Introduction. REAC/TS continues to search for quick, effective, and inexpensive ways to determine the magnitude of acute local radiation injury (LRI) before the extent of the injury becomes fully manifest.

Last month’s article looked at the use of ultrasound to evaluate acute LRIs. Indeed, ultrasound may have a place in evaluation of skin and subcutaneous (below the skin) injury. The equipment is widely available in the United States and many physicians are capable of using the equipment and interpreting findings. But ultrasound has not been widely used for interpretation of extent and magnitude of LRI. REAC/TS is currently evaluating progression of acute LRIs in order to develop a methodology for interpretation that could be standardized.

For any methodology to be successful in evaluating ionizing radiation injuries, the equipment has to be available. Personnel who are able to use the equipment and interpret the findings must also be available.

Another method that shows promise to evaluate the spatial extent of LRI is thermography. Unlike ultrasound, thermography is not as widely used in the United States as it is in other countries of the world. It has been used in the United States for evaluation of skin lesions such as diabetic ulcers or the potential for ulcer formation. It has also been used for breast-cancer detection because of increased skin heat generation related to an intramammary tumor and its increased metabolism and blood supply.

Thermography equipment is exceedingly simple to operate, but there are not many physicians available who can interpret the findings. So the same issue exists for thermography as for ultrasound—standards for interpretation must be developed.

Key to understanding the need for these techniques is that the radiation dose to skin and subcutaneous tissues (below the skin) is rarely known when a patient is first seen. This is especially the case if the exposure is accidental rather than from a planned procedure such as teletherapy. The real magnitude of acute LRI is only known in retrospect after the injury has fully evolved. The human body gives clues to what the radiation dose was, but those clues are not immediately detectable. This delay in injury expression is the nature of ionizing radiation injuries; therefore, therapy is often delayed.

If pathologic changes in the skin and subcutaneous tissues could be detected before clinical signs appear, earlier treatment might result with better medical results, reduction of pain and suffering, and avoidance of long and expensive reactive medical treatments.

Principles of Thermography. The physics of thermography is fairly straightforward. A “picture” of the patient is taken in the 6-14 micron infrared range using a silicon microbolometer as a detector in a type of thermal camera. When infrared radia-
ion strikes the detector material, it is heated and its electrical resistance changes. The resistance change is measured and processed into temperatures that can be used to create an image. The surface temperature for 76,000 points (320 x 240 pixels) on a subject is calculated and interpolated to VGA 640 x 480 pixels over an 8-degree Celsius range. An image is therefore developed, showing gradations of temperature by color. Figure 1 shows the back of a normal subject. Darker purple areas are cooler and green areas are warmer. Generally, temperature gradations on the body surface should be approximately symmetric.

Case Review. In November 2007, a 53-year-old man was scuba diving off the coast of Thailand. The man, with a history of insulin-dependent diabetes mellitus and coronary artery disease with previous coronary artery stent placement, began to have chest pain on his way back to the United States. His flight was diverted to allow the plane to land in a metropolitan area in Southeast Asia.

At a local hospital, a stent was placed for another arterial occlusion and the man eventually returned to the United States.

For some reason, the man decided to return to that Southeast Asian hospital for further coronary artery surgery in April 2008. During that procedure, the exact details of which are unknown, the man underwent over five hours of fluoroscopy. Over the ensuing several months, he developed large ~30 cm erythematous (red) swollen lesions on his back—one over his left scapula (shoulder blade) and another on the right side of his back lateral to the right scapula. Even months after the injuries, the rectangular outline of the beam collimation could be seen around both of the lesions. They can't be seen on the photograph in Figure 2.

