

SECTION EDITOR: ANITA G. LICATA, MD

# Fluoroscopy-Induced Skin Necrosis

Jin Lee, BA; Diane Hoss, MD; Tania J. Phillips, MD; Boston University School of Medicine, Boston, Mass (Ms Lee and Dr Phillips); University of Connecticut Health Center, Farmington (Dr Hoss)

Critical Situations: Dermatology in the Acute Care Setting

## REPORT OF A CASE

A 48-year-old obese man<sup>1</sup> with a history of hypertension, coronary artery disease, and status post–quadruple bypass presented with an 8-month history of painful ulceration on the right midback. The initial lesion was described as a 4-cm square area of eroded eczematous dermatitis, which later developed 2 areas of ulceration that worsened despite various treatments, including oral and intralesional corticosteroids, oral antibiotic agents (erythromycin and ciprofloxacin), dapsone, and a hydrocolloid dressing.

Six months after onset, after initiation of high-dose prednisone therapy, examination revealed progression of the lesions into a large, necrotic ulcer measuring 4 × 4 × 3 cm, with copious amounts of expressible pus and foul-smelling discharge and muscle readily palpable on probing. Initial laboratory tests revealed a normal blood count, liver function, and serum protein electrophoresis.<sup>1</sup> Wound culture revealed moderate *Enterococcus* species, diphtheroids, rare hemolytic streptococcus B, and α-hemolytic *Streptococcus* species.<sup>1</sup> On immediate hospital admission, it was first discovered that he had undergone a complicated single-vessel angioplasty lasting over 2½ hours, during which he experienced angina and electrocardiogram changes, 1 month before his initial presentation to a dermatologist. Fluoroscopy-induced skin necrosis was likely the cause of his cutaneous ulceration. The wound was explored under general anesthesia, and debridement of the necrotic, infected material was performed. Histopathologically, there was extensive necrosis of the reticular dermis and subcutis, neutrophilic infiltrates, and numerous gram-positive cocci, occasionally in chains. Wound culture grew *Enterococcus*. Intravenous ampicillin sulbactam was administered, 3 g every 6 hours. A second surgical debridement was performed 1 week later and included a portion of fascia, which demonstrated serous exudation and inflammation. The depth of the wound was such that a latissimus dorsi musculocutaneous flap was necessary for closure.

## DIAGNOSTIC CHALLENGE

The initial differential diagnosis included factitial dermatitis or excoriations, and the lesion was treated with 0.025% fluocinolone ointment and a hydrocolloid dress-

ing without improvement. As the ulcers began to increase in size and depth, pyoderma gangrenosum was considered as a possible diagnosis, and treatment with 5 mg/mL of intralesional triamcinolone (0.75 mL total) was attempted but was limited secondary to tissue fibrosis and pain. Treatment with folic acid supplements and dapsone was also initiated. Treatment with prednisone for possible pyoderma gangrenosum was associated with rapid worsening of the ulcers and necrotizing fasciitis.<sup>1</sup> Causes of necrosis such as trauma secondary to the rectangular Bovie grounding pad and fluoroscopy-induced skin necrosis resulting from the complicated percutaneous transluminal coronary angioplasty procedure were not considered possible causes until the late discovery on admission that this procedure had been performed.

This case highlights the need for a full medical and procedural/surgical history, including fluoroscopic procedures in a patient who presents with ulcerative or necrotizing skin lesions. As occurred in our case, patients are likely not to associate prior fluoroscopic procedures with their skin eruptions and often do not contact their interventional cardiologist or radiologist to report this adverse event. Instead, they may present to a dermatologist who must recognize this type of lesion, contact the physicians who performed the procedure, and refer the patient for any necessary surgical intervention.

## COMMENT

The use of high-dose fluoroscopically guided interventional procedures began to increase rapidly in the 1990s, including radiofrequency ablation, coronary artery angioplasty and stent placements, neuroembolization, and transjugular intrahepatic portosystemic shunt placement.<sup>2</sup> These procedures are often the treatment of choice for serious, life-threatening conditions<sup>3</sup> and involve fluoroscopy to a single localized area for a prolonged time, ranging from 30 minutes to 1 hour. Radiation therapy differs from fluoroscopically guided interventional procedures in that radiation therapy delivers treatment in modest fractionated doses with beam energies designed to spare the skin from injury and rarely produces adverse cutaneous events, whereas interventional procedures use beams with no skin-sparing quality with doses delivered at a high level in a single fraction or in a few

fractions when repeated procedures are necessary. Skin is the organ at greatest risk during interventional procedures, whereas in radiation therapy, organs beneath skin are susceptible to adverse reactions.<sup>2</sup>

