Radiation-induced Effects to Nontarget Abdominal and Pelvic Viscera

Christine M. Peterson, MD[a,*], Christine O. Menias, MD[b,c], Douglas S. Katz, MD[d,e]

KEYWORDS

• Radiation • Injury • Veno-occlusion • Fistula • Stricture • Osteopenia

KEY POINTS

- Radiation therapy is a useful tool for the treatment of some patients with cancer. However, sometimes nontarget organs are irradiated.
- Radiation therapy can have temporary or permanent effects on nontarget organs.
- It is vitally important for radiologists to recognize these effects and not mistake them for other entities, particularly tumor metastasis or recurrence.

INTRODUCTION

Radiation therapy has become a mainstay of treatment of many forms of cancer. Although this article does not discuss the specifics of radiation therapy, it is of utmost importance for the radiologist interpreting an imaging examination to recognize some of the expected and unintended consequences of treatment so that the radiologist can suggest or establish the correct diagnosis, aid in the direction of further management, and not misattribute the imaging appearance of these consequences to other entities, particularly tumor recurrence or the development of metastatic disease.

Although some newer radiation therapy delivery methods decrease the dose delivered to the targeted organs so that the amount of radiation is effective but not excessive, and deliver less radiation to adjacent tissues, neighboring tissues are still exposed to radiation to some degree. As a result, inadvertent organ damage may still occur. Familiarity with the consequences of radiation therapy and their imaging appearances makes radiologists' input more clinically relevant and useful.

Newer radiation therapy techniques, such as stereotactic body radiotherapy, deliver a precise radiation dose to a small volume of tissue. As a result, less normal adjacent tissue is exposed to radiation. When exposure and subsequent damage do occur, the underlying pathologic mechanism of tissue damage is similar between the different forms of therapy. Damage to organs usually occurs as a result of microvascular injury and endothelial damage, venous thrombosis, and tissue fibrosis.[1]

Underlying chronic systemic disease may potentiate injury to normal adjacent tissues. These diseases may be as frequently encountered as diabetes and hypertension.[2]

[a] Department of Radiology, Penn State Hershey, Hershey, PA 17033, USA; [b] Mayo Clinic LL Radiology, 13400 East Shea Blvd, Scottsdale, AZ 85259, USA; [c] Mayo Clinic Hospital, 5777 East Mayo Boulevard, Phoenix, AZ 85054, USA; [d] Department of Radiology, Winthrop-University Hospital, Mineola, NY 11501, USA; [e] State University of New York at Stony Brook, Stony Brook, NY 11794, USA
* Corresponding author.
E-mail address: cpeterson3@hmc.psu.edu

Radiol Clin N Am 52 (2014) 1041–1053
http://dx.doi.org/10.1016/j.rcl.2014.05.004
0033-8389/14/$ – see front matter

LIVER

As with other abdominopelvic radiation-related organ injury, damage to the liver, or radiation-induced liver disease, is thought to occur as the result of veno-occlusive disease at the microscopic level, to the small branches of the hepatic and portal veins. As underlying liver abnormality increases, the ability of the liver to heal and regenerate decreases. Patients with chronic underlying liver disease, particularly cirrhosis or fatty deposition, have a worse prognosis with respect to liver damage from radiation therapy, compared with those individuals with otherwise normal livers.

Acute radiation injury to the liver usually occurs 4 to 16 weeks after radiation therapy,[3] and may manifest as the classic triad of hepatomegaly, ascites, and increased alkaline phosphatase,[4] and patients may have right upper quadrant abdominal pain.[5] However, there is no definitive treatment of these patients with regard to their liver abnormalities.[4] Treatment is often supportive.

The liver typically tolerates a dose of up to 35 Gy using more conventional techniques in which much of the liver is exposed. If newer techniques are used that only expose a small portion of the liver, doses up to 70 Gy can be tolerated.[6] In high-dose radiation targeted liver therapy (stereotactic therapy), tumor treatment is maximized and the dose to surrounding tissue is minimized by precise and accurate delivery of multiple radiation beams to the targeted region.[7]

On computed tomography (CT) and magnetic resonance (MR) imaging, a characteristic geographic but nonanatomic straight line (with conventional external beam radiation therapy) of low attenuation or low T1-weighted signal intensity may be seen, respectively, demarcating the edematous affected portion of the liver from the nonaffected portion (**Figs. 1–3**).[3] If CT arterial phase imaging is obtained, increased density of the affected portions of the liver may be seen, presumably as a result of decreased portal venous flow and resultant increased hepatic arterial flow. As part of a multiphasic CT protocol, portal venous phase images again show the area of low attenuation. Delayed CT images may show abnormally persistent enhancement of the affected parenchyma, likely caused by altered venous dynamics.[8]

Patient with otherwise normal livers most often fully recover from the insult, and any radiologic abnormality of the liver resolves over time. As with other organs, concomitant chemotherapy may potentiate radiation-related liver injury.[8]

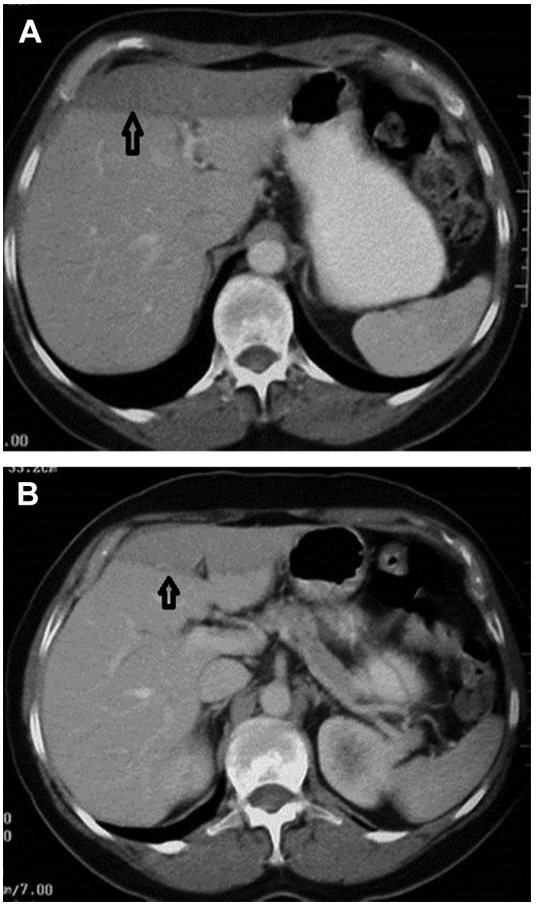

Fig. 1. Radiation injury to the liver. Axial contrast-enhanced CT (CECT) images (*A*, *B*) of the abdomen show a geographic linear area of decreased attenuation in the anterior aspect of the liver corresponding to the radiation port (*arrows*) in this patient who underwent radiation to the right chest wall for advanced breast carcinoma.

SPLEEN

The spleen, as with other lymphatic tissues, is exquisitely radiosensitive. However, splenic injury related to radiation is uncommon. As with the liver, radiation-related splenic injury is apparent on noncontrast CT and MR imaging as a well-defined but nonanatomic area of low attenuation or signal intensity in the parenchyma, corresponding with the radiation port. This treated area may then progress to parenchymal atrophy (**Fig. 4**).[9]

PANCREAS

The pancreas in uncommonly inadvertently injured during or after radiation injury, but, if there is injury,