electrical field exceeds the electrical breakdown strength of skin cells. Then the electrons are released, producing the enigmatic LF.

The relationship between LF and jewelry and ECG electrodes also remains unknown. LFs appear to emanate from or end in the immediate vicinity of metallic objects on the skin. Why? We speculate that space charges collect in the metallic jewelry and in the skin near the jewelry at a faster rate than in other parts of the body, resulting in a high-charge density immediately under the jewelry. When there is a dielectric breakdown in the skin, the breakdown (and associated LFs) should be initiated in this area and radiate outward from the point close to the jewelry. The appearance of LFs near the ECG electrode long after the lightning strike suggests there may be an epidermal space charge throughout the body surface.

If LFs are caused by these released electrons, why are the lesions pink-red in color? LF lesions are neither burns nor vascular markings. What are the biochemical changes that accompany the induced temporary space charges resulting in a red ferning pattern on the skin? The biochemical changes are fully reversible, with no structural damage to tissues. Chemicals such as carotenoids, keratin, and melanin already reside in the epidermis. We speculate that lightning may produce a chemical change, resulting in the appearance of a red color.

We hope that these thoughts will inspire other researchers to study this remarkable clinical finding.

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