

# Bone Marrow Embolism to the Lung in Electrocution Two Case Reports

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**Abstract:** Bone marrow embolism in electrocution was first described in the literature by Rappaport et al (Am J Pathol. 1951;27(3):407Y433) in 1951. Two case studies demonstrating this phenomenon are reported here, one involving high-voltage exposure with associated skeletal in-juries and the other involving domestic current and without evidence of skeletal injury. Both cases demonstrated bone marrow embolism on histologic examination of the lungs. The purposes of this article are to reiterate the existence of this unusual phenomenon and to consider possible pathogenetic mechanisms.

**Key Words:** bone marrow embolism, electrocution, autopsy, histology

We report on two electrocution case studies, one involving high-voltage exposure with associated skeletal injuries and the other involving domestic current and without evidence of skeletal injury. Both cases demonstrated bone marrow embolism on histologic examination of the lungs-a finding that was first reported on more than 60 years ago but with few subsequent reports thereof having been published. This article revisits this apparently rare phenomenon and the possible pathogenetic mechanisms. Consent to report on these case studies was granted by our institutional ethics and integrity committee.

## CASE 1

An adult man was found dead immediately adjacent to a live high-voltage (91000 V) electric cable next to a railway line. The deceased was wearing thick gloves, which had become partially displaced. Police investigation suggested the possibility of attempted theft of copper cables. Autopsy showed multiple defects to the clothing (including the shoes and gloves) and multiple injuries to the skin, most notably to the left shoulder, the right hand, and the left upper arm, all of which had characteristic features of electrothermal injury. A large, irregular wound (8 X 7 cm) with central areas of crater formation and a charred, parchmentlike appearance was located over the region of the left acromioclavicular joint. Further skin lesions with distinctive electrothermal appearances (Joule burns) were noted especially on the right hand and the left upper arm. Interestingly, widespread antlike abrasions were also noted, being a postmortem artifact (but initially presenting a diagnostic challenge because these were similar in appearances to the arcing lesions often seen in

high-voltage exposure cases). Internally, the salient findings were fracture-dislocation injuries of the left shoulder and of the upper thoracic vertebrae with associated soft tissue disruption as well as features of acute traumatic emphysema and subpleural bullous blebs on the surfaces of the lungs. Histologic examination of lung tissue later revealed features of bone marrow embolism (Fig. 1).

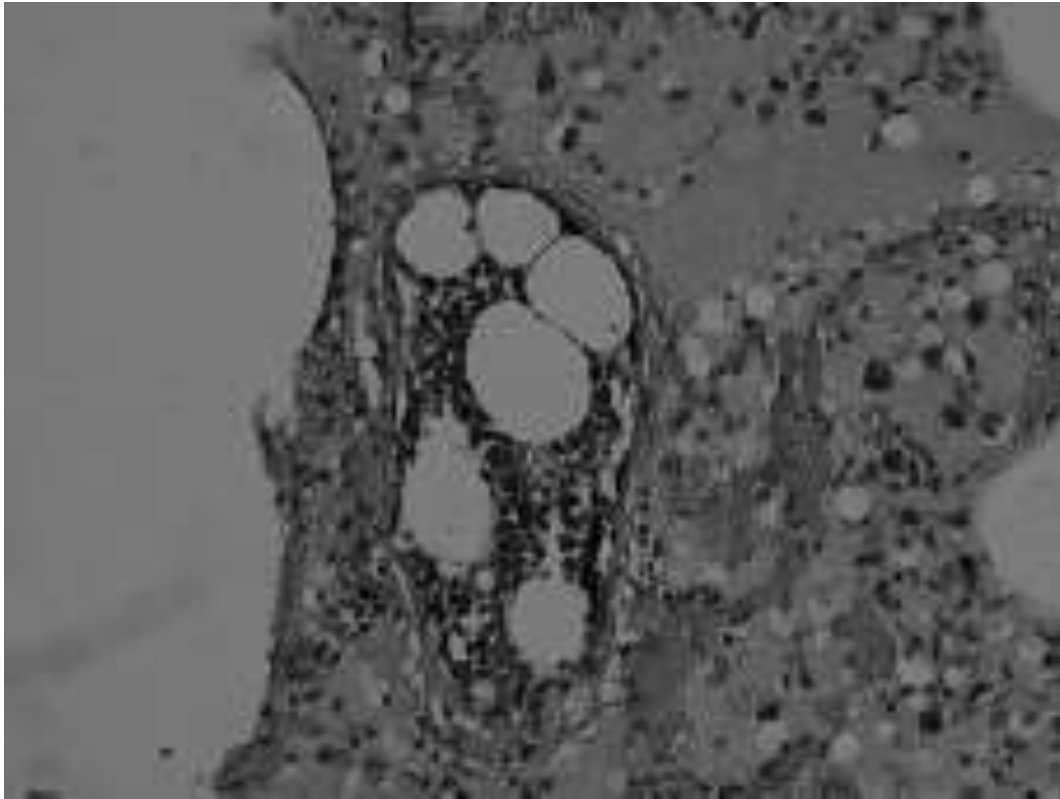


FIGURE 1. Bone marrow embolism. Bone marrow embolism lodged within 1 of the distal pulmonary arterioles.

