Chapter 5

Radiation-induced Brachial Plexopathy: MR Imaging

Neurological symptoms and signs of brachial plexopathy may develop in patients who have had radiation therapy to the axilla, infraclavicular and supraclavicular regions. Symptoms consist of paresthesias, hypesthesias, weakness, decreased muscle stretch reflexes and pain. The most common causes are neoplastic, due to recurrent or metastatic tumor, or radiation-induced brachial plexopathy. Radiation-induced brachial plexopathy is a well recognized clinical entity, but there have been only a few reports about the MR imaging findings. In this chapter we describe three patients with three different MR imaging appearances of radiation-induced brachial plexopathy.

Case Reports

All MR studies were performed on a 0.5 Tesla system (Gyroscan T5-II, Philips, Philips Medical Systems, Best, The Netherlands), except for the second investigation of case 1, which was done on a 1.5 Tesla system (Gyroscan ACS-NT, Philips, Philips Medical Systems, Best, The Netherlands).

Case 1 (patient No. 70, see Table 6, Chapter 3)

A 75-year-old woman presented with weakness of the left hand and paresthesias in the fingers, radiating to the upper arm. Physical examination revealed absent reflexes of the left arm, sensory loss in the C6, C7 and C8 dermatomes and atrophy of the small hand muscles, especially the thenar muscles and the first interosseus muscle. The patient had undergone a mastectomy and axillary lymph node dissection on the left side 17 years earlier for breast carcinoma, followed by radiation therapy. Nine years later the symptoms, which were slowly progressive, started. The total given dose was 4000 centiGray (cGy) in 20 fractions with a cobalt unit, delivered to the thoracic wall and regional lymph nodes. EMG confirmed an extensive brachial plexus lesion. MR imaging of the brachial plexus showed that the perineural fat was replaced by structures with a low signal intensity on both T1- and T2-weighted images (Fig. 1A and B), consistent with perineural fibrosis. Three-year clinical follow-up revealed no signs of metastatic tumor. Repeated MR imaging results (Fig. 1C) were unchanged. The normal right side was studied for comparison (Fig. 1D).
Case 2 (patient No. 82, see Table 6, Chapter 3)
A 45-year-old woman with a left-sided breast carcinoma underwent mastectomy and axillary lymph node dissection. Postoperative radiation therapy (total dose 4700 cGy in 20 fractions with a linear accelerator) was given to the thoracic wall and...
Case 2.

A. Coronal T1-weighted image shows a straight course of the slightly swollen left brachial plexus (arrows).

B. For comparison the normal right brachial plexus (arrows).

C. Sagittal T2-weighted image at the level of the cords of the left brachial plexus clearly shows the increased signal intensity (arrow).

regional lymph nodes. Adjuvant chemotherapy in six cycles (cyclophosphamide, methotrexate and 5-fluorouracil) followed radiation therapy. One month after the radiation therapy the patient noticed paresthesias, with pain and weakness of the left hand. EMG located the lesion proximally in the brachial plexus. The pain and weakness were progressive. Nine months after radiation therapy MR imaging showed a slightly swollen brachial plexus with an increased signal intensity on T2-weighted images within the trunks through to the cords (Fig. 2). Seven months later the symptoms had improved, with less weakness and only a slight disturbance of the coordination of the small hand muscles. Three and a half years after surgery, there were no signs of metastatic tumor, although the left arm was still painful and a slight weakness of the hand remained.
Case 3 (patient No. 76, see Table 6, Chapter 3)
A 41-year-old man with Hodgkin’s lymphoma was irradiated on the following four irradiation fields: (1) mediastinum, (2) neck, supraclavicular and submandibular regions on both sides, (3) right and (4) left axilla with a cobalt unit. The estimated total dose given for each area was 4000 cGy; the gap between different fields was 0.5 cm. The patient had no symptoms until 19 years later, when he presented with weakness of the right hand. At physical examination a decreased sensibility of the ulnar side of the hand and atrophy of the thenar, hypothenar and interosseus muscles was found. One year later a surgical deviation of the ulnar nerve was performed, without any relief of the complaints. MR imaging (Fig. 3), 21 years after the radiation therapy, showed indistinctness of the whole brachial plexus due to the replacement...
of the perineural fat by low signal intensity tissue on T1-weighted images. A markedly increased signal intensity was seen on the T2-weighted images, and after administration of gadolinium-DTPA diffuse enhancement was noted. To establish the diagnosis and to rule out recurrence of Hodgkin’s disease surgical exploration and biopsy were performed. At surgery extensive fibrosis was seen around the brachial plexus; the biopsy revealed sclerotic scar tissue around the brachial plexus and thick-walled vessels without signs of malignancy. The symptoms have changed little up to now, two years after surgery.

