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Case Presentation

Fluoroscopy-induced radionecrosis

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Abstract

Complications from radiation exposure during fluoroscopic guidance of cardiac catheterization may occur. With repeated procedures, the risk for cutaneous injuries increases. Herein, we describe a 59-year-old man with extensive coronary artery disease, who had undergone multiple revascularization procedures and developed a non-healing ulcer on his left inferior scapula. The patient's medical history, physical exam findings, and histopathology gave clues to a case of radiation-induced dermatitis and necrosis.

Keywords: Radiation, Fluoroscopy, Necrosis, Dermatitis.

Case synopsis

A 59-year-old man with extensive coronary artery disease and history of multiple revascularization procedures, presented to the dermatology clinic with an ulcer on his left inferior scapular region. His dermatologic history is remarkable for a melanoma *in situ* of the left ankle completely excised 2 years prior to presentation. The patient reported the presence of a square-shaped, pink plaque with ill-defined borders located on his upper back, which persisted for 11 years. He also noticed a similar rash on his mid anterior chest, which had resolved prior to his current presentation.

Two months prior to his first clinic visit, the left upper back area became crusted and developed a central fibrotic ulcerated area that was associated with tenderness and intermittent pain. His physical exam revealed a sharply defined, 5.0 cm x 5.0 cm indurated firm square-shaped atrophic plaque with telangiectasia and a central angulated ulceration on the left inferior scapular area (Figure 1).

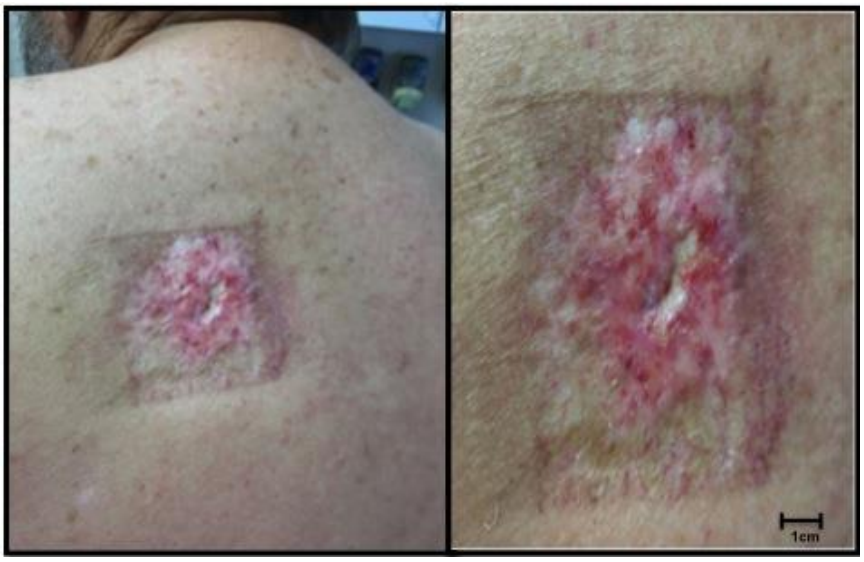

Figure 1. Left inferior scapular area (left) with indurated, firm square-shaped atrophic plaque with telangiectasia and central angulated ulceration (right).

A punch biopsy of the ulcerated plaque was performed. The histopathology revealed a necrotic epidermis and a densely fibrotic dermis with enlarged, stellate fibroblasts scattered between thickened collagen bundles. There was no evidence of malignancy (Figure 2).