Multiple sequential sessions of treatment may be required for some patients undergoing interventional procedures, resulting in high skin doses.<sup>2</sup> Although there may be delay in time between treatments, permitting the skin to recover from prior exposure, recovery from high doses may be incomplete.<sup>4</sup> Skin reactions may occur as early as 1 week after irradiation and peak at about 3 weeks, or lesions may appear years later.<sup>2</sup> Lesions may vary in presentation from mild erythema to ulceration and necrosis requiring skin grafts or myocutaneous flaps. Patients may be asymptomatic and unaware of skin changes such as hypopigmentation and hyperpigmentation and telangiectasias,<sup>2</sup> especially when located in an area that cannot be readily visualized (ie, the back). In all cases of skin reactions associated with these procedures, doses are thought to have been high, and prolonged exposure to fluoroscopy was likely a contributing factor.<sup>2</sup>

Patients with preexisting conditions are at higher risk for an exaggerated response compared with otherwise healthy individuals.<sup>2</sup> Risk factors may include a previous high-dose radiation exposure, homozygosity for the ataxia telangiectasia gene, connective tissue diseases (especially systemic lupus erythematosus, scleroderma, or mixed connective tissue disease), and types 1 and 2 diabetes mellitus.<sup>4</sup> Factors influencing radiation doses vary according to the type of procedure, the medical institution, the fluoroscopic equipment, and the proficiency of the interventional physician. The most important factor in determining the dose of radiation a patient receives is the physician performing the study, since mean fluoroscopy times can vary among physicians and medical institutions by as much as 6-fold.<sup>4</sup>

In the literature to date, there have been 9 documented cases of fluoroscopy-induced skin necrosis.<sup>2-7</sup> According to histories provided, patients were typically middle-aged (40-75 years) men, who had undergone percutaneous transluminal coronary angioplasty with or without stent placement (8 cases) and transjugular intrahepatic portosystemic shunt procedure (1 case).<sup>2-7</sup> Owing to poor documentation, total exposure times were estimated and ranged from 48 to 300 minutes.<sup>2-7</sup> The common description of the injuries was an area of ulceration near the scapula of patients, which often corresponded to beam location.<sup>2-7</sup> Lesions varied in size in upwards of 15 × 12 cm and were initially described as pruritic, painful lesions that progressed from erythematous lesions to ulcerations, which typically necrosed. Therapies included surgical excision and multiple skin grafts, which in 1 case was unsuccessful, resulting in exposure of several ribs.<sup>2-7</sup>

The incidence of severe skin injuries related to high-dose fluoroscopic procedures is relatively low compared with the number of procedures performed each year.<sup>2</sup> Since 1992, the US Food and Drug Administration (FDA) has received approximately 40 separate reports<sup>2</sup> of radiation-induced skin injuries in patients who had undergone fluoroscopically guided interventional procedures, ranging in severity from erythema to tissue necrosis that required skin grafting. These injuries typically occurred after a variety

### Radiation-Induced Skin Injuries\*

Effect	Typical Threshold Absorbed Dose, rad	Hours of Fluoroscopic "On Time" to Reach Threshold†		Time to Onset of Effect‡
		Usual Dose Rate of 2 rad/min	High-Level Dose Rate of 20 rad/min	
Early transient erythema	200	1.7	0.17	Hours
Temporary epilation	300	2.5	0.25	3 wk
Main erythema	600	5.0	0.50	10 d
Permanent erythema	700	5.8	0.58	3 wk
Dry desquamation	1000	8.3	0.83	4 wk
Invasive fibrosis	1000	8.3	0.83	NR
Dermal atrophy	1100	9.2	0.92	>14 wk
Telangiectasia	1200	10.0	1.00	>52 wk
Moist desquamation	1500	12.5	1.25	4 wk
Late erythema	1500	12.5	1.25	6-10 wk
Dermal necrosis	1800	15.0	1.50	>10 wk
Secondary ulceration	2000	16.7	1.67	>6 wk

Abbreviation: NR, not reported.

\*Adapted from Wagner et al<sup>14</sup> and the Food and Drug Administration.<sup>13</sup>

†To convert rads to grays, divide by 100.

‡Time required to deliver the typical threshold dose at the specified dose rate.

