G81 Analysis of Electric Injury Patterns in Human Skin by Magnetic Resonance Microscopy

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The goals of this presentation are to gain a greater understanding of emerging diagnostic technologies; to develop correlations between magnetic resonance microscopy and light microscopy for electrical injuries; and to better recognize the histopathology and pathophysiology of electrical damage to the skin.

Introduction: The pattern observed for an electric injury depends on the strength and frequency of the electric field, the path of the current, and the histoarchitecture of the tissues. Tissue trauma results from (a) electric field effects and (b) Joule heating due to the passage of electricity. To characterize the electric injury pattern in skin a variety of techniques, ranging from histology to scanning electron microscopy, have been applied. These techniques give detailed information about changes to cell morphology in sections taken at the site of the entrance and exit wounds, but provide little information about the extent of tissue damage in peripheral and deep tissues. Clinical MRI studies can provide some information about vessel patency and muscle necrosis, but the injury pattern is lost due to limited spatial resolution. In this work, MRM was used for the first time to characterize the microanatomy of an electric injury pattern in human skin.

Materials and Methods: Skin specimens, with visible epidermal lesions, were dissected from the left and right foot of a human cadaver that had received a fatal electric shock. Fixed skin samples were rehydrated in phosphate buffered saline prior to imaging. All experiments were performed on a Bruker Biospec spectrometer (Bruker Instruments, Inc. Billerica, MA) coupled to horizontal magnet operating at 7T (300 MHz for protons). Quantitative 2-D images had a slice thickness of 2 mm and an in-plane resolution of 120 mm. 3-D images were acquired with a RARE imaging sequence. The microanatomy of the resulting electric injury pattern was characterized by MRM and images were validated against histologic sections taken through the wound site.

Results and Discussion: On gross inspection, electric lesions were found to be composed of three zones: a central zone, an intermediate zone, and a peripheral zone. In the central zone the epidermal layer was completely destroyed and the underlying dermis was thermally damaged. In the intermediate zone, dermal necrosis was observed under the detached epidermis and in the peripheral zone there was little evidence of damage to cutaneous tissues.

Three-dimensional MRM images of formalin-fixed skin specimens were found to provide a complete view of the damaged tissues at the site of an electric injury as well as in neighboring tissues, consistent with histologic reports. The signal intensity of the dermal layer in the central zone was reduced due to thermal damage and increased in the intermediate zone because of cellular necrosis caused by the electric field. A subjacent blood vessel with extensive intravascular thrombosis supports the hypothesis that electricity traveled through the vascular system before arcing to ground. MRM images of intact skin samples confirm that the resulting electric injury pattern was comparable to that of a vascular lesion.

Forensic Science, Electric Injury, Magnetic Resonance Microscopy