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EXTENSIVE LATE BONE NECROSIS AFTER POSTOPERATIVE ORTHOVOLTAGE IRRADIATION OF BREAST CARCINOMA

Report of a case

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Abstract

Extensive osteonecrosis of the clavicle, scapula and humerus was observed in a patient treated postoperatively 22 years earlier, with 250 kV roentgen rays, for breast carcinoma. Retrospective calculations based on the absorption in soft tissue and bone revealed very high absorbed doses in the bone (about 120 Gy).

Radiation osteitis or osteonecrosis is a well-known though relatively rare complication of radiation therapy. The histologic features of this condition were described by EWING already in 1926 (4). Since then, several reports have dealt with the clinical, roentgenologic and histologic characteristics of this type of radiation damage (1–3, 5, 6, 8, 10–13).

The absorbed dose in bone, from orthovoltage roentgen therapy, is usually 50 to 100 per cent higher than the absorbed dose in soft tissue. Nevertheless, much more attention has been paid to radiation damage of skin and subcutaneous tissue than to bone damage. The reasons for this are probably that skin damage is more easily observed, that bone tissue is less vulnerable to radiation, and also that many patients did not survive long enough for bone lesions to become manifest.

In the present report, extensive bone necrosis is described in a patient who had received postoperative orthovoltage roentgen therapy a long time previously, for breast carcinoma. The case illustrates the very large absorbed doses in the bone that could be obtained with orthovoltage roentgen treatment.

Case report

In 1979, an 83-year-old woman presented for pain and swelling of the right arm that had been increasing for several years. In 1957 (22 years previously), the patient had undergone radical mastectomy for adenocarcinoma of the right breast. She had been irradiated postoperatively in another hospital with a 250 kV Picker roentgen therapy unit (SSD=50 cm, HVL=1 mm Cu) against four fields: 1) an anterior field including the axilla and supraclavicular fossa (10 cm×15 cm), 2) a posterior field including the axilla and supraclavicular region (10 cm×15 cm), 3) an axillary field with beam direction straight into the axilla (10 cm×12 cm), and 4) a parasternal field (6 cm×15 cm).

A dose of 1 600 R in air was delivered in 3 weeks to both the anterior and the posterior axillary and supraclavicular field; a second course of 1 600 R was delivered to the same fields 17 weeks later. During this interval, the axillary and parasternal fields (fields 3 and 4) were treated concomitantly, with 1 600 R in air to the axilla and 4 800 R in air to the parasternal field.

The patient was lost to follow-up until her presentation in 1979. Physical examination revealed a marked lymphedema of the right arm, telangiectasia in the irradiated areas, sclerotic tissues in the right axilla, and limited movements of the right shoulder. Roentgen films of the right shoulder showed almost completely destroyed bone structures in the shoulder girdle (Fig. 1a). A bone scan

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revealed increased uptake in the involved areas. Further examinations, including blood counts, blood chemistry, bone and liver scans, and roentgen films showed no metastatic disease. Further deterioration of the local bone destruction was observed during the next 2 years of observation (Fig. 1b).

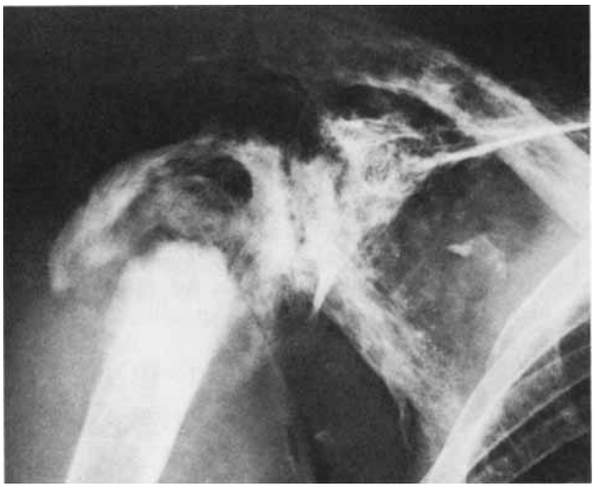
Re-evaluation of dosimetry

The absorbed doses in the clavicle, the scapula and the humerus were calculated using a method described by JOHNS & CUNNINGHAM (7). The calculations were carried out for the compact bone as a whole. Only fields 1, 2 and 3 were considered, as field 4 (parasternal) did not essentially contribute to the dose within the volume under investigation. The air doses originally expressed in R (roentgen) were converted to Gy by multiplying with the f factor for soft tissue and adding the back scatter component, yielding reference doses of 21, 21 and 20.5 Gy per treatment course to fields 1, 2, and 3, respectively. A graphic demonstration of the estimated absorbed doses from the three treatment fields is given in Figs 2 and 3 in a semilogarithmic scale.