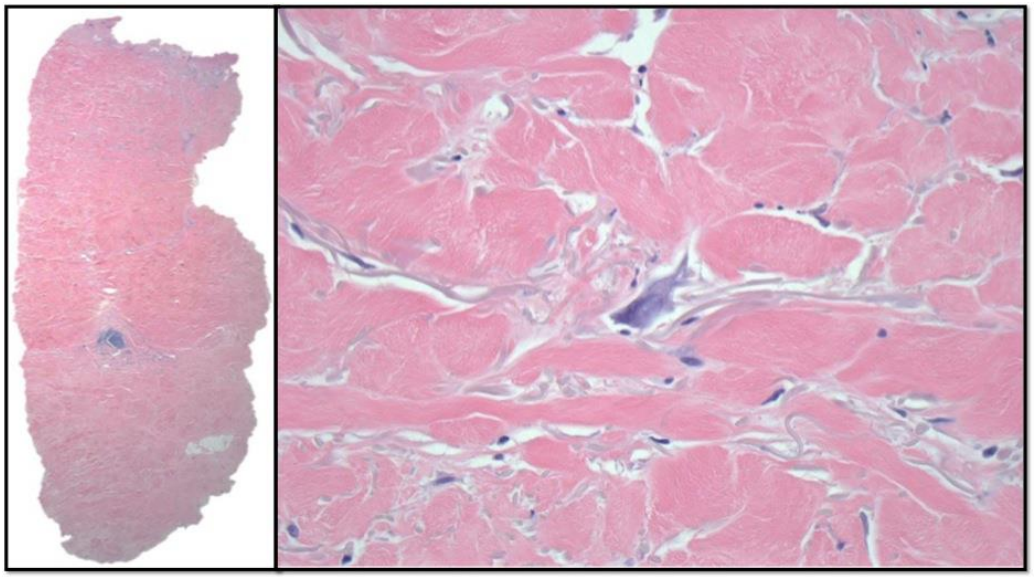

Figure 2. Histopathology findings. (Left) At scanning magnification, the epidermal surface has been lost, adnexal structures are absent, and there is pan-dermal fibrosis (hematoxylin & eosin, original magnification x20). (Right) Stellate fibroblasts, some markedly enlarged, are scattered between thickened collagen bundles (hematoxylin & eosin, original magnification x400).

The patient's medical history revealed that he had severe coronary artery disease, which warranted multiple diagnostic and therapeutic fluoroscopic-guided procedures, including a triple vessel coronary artery bypass grafting (CABG). A year later, he required coronary angioplasty with the placement of cardiac stent, followed 13 months later by a cardiac catheterization procedure. One year afterwards, the patient underwent another fluoroscopy-guided catheterization with the placement of two cardiac drug-eluting stents. Finally, two years later, he had a cardiac catheterization with plain angioplasty.

Diagnosis and treatment

The medical history, physical exam findings, and histopathology support the diagnosis of fluoroscopy-induced dermatitis and necrosis. Our patient was offered various treatment options, including tissue expansion with excision and primary closure. At this point, the patient opted for continued wound care.

Discussion

In spite of technological and medical advances in the treatment of cardiovascular disease[1-4], the use of ionizing radiation still poses risk to the patient [2,5-16]. During interventional procedure with fluoroscopy, the irradiation ranges from 0.01 Gray (Gy)/minute up to 2 Gy, depending on the length of the procedure [2-10]. A cardiac catheterization procedure typically lasts 30 minutes. However, an interventional procedure such as percutaneous transluminal coronary angioplasty with or without stent placement generally takes 90 to 120 minutes, and it may last longer in patients with previous CABG, such as our patient. The fluoroscopy time has been reported as an indirect proxy assessment of the level of radiation exposure [7-10]. The more complex the procedure is, the longer the procedure time and the associated fluoroscopic time will be; thus there is increased potential for more radiation exposure and related consequences [2,3,5-10]. Fluoroscopy-guided procedures may occur on one or more occasions during an interval that may vary from days to months [2,5,6,9,10]. The time interval between procedures depends on the risk/benefit assessment of every patient's condition [2,5,6,9]. The risk for cutaneous injury is determined by the peak skin dose (PSD), which is the highest amount of radiation absorbed by any area on a patient's skin [5,6]. It is measured in Gray and can only be approximated at the completion of the procedure because various areas of the skin may receive radiation as the X-ray and the framework moves during the procedure [2,5-10]. Cutaneous manifestations of radiation exposure from fluoroscopy-guided procedures are infrequently recognized [2,3,5-10]. In fact, the majority of fluoroscopic-induced skin alterations are unexpected [2,3,5-10].

Radiation dermatitis typically occurs secondary to additive radiation doses from numerous exposures during diagnostic and interventional procedures [2,3,5-17]. The initial skin damage is subtle and may be mistaken for allergic or contact dermatitis [5-10]. The pathophysiology of irradiation-induced damage is based on cellular DNA injury with the generation of free radicals that perpetuate the insult [5,6,9,17]. The M phase of mitosis is the most sensitive to the effect of radiation as the DNA is condensed [17-19]. The damage is manifested in delayed cellular division, failure of reproduction, and interphase death via apoptosis [9,17-20].