## CASE 2

An adult man sustained fatal accidental exposure to domestic current (220Y240 V) while trying to connect two wires. The decedent was found with a length of insulated electric wire passing through the right hand, which also held a looped coil of white insulation tape. There had been no attempts at cardio-pulmonary resuscitation. The deceased was found approximately 12 hours after the incident. At autopsy examination, the right hand revealed the presence of a patterned electrical mark between the third and fourth digits with a further wound on the posterior aspect of the right forearm. The latter had a “targetlike” appearance, suggestive of electrothermal injury, with signs of (ruptured) blister formation, central charring, and a parchmentlike appearance. Indistinct surrounding “halos” of blanching and erythema were noted. No other obvious macroscopic injuries were noted at autopsy; specifically, no skeletal injuries were noted. Routine histology of the lung showed incidental but typical features of bone marrow embolism (Fig. 2).

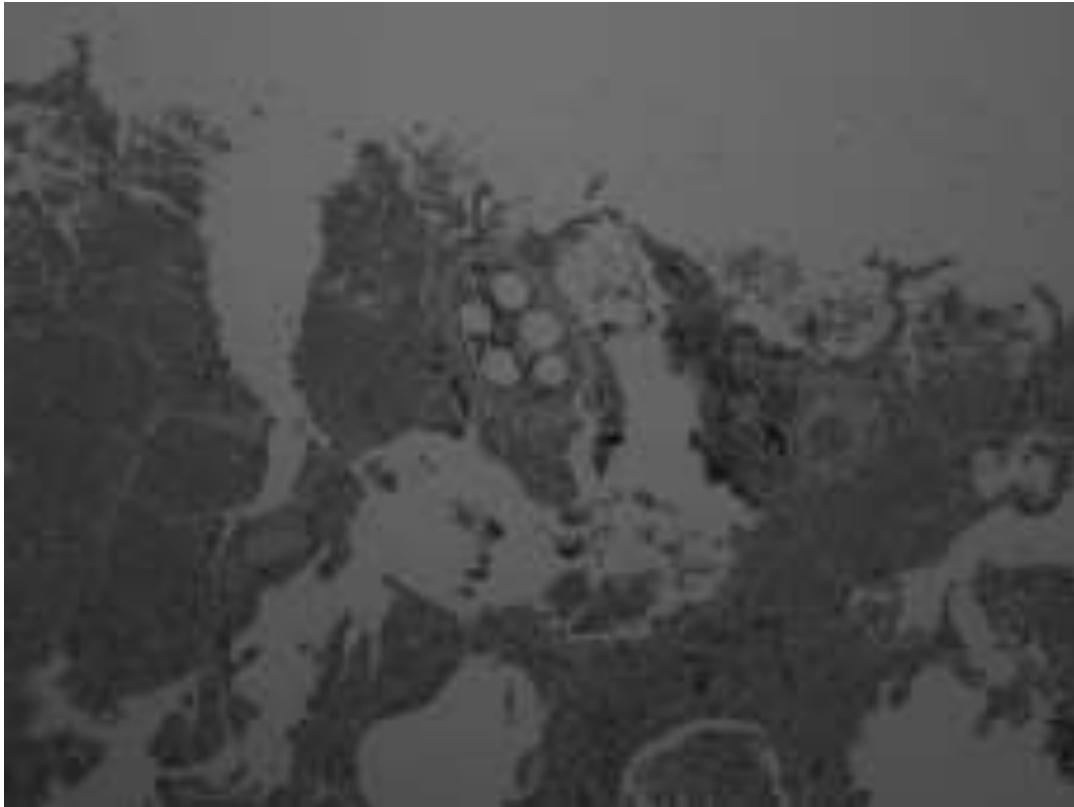


FIGURE 2. Bone marrow embolism. Routine histology of the lung showed incidental but typical features of bone marrow embolism.

## DISCUSSION

At autopsy, there are often minimal or only nonspecific macroscopic internal findings in electrocution cases. It has been reported that “electrical petechiae” represent a nonspecific but typical finding in electrocution irrespective of the mechanism leading to death.<sup>1</sup> There are also no pathognomonic or specific histomorphological features in the internal organs or tissues of persons killed by exposure to electric current. Without the presence of (electro) thermal-type injuries and/or other evidence to suggest exposure to electric current, the diagnosis of electrocution may be difficult and based on circumstantial evidence only.<sup>2</sup> Bone marrow embolism in electrocution was first described in the literature by Rappaport et al<sup>3</sup> in 1951. The presence of marrow emboli is of forensic significance because they suggest that skeletal trauma occurred before the cessation of circulation.