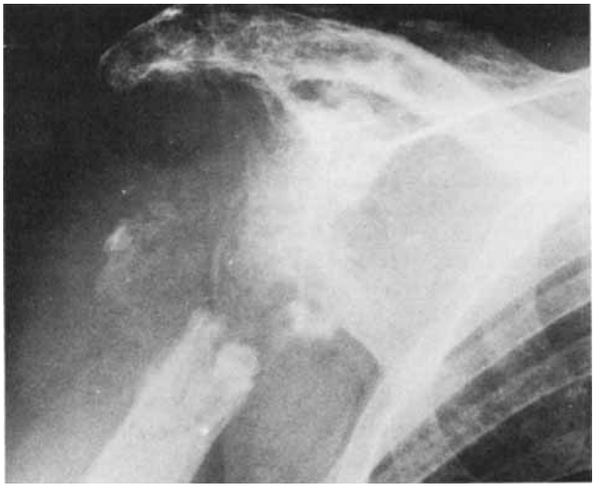
The dose from the anterior axillary field is demonstrated in Fig. 2a. The curve A P S P_1 S_1 B represents the nominal depth dose in soft tissue at an HVL of 1 mm Cu. To obtain the dose absorbed by the bone, the nominal depth dose in soft tissue must be multiplied by the f factor for bone (1.8) and divided by the f factor for soft tissue (0.95). Accordingly, the absorbed dose at the anterior surface of the clavicle is represented by point Q and equals 192 per cent of the skin surface dose. Point S (95%) represents the nominal depth dose in soft tissue at the exit point of the bone. The reduction of the nominal dose at this point after having passed through 1 cm of bone yields 81 per cent at point T. This value must be multiplied again by the factor 1.8/0.95=1.89, yielding point U (153%), which corresponds to the absorbed dose at the exit side of the clavicle. Similarly, points Q_1 (134%) and U_1 (91%) represent the corresponding calculated absorbed doses at the entry and exit surfaces of the scapula from field 1.

Fig. 2b shows a similar calculation carried out for field 2. Fig. 3 demonstrates calculated absorbed doses in the humerus from fields 1, 2, and 3.

When the estimated absorbed doses in different points were summed up, values of 124 Gy, 122 Gy and 131 Gy were obtained for the anterior parts of the clavicle, scapula and humerus, respectively.



a



b

Fig. 1. Shoulder girdle. a) In 1979 and b) in 1981.

The corresponding values for the posterior parts of these bones were 119 Gy, 126 Gy and 131 Gy.

It must be underlined, however, that the dose reconstruction illustrated in Figs 2 and 3 only gives crude estimates of the real absorbed doses. Some errors are involved in the anatomic reconstruction but are probably of minor significance. More important errors are due to the fact that the parts of the skeleton under discussion do not consist only of compact bone. They also contain some bone marrow (spongy bone), and the compact bone itself contains some soft tissue parts (such as haversian canals) which on a microscale may modify the ab-

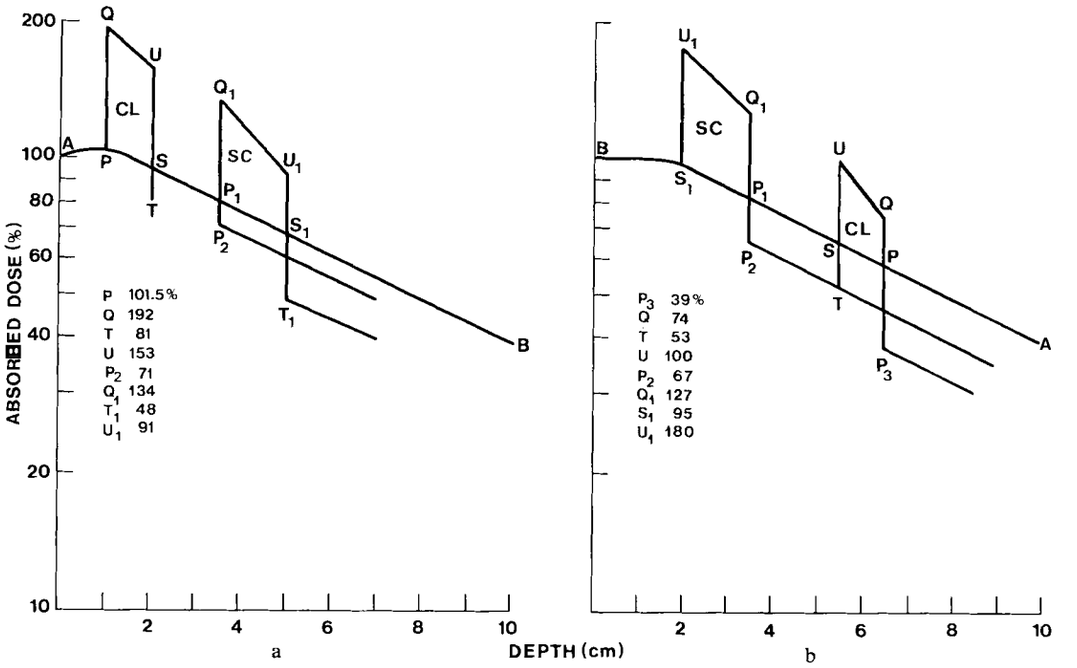


Fig. 2. Absorbed dose in clavicle (CL) and scapula (SC) from a) anterior axillary and supraclavicular field (field 1) and b) from posterior axillary and supraclavicular field (field 2).