The injuries gradually underwent ulceration. The man came to the attention of REAC/TS in November 2008 and was eventually seen in December at the REAC/TS facility in Oak Ridge, Tennessee. The left-sided lesion had gradually healed with a result-

Figure 2. 53-year-old patient with acute LRI from prolonged fluoroscopy on both left and right sides of the upper torso. The wound on the left is atrophied (thinned) and fibrotic (scarred) in the center. The lesion on the right has green-gray liquefaction necrosis in a 12 cm area. The white material over the patient's right lateral chest wall is silver sulfadiazine cream, long used for thermal burns.
ing ~30 cm area of residual erythema and fibrosis over the left scapula. The right-sided lesion was a ~12 cm area of ulceration with liquefaction necrosis. It was surrounded by firm erythematous swelling. Treatment up to that time had been with topical (on the skin) silver sulfadiazine cream, customarily used for first-degree and shallow second-degree burns. Figure 2 shows the patient with 1 percent silver sulfadiazine cream over the right-sided lesion.

Plastic surgeons evaluated the patient’s injuries and recommended a pedicle graft to close the right-sided lesion. Because the central part of the right-sided lesion is probably devoid of much tissue substrate including vascular supply, REACT/S advised against such surgery pending further determinations of extent of injury.

Figure 4 shows the initial lesion on the patient’s right back. Figure 5 shows the lesion after 100 episodes of HBO. Unfortunately, a measuring device is not visible in these photos, but the lesion in the before photo is about 12 cm long vertically and only about 8 cm in the after photo. The dark-colored blood vessels peripheral to the central ulceration in Figure 5 are new.

![Figure 4. Initial lesion before HBO](image)

Clinically, before HBO, the lesions including the surrounding red and swollen areas were cool to the touch. Following HBO, the temperature of the skin is decidedly warmer.

![Figure 5. After HBO therapy](image)

Hyperbaric oxygen (HBO) therapy was recommended and began in mid-2009.

The patient underwent 100 treatments at 2.3 atmospheres. Tremendous improvement was noted following HBO therapy. Neovascularization (formation of new blood vessels) was evident at the periphery of the central ulceration on the right side.

Ultrasonography at 12 MHz has also been performed on the lesions in an effort to determine the magnitude of subcutaneous tissue damage. Angiogenesis has been demonstrated in the right lesion by color Doppler imaging.

![Figure 3. Thermography of bilateral lesions showing angiogenesis (red areas are warmer).](image)

Note the cooler center of the right-sided lesion where vascularization, which progresses centripetally from less damaged tissue, is probably not yet underway. Increased temperature in the lumbar spine area is from disc irritation at L4-5.

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the depth of damage. Repetitive analyses will be used to help determine if sufficient substrate, including vascular supply, is available to support a skin graft.

PET scanning and bone scans with blood-pooling imaging are too expensive to be used repetitively for evaluation of these cases. A pedicle graft is certainly a possibility here because the pedicle would bring blood supply with it. However, eventually the grafted area would need to support the new tissue.

There has been no good and relatively inexpensive way to determine extent of injury early after an exposure. One would like to know what the extent of an injury is going to be before one can actually visually see it in order to begin appropriate therapy as early as possible.

The Future. REAC/TS physicians have undertaken research into the value of using some noninvasive, well-researched, and inexpensive modalities to get better ideas about extent and magnitude of acute LRIs. Current REAC/TS research is directed toward development of techniques to enable physicians to evaluate the extent of LRI before the full extent of injury is clinically obvious. It is hoped these techniques would be able to monitor and potentially forecast tissue and vascular regeneration.

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Who ARE these guys, anyway?

Of course many of you know our colleagues Mark Miller and Bob Meyer (middle and right), but most of you probably don’t know Joe Shuster (left), author of Beyond Fossil Fools: The Roadmap to Energy Independence by 2040 (http://www.beyondfossilfools.com/). It turns out that Bob and Mark had read Shuster’s book and, discovering that he lived in the Minneapolis area, invited him to attend the 2009 Health Physics Society Annual Meeting Power Reactor Special Session—“Radiation Protection in a Nuclear Power Renaissance”—to hear our perspectives and share his insights as well. After the break, they and several others gathered in the lobby for coffee, discussion, and brainstorming. There was a lot of “scintillating” conversation, let me assure you! Perhaps with more interactions like this (leading to a chain reaction?) there will actually be a nuclear renaissance before too many of us retire to help make it become a reality.

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