Unspecified liquefaction and tissue discontinuities may occur in the bone through the effects of electric current.<sup>4,5</sup> In bony tissue, electrothermal effects and laser beams cause destruction of the bone collagen and melting of the inorganic material. This may play a role in the pathogenesis of bone marrow embolism. Bone marrow emboli consist of fat vacuoles surrounded by hematopoietic elements derived from the marrow.<sup>6</sup> Extrapulmonary involvement is unusual but may, on rare occasions, be responsible for death.<sup>7</sup>

The number of bone marrow emboli is significantly higher in cases in which cardiac massage is carried out, with cardiac massage reportedly being the most important of all predisposing factors of bone marrow embolism.<sup>8</sup> The gross appearance of the lungs in bone marrow embolism is not

distinctive because the number of involved vessels is usually small. Bone marrow emboli are found in the lungs of 20% to 40% of patients who die within 8 hours after sustaining fractures after closed chest massage and in association with indirect trauma to the skeleton after epileptic attacks and electric shock.<sup>9</sup>

Histologically, the pattern is similar to what is seen in fat embolism.

De Vries and colleagues<sup>10</sup> presented clinical and experimental data indicating that cryosurgery of intact bone could cause bone marrow intravasation and embolism. A mechanical-biological theory was postulated, stating that the intravasation of bone marrow after cryosurgery of bone is caused by an increased intramedullary pressure, the latter being due to edema in the medullary cavity caused by cryosurgery damage to cell membranes. The bone marrow embolism intravasates and can embolize to the lungs and thus cause respiratory insufficiency, which could be a serious complication after cryosurgery of intact bone. Prophylactic decompression of the medullary cavity can possibly prevent the rise in intramedullary pressure and thus intravasation and embolization of the bone marrow after cryosurgery of intact bone.<sup>10</sup>

To investigate the initial lesions of pulmonary bone marrow embolism and its pathogenesis, Yamamoto injected fresh allogeneic bone marrow into the marginal ear veins of rabbits. The research of Yamamoto and Nagahara<sup>11,12</sup> suggested that embolized bone marrow in the small arteries and related vasculitis may lead to arteriosclerosis in the future or even persistent pulmonary hypertension.

According to Jansen,<sup>2</sup> the development of an electric skin lesion is dependent on many electrophysical factors, in particular the current density under the point of contact and the affected part of the body. Whether this is true for the development of bone marrow embolism in electrocution needs to be further investigated because there seems to be scant published research in this regard.<sup>13,14</sup>

The purposes of this article are to raise awareness of bone marrow embolism in electrocution cases and to consider the possible pathophysiological mechanism(s) of causation, specifically in the absence of macroscopic fractures.

## REFERENCES

1. Karger B, Suggeler O, Brinkmann B. Electrocution-autopsy study with emphasis on "electrical petechiae". *Forensic Sci Int.* 2002;126: 210-213.
2. Jansen W. *Forensic Histopathology*. Berlin, Germany: Springer-Verlag; 1984 ISBN 3-540-12466-7. Chapter 4. 219.
3. Rappaport H, Raum M, Horrell JB. Bone marrow embolism. *Am J Pathol.* 1951;27(3):407-433.
4. Kolár J, Vrabec R. Knochenschäden bei Stromverletzungen. In: *Handbuch der Medizinischen Radiologie*. Berlin, Germany: Springer; 1976:345.
5. Harsányi I. Knochenschäden durch elektrothermische Wirkung and Laserstrahlen. *Kriminal Forens Wiss.* 1979;35:31.
6. Perper JA, Wecht CH. *Microscopic Diagnosis in Forensic Pathology*. Illinois, USA: Charles C. Thomas Publisher Springfield; 1980:231.

7. Ghatak NR, Zimmerman HM. Cerebral bone marrow embolism. Report of a case with observations on the genesis of traumatic fat embolism. *Arch Pathol.* 1971;92:112-118.
8. Arai H. Pulmonary bone marrow embolism: a review of 350 necropsy cases. *Acta Pathol Jpn.* 1979;29(6):911-931.
9. Brinkhous KM. *Accident Pathology: Proceedings of an International Conference, Sheraton Park Hotel, Washington, DC, June 6-8, 1968.*
10. De Vries J, Oosterhuis JW, Oldhoff J. Bone marrow embolism following cryosurgery of bone: an experimental study. *J Surg Res.* 1989;46: 200-208.
11. Yamamoto M, Nagahara S. Post-traumatic pulmonary microembolism-report on sixteen autopsy cases of pulmonary bone marrow embolism from a viewpoint of shock lung or microembolic lung. *Nihon Kyobu Shikkan Gakkai Zasshi.* 1980;18(4):231-239.
12. Yamamoto M. Pathology of experimental pulmonary bone marrow embolism. I. Initial lesions of the rabbit lung after intravenous infusion of allogeneic bone marrow with special reference to its pathogenesis. *Acta Pathol Jpn.* 1985;35(1):45-69.
13. Havig O, Grüner OP. Pulmonary bone marrow embolism. A histological study of a non-selected autopsy material. *Acta Pathol Microbiol Scand A.* 1973;81(3):276-280.
14. Reidbord HE. Pulmonary fat embolism. An ultrastructural study. *Arch Pathol.* 1974;98:122-125.