According to the Law of Bergonie and Tribondeau [21], radiosensitivity is directly proportional to the rate of cell division and inversely proportional to the degree of cell differentiation. Therefore, epidermal keratinocytes, hair follicles, and sebaceous glands are the most sensitive, whereas connective tissue is more resistant [17,20]. When a threshold dose of radiation is reached, the sequelae of radiation tend to be acute and have been referred to as non-stochastic or deterministic effects of radiation [2,5,9,18]. Individuals with defects in DNA repair genes and other genetic disorders (i.e, Fanconi anemia, xeroderma pigmentosum, hereditary malignant melanoma, dysplastic nevus syndrome) also have higher radiation sensitivity [6,9].

The National Cancer Institute [12] has defined acute cutaneous changes as those occurring within 90 days of radiation exposure. Lesions can be classified as grade 1 through 4, ranging from faint erythema to skin necrosis and ulceration. Grade 1 occurs with exposure at 2-5 Gray (Gy) and manifests as erythema with no observable long-term effects [6,9,11,12]. Grade 1-2 also manifests with transient erythema and long-term recovery but with a risk for dermal atrophy [6,9,11,12]. Between 10 to 15 Gy, telangiectasia and dermal atrophy are likely to occur in the long term [6,9,11,12]. Above 15 Gy, grade 3-4 insults lead to irreversible skin damage that might require surgical intervention [6,9,11,12].

The long-term effects take place from 15 days to decades thereafter and represent the cumulative result and extension of the acute process [5-15,22]. There is a loss of hair follicles, accompanied with increased fibrosis, and ulceration [5-15,17-24]. Long-term follow-up of skin ulceration is usually warranted as those ulcers can harbor skin cancers, including basal cell and squamous cell carcinomas [5-15,17-24]. Indeed, with incremental dosage, the probability of occurrence of radiation stochastic effects, which encompass genetic defects and cancer, increases [2,5,9,17-24]. Hence, it is important to perform a skin biopsy in the non-healing radiation-induced chronic wound.

The complexity of interventional fluoroscopic procedures (i.e., stent placement) has been associated with higher doses of radiation [2,3,5-10]. The conventional mode of fluoroscopy delivers the X-ray beam continuously, whereas newer systems use a pulsed delivery method, which reduces the exposure time and cumulative radiation dosage compared to the former [22,23]. The X-ray port can be adjusted to give different beam shapes, which in turn can result in sharply demarcated borders of skin injury post-radiation [5,6,9,22-24]. During cardiac catheterization with fluoroscopy, the average X-ray dosage is 0.02Gy/minute and can reach up to 2 Gy [2-10]. As the X-ray beam exits the port, the focus of the beam is on the anterior chest, but since radiation spreads

outward from its origin according to the square of the increasing distance, when it reaches the posterior wall of the chest it will have irradiated a much larger area [5,6,9,22-24]. This explains how the stray radiation reached this patient's back, although the dosage delivered to this larger area is lower. In addition to the radiation dose, the extent of the injury is also determined by some other factors, including the site of irradiation, the patient's nutritional status, smoking status, underlying impaired healing potential or associated co-morbidities (diabetes, obesity, connective tissue disease), and genetic disorders [2,5,6,9,22-24].

The technique to reduce radiation dosage is operator-dependent. However, this goal may be accomplished in various ways such as: reducing the fluoroscopy time, adjusting the beam collimator, minimizing the distance from the X-ray source to the patient, using a pulsed beam, and providing a shield for sensitive tissue or organs [2,3,5,6,9,22]. Once the injury occurs, management is focused on minimizing the damage and speeding the healing. The literature is scarce on effective treatments for radiation dermatitis. The limited treatment suggestions include: maintenance of a clean wound bed, use of mild soap, avoidance of contact with irritants, and avoidance of elevations in temperature [5,6,9,24-31]. Although topical steroids have often been recommended [24-31], they should be applied with caution, in light of their known effects of slowing the healing process. Various non-steroidal topical agents have been advocated including aloe vera, sucrafalte, and non sucrafalte derivatives with no superior activity when compared to placebo 24-31]. Systemic therapies such as amifostine, pentoxifylline, zinc, and vitamin E have shown some benefit [24-31].

Conclusions

The evolution of minimally invasive cardiovascular procedures has significantly increased the use of fluoroscopy. The complexity of diagnostic and therapeutic interventions has considerably impacted the risk for cutaneous injuries ranging from transient erythema to potential skin malignancies.

This case highlights the importance of appropriate patient counseling during interventional procedures involving fluoroscopy, especially if repeated procedures are performed. It also reminds caregivers of the importance of patient follow-up and skin surveillance and the possible need for repeat biopsy to rule out malignancy in chronic non-healing ulcers arising in areas that have received radiation as a result of fluoroscopy.

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