Discussion

Because of its location, radiation-induced damage to the brachial plexus can occur in patients who have had radiation therapy for neoplasms of the mediastinum, breast, lung or lymph nodes. This was recognized in 1966 by Stoll, who found delayed damage to the brachial plexus in patients treated with radiation therapy after surgery for breast carcinoma. Besides this progressive radiation-induced brachial plexopathy, reversible brachial plexopathy has also been reported. Salner reported eight of 565 patients with paresthesias, less commonly with weakness and pain at a median time of four and a half months after radiation therapy. Complete resolution of all complaints was found in five patients, in three patients mild paresthesias persisted. A relationship to chemotherapy has been noted by several authors however the etiology is not known.

The main problem in diagnosing radiation-induced brachial plexopathy is its differentiation from neoplastic brachial plexopathy. Clinical signs and symptoms may be useful. Kori studied 100 patients and found useful clinical criteria. Horner’s syndrome, lower brachial plexus (C7, C8, Th1) involvement, early and severe pain, hand weakness, a radiation dose less than 6000 cGy and a latency period more than a year are suggestive of tumor infiltration. On the other hand, upper brachial plexus (C5, C6) involvement, doses more than 6000 cGy, a latency period of less than a year, no pain and lymphedema favor radiation-induced brachial plexopathy.

CT was the first useful radiographic study. CT is able to show axillary masses consistent with metastatic or recurrent tumor. In patients with radiation-induced brachial plexopathy distortion of the tissue planes and increased density of the axillary fat can be present. MR imaging has several advantages above CT, the most important being the inherent contrast differences between the brachial plexus, the vessels and the surrounding fat, and the multiplanar imaging possibilities. MR imaging has proven to be useful in diagnosing masses in or near the brachial plexus. Early reports about radiation fibrosis in general suggested that radiation fibrosis can be differentiated from recurrent tumor using T2-weighted sequences. Radiation fibrosis usually has a low signal intensity, while
tumor shows a higher signal intensity on T2-weighted images.\textsuperscript{61,85} There have been some reports about the appearance of radiation-induced brachial plexopathy on MR imaging.\textsuperscript{21,25,152,194,200,248} Three studies reported low signal intensity tissue on T2-weighted images around the brachial plexus;\textsuperscript{21,152,200} another author\textsuperscript{194} reported a case with slightly hyperintense tissue on T2-weighted images. One study\textsuperscript{248} found high signal intensity on T2-weighted images in or around the brachial plexus in patients with neoplastic brachial plexopathy as well as in patients with radiation-induced brachial plexopathy, but the presence of a mass was the most reliable sign in differentiating between the two. Another study\textsuperscript{25} confirmed these findings in a patient who was treated for a supraglottic carcinoma.

In this paper we describe three appearances of radiation-induced brachial plexopathy on MR imaging: one case with low signal intensity fibrosis, another case with high signal intensity fibrosis, and a third case with more extensive high signal intensity fibrosis with gadolinium-DTPA enhancement 21 years after radiation therapy. Cases 1 and 2 were confirmed by strong clinical evidence with a follow-up of respectively three and three and a half years; case 3 was diagnosed by surgical biopsy. In case 3 the possibility exists that the dose exceeded 5000 cGy due to overlap of fields and the use of the cobalt unit; however it is remarkable that this patient was irradiated on both sides and did not have any symptoms on the left side. In cases 1 and 2 the given doses were within the normal limits. The histories of cases 1 and 3 are both consistent with radiation-induced brachial plexopathy; the progressive symptoms started nine and 19 years respectively after the radiation therapy. The history and clinical course of case 2 are consistent with the reported reversible brachial plexopathy.\textsuperscript{214} This patient also had chemotherapy, which is said to be related to the induction of brachial plexopathy. In this case, where there was an improvement of the symptoms, the perineural fibrosis seemed to be less extensive on the MR images than in cases 1 and 3.

We conclude that radiation-induced brachial plexopathy can be of low and high signal intensity on T2-weighted sequences, and that fibrosis can enhance even 21 years after radiation therapy. High signal on T2-weighted images and contrast enhancement do not preclude the diagnosis of fibrosis.