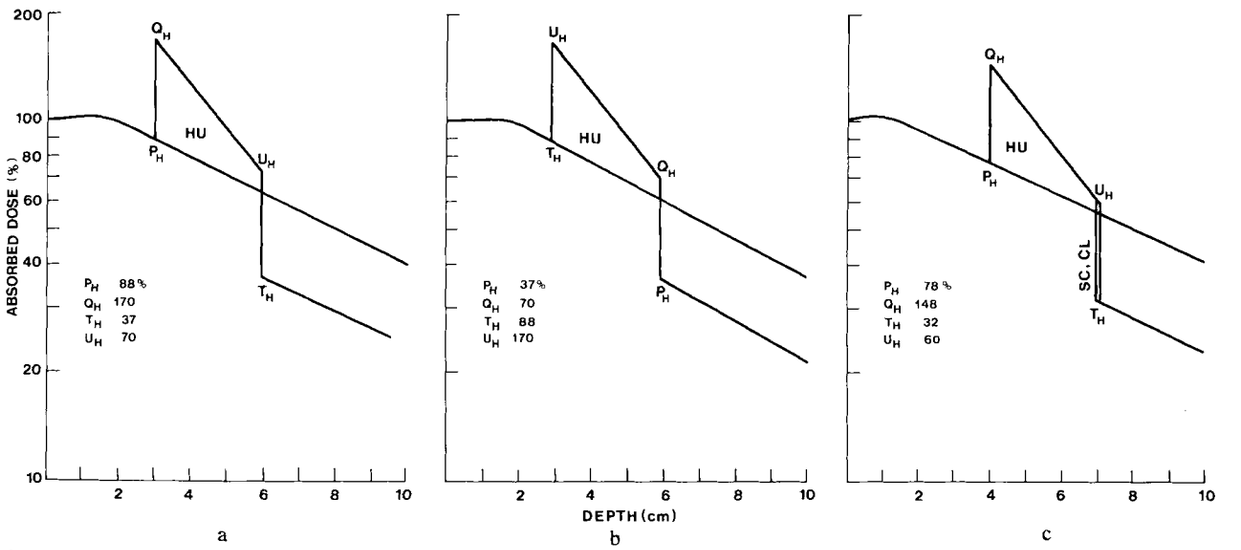


Fig. 3. a) Absorbed dose in humerus (HU) from field 1. b) Absorbed dose in humerus (HU) from field 2. c) Absorbed dose in humerus (HU), clavicle (CL) and scapula (SC) from direct axillary field (field 3).

sorbed doses considerably. It can, however, be stated with certainty, that the real average absorbed doses in the most heavily irradiated bone parts must have been very large, probably in the order of 100 Gy.

Discussion

The reported latent period of radiation osteonecrosis varies between one and 29 years with an average of about 3 years (2, 6, 8, 10, 12). The reported changes were more often caused by ortho-

voltage than by megavoltage therapy. With orthovoltage roentgen therapy, the absorbed dose in compact bone is approximately twice as high as the absorbed dose in soft tissue. Marked atrophic changes in bone have been observed after absorbed doses in the range of 100 Gy in 3 weeks (6). It is known that heavy irradiation of weight bearing bones such as the pelvis or the femoral neck can cause bone necrosis within only 3 years (13). In the humerus and the shoulder girdle bones, radiation necrosis has been more rarely demonstrated, probably due to the fact that these bones are not weight bearing and hence that pathologic fractures are delayed (11).

The patient in this report was obviously treated without recognition of the real absorbed doses which could be obtained when orthovoltage roentgen treatment was given according to an exposure dose in air. Retrospective calculations showed absorbed doses in the compact bone in the range of 120 to 130 Gy. Even if the modifying effect of split course treatment is considered (9) the absorbed dose was large enough to cause serious bone damage. It is also important to note that orthovoltage roentgen rays give RBE values which are 10 to 15 per cent higher than the RBE value of supervoltage irradiation.

After supervoltage irradiation, the absorbed dose is much more homogeneous, which reduces the risk of overdosage in bone. Nevertheless, we believe that the present case calls attention to the late effects of irradiation and the importance of careful dose planning also when supervoltage irradiation is used.

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