Partial-Body Radiation Diagnostic Biomarkers and Medical Management of Radiation Injury Workshop
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Medical Treatment of Radiological Casualties

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The US experience in partial-body exposure has usually been high-level low LET exposure to relatively small areas of skin, either from sealed sources or X-ray or accelerator accidents. For a clinically significant lesion to occur, generally greater than 10 cm^2 of the basal layer of the skin must be irradiated. In order to devise a care plan for patients with partial-body irradiation, the treating physician and nursing staff need to ascertain the relative magnitude of the event. The medical history is particularly helpful for partial-body injury since signs and symptoms generally take days to weeks to manifest. In addition, serial color photographs are crucial, possibly along with drawings of the lesion, to document its evolution. In the US, diagnosis of high-level skin dose has generally been estimated by physicians in radiation medicine observing the serial evolution of symptoms and often augmented by cytogenetic dosimetry and diagnostic tools such as PET scans, MRI, ultrasound, and Doppler or laser flow profiles in the affected area. Most physicians in the US have also found it important to engage the consultative services of a plastic and reconstructive surgeon early in the process should skin grafting and/or amputations need to be performed. The key clinical management issues with cutaneous radiation injury are infection control, state-of-the art wound care, and pain management. The US Centers for Disease Control and Prevention have published physician guidelines for grading cutaneous radiation injury: Grade I: >2 Gy; Grade II > 15 Gy; Grade III > 40 Gy; Grade IV: >55 Gy. Generally Grade I lesions will recover early, possibly with minimal erythema or after dry desquamation has healed. Delayed effects may include minimal skin atrophy. Grade II lesions include edema, moist desquamation, late epithelization, but with possible tissue necrosis and blood vessel compromise in the higher dose ranges. The pathophysiology for erythema includes arteriolar constriction with capillary dilation and local edema. There is also generally diminished mitotic activity in cells of the basal and parabasal layers with thinning of the epidermis and desquamation of large macroscopic flakes of skin. In cases of moist desquamation, microscopically, there is intracellular edema, coalescence of vesicles to form macroscopic bullae, and a wet dermal surface, coated by fibrin. Late effects of Grade II lesions will include skin atrophy or recurring ulcer formation and possible telangiectasis many years after the event. In the upper range of Grade II lesions (30-40 Gy), plastic reconstruction with grafting may also be necessary. Grade III lesions (>40 Gy) pose significant clinical challenges with small vessel damage and occlusion, large areas of tissue necrosis and, historically, have involved serial amputation, usually of extremities. Late effects are multiple, including skin atrophy, depigmentation, small vessel occlusion, tissue fibrosis and sclerosis of connective tissue. Grade IV lesions are extremely severe, with rapid tissue ischemia, and these patients generally require multiple amputations and continued reconstructive surgery over several years if they survive the cutaneous syndrome at all. The cutaneous syndrome has been defined and expanded by Peter and colleagues over the past 15 years and this syndrome poses many significant medical challenges in patient management. As with the acute radiation syndrome (ARS), local injuries should be treated symptomatically and any surgical trauma should be dealt with in

the first 48 hours. Additionally a baseline CBC with differential should be taken since the ARS can be an additional complication to be dealt with in high-level, partial-body dose. Speaking directly to the management of local partial-body injury, the patient should be treated in a burn unit with reverse isolation if available to prevent infections, use of medications to reduce inflammation, inhibit proteolysis, relieve pain, and stimulate regeneration of the skin and improve circulation. In the early phase of the radiation injury, use of corticosteroids and sedatives should be considered. Later, proteinase inhibitors (such as Gordox®) and antibiotics will be necessary. Lioxasol® has also been suggested as a possibility to regenerate DNA in the wound and when skin regeneration has started, biogenic drugs such as Actovegin® and Solcoseril® have been recommended by our Russian colleagues. During the third and fourth week when small vessel occlusion and fibrosis will be occurring, Pentoxifylline® has been used successfully in the US to increase blood flow. After immediate stabilization of the clinical phase, there is generally a long and painful healing process for the patient. Here, pain management will be the most crucial issue and physicians and nurses trained in the various aspects of pain management should be consulted. In the later phase of healing, additional medical products could be used to stimulate vascularization of the wound area as well as inhibit fibrosis and infection. These medications would include Pentoxifylline®, vitamin E and interferon gamma. In spite of these medications, proper care of the wound may still require reconstructive surgery. Full thickness grafts and microsurgical techniques often provide the best results. There appears to be no general consensus in the literature in the use of what medical agent for proper treatment of partial-body injury and in what order of application. In addition, hyperbaric oxygen therapy has proven useful in certain specific radio-induced lesions of bone, particularly involving the mandible and other bones. The experiences of the US, Canada, Japan, and Europe, particularly including Russia, will be compared in the use of drug formulations for acute partial-body injury. In conclusion, it is important to remember that psychological support for the patient and his/her family is also crucial. Patients with profound partial-body radiation exposure may express feelings of anger, disbelief, sadness, irritability, arousal, sleep disturbance, dissociation, or increased use of alcohol, or stimulants such as caffeine and tobacco, or drugs. Patients exposed to high-level radiation events that actually threaten their lives are at the highest risk of psychiatric morbidity, which may meet the criteria for psychiatric diagnoses such as Acute Stress Disorder or Post Traumatic Stress Disorder (PTS).