§Time after single irradiation to the observation of effect.

of interventional procedures requiring extended periods of fluoroscopy<sup>3</sup>; however, difficulty arose in estimating the absorbed dose because of poor record-keeping of the fluoroscopic exposure times and facilities were unwilling to share information for fear of legal action and liability or adverse publicity. The common procedures associated with skin injuries were percutaneous transluminal coronary angioplasty,<sup>8,9</sup> cardiac catheter ablation, catheter placement for chemotherapy, transjugular intrahepatic portosystemic shunt, multiple hepatic or biliary procedures (ie, angioplasty, stent placement, and biopsy) and percutaneous cholangiography followed by multiple embolization procedures. In particular, percutaneous transluminal coronary angioplasty may have a higher incidence of severe skin injury owing to the complicated and lengthy nature of the procedure (exposing patients to 3.4 times more radiation vs angiography),<sup>8</sup> the cumulative effect of repeated procedures (which patients often require),<sup>4</sup> and delayed diagnosis resulting from poorly visualized locations.<sup>10</sup>

As radiation-induced skin injuries are becoming increasingly reported in the literature, the FDA has recommended several steps for reducing these injuries, including establishing protocols for each procedure, determining radiation dose rates for specific fluoroscopy systems and operating modes, and monitoring cumulative absorbed doses to areas of skin.<sup>3</sup> On September 15, 1995, the FDA recommended that the facilities record in the patient's medical chart the absorbed dose to the skin that approaches or exceeds some threshold dose for injury.<sup>11</sup> The FDA suggested a threshold absorbed dose in skin of 2 rad/min (0.02 Gy/min) and 20 rad/min (0.2 Gy/min) of areas of skin irradiated by a stationary, continuous fluoroscopic x-ray beam, with the amount of absorbed radiation of the skin for typical procedures ranging from 1 rad/min (0.01 Gy/min) to no more than 50 rad/min (0.5 Gy/min), depending on the mode of operation of the equipment and the size of the patient<sup>12,13</sup> (**Table**).

Several precautions should be taken to prevent radiation-induced skin injuries, including continuous surveillance of the x-ray dose, the use of different projections to avoid exposure to 1 skin area throughout the procedure, keeping the irradiated area as small as possible<sup>6</sup> and using pulsed fluoroscopic output rather than continuous, which decreases the radiation dose from one half to one quarter.<sup>15</sup> Improving radiation safety could be achieved by instituting mandatory education and appropriate use of fluoroscopy, which some hospitals have already implemented.<sup>8</sup> Patients undergoing multiple procedures should be screened for connective tissues disease before prolonged interventional procedure requiring fluoroscopy in a single location is performed.<sup>2</sup>

From a dermatologic perspective, we recommend that a thorough procedural history be obtained from patients who present with dermatitis or ulceration in unusual locations. Patients with systemic lupus erythematosus, scleroderma, ataxia telangiectasia, mixed connective tissue disease, diabetes mellitus, or skin damage from a prior procedure should be followed up carefully if lesions appear and be advised of the possibility of an adverse skin reaction if they undergo repeated procedures.<sup>2</sup> Also, patients with cardiac conditions should be followed up closely because lesions that are difficult to visualize may develop and patients may be asymptomatic until extensive necrosis and ulceration has occurred. Large patients are at greatest risk because their size will require high fluoroscopic outputs, and the geometry of the examination in a large patient will additionally cause doses to be elevated owing to the proximity of the skin to the x-ray source.<sup>2</sup> As fluoroscopic procedures have become more common, a concerted effort is required to minimize adverse skin reactions in patients undergoing these procedures. This necessitates the need for multidisciplinary approach to treating patients, including interventional radiologic or cardiologic procedures, dermatologic procedures, and plastic surgery if necessary.

Treatment modalities vary according to the extent of damage to the skin. Superficial injuries may respond to good wound care; however, most reported cases involving necrosis required surgical excision with split- to full-thickness grafts, depending on the depth of injury incurred.<sup>2-7</sup> Our patient responded well to surgical debridement with a latissimus dorsi muscle flap closure, which has completely healed.

In summary, fluoroscopic procedures have allowed for the treatment of patients in innovative ways. However, these technically complicated and often lengthy procedures place patients at increased risk of developing skin injuries, which may range from mild erythema to life-threatening necrotizing fasciitis. As dermatologists, it is imperative that we recognize these lesions early to prevent morbidity related to radiation-induced skin injuries.

Accepted for publication April 19, 2002.

This case history was previously presented in detail by Bello et al<sup>1</sup> as a presumptive diagnosis of necrotizing fasciitis.

Corresponding author: Jin Lee, BA, Department of Dermatology, Boston University School of Medicine, 445 Marlborough St, Apt 2, Boston, MA 02115.

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