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Surgical management of the radiated chest wall and its complications

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Synopsis

Radiation to the chest wall is common before resection of tumors. History of radiation does not necessarily change the surgical approach of soft tissue coverage needed for reconstruction. Osteoradionecrosis can occur after radiation treatment, particularly after high dose radiation treatment. Radical resection and reconstruction is feasible and can be life saving. Soft tissue coverage using myocutaneous flap or omental flap is determined by the quality of soft tissue available and the status of the vascular pedicle supplying available myocutaneous flaps. Radiation induced sarcomas of the chest wall occur most commonly after radiation therapy for breast cancer. While angiosarcomas are the most common histology of radiation induced sarcoma, osteosarcoma, myosarcomas, rhabdomyosarcoma, and undifferentiated sarcomas also occur. The most effective treatment is surgical resection. Tumors not amenable to surgical resection are treated with chemotherapy with low response rates.

Keywords

Chest wall; radiation; osteonecrosis; sarcoma; breast cancer

Radiation therapy to the chest wall is common, and is most commonly administered for treatment of primary or recurrent breast cancer. Radiation therapy may cause both early and late radiation tissue injury. Radiation therapy causes tissue damage primarily by means of reactive oxygen species-mediated damage to differentiated soft tissue cells, soft tissue progenitor cells, and vascular endothelial cells. These changes lead to fibrosis, an abnormal response to tissue injury, and tissue death.[1] In addition, cytokine and chemokine release

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after irradiation perpetuate a chronic inflammatory response that can cause ongoing tissue injury. A host of pro-inflammatory cytokines, including interleukin-1 (IL-1), IL-6, transforming growth factor (TGF- β), and tumor necrosis factor (TNF- α) contribute to the chronic inflammation and tissue damage observed after radiation therapy. [1-4]

A spectrum of chest wall injury can be seen after radiation treatment. Skin toxicity including hyperpigmentation, telangiectasias, and dryness are common.[5, 6] Soft tissue edema and minor fat necrosis are fairly common. Rib fractures can occur and may lead to acute and chronic pain. Symptomatic chest wall tissue injury with impending or early skin ulceration may benefit from hyperbaric oxygen treatment (HBO2).[7, 8] HBO2 involves administration of pure oxygen in a pressurized chamber, typically greater than 2 atmospheres, dosed as daily or twice daily sessions. HBO2 increases the partial pressure of oxygen in the soft tissues and has been shown to speed healing of radiation induced injury. The most common use of HBO2 for treatment of radiation associated tissue injury is osteoradionecrosis of the mandible in the setting of head and neck cancer, however HBO2 treatment for chest wall wounds has also been utilized with some reported success. [7, 9, 10]

At the other end of the spectrum of radiation induced soft tissue injury are severe osteoradionecrosis and radiation induced sarcoma.[5, 11] Osteoradionecrosis presents with ulceration and sometime extensive soft tissue changes. When left untreated, full thickness necrosis ensues and superimposed infection can occur. Soft tissue biopsy is recommended to rule out recurrent breast cancer, as this may change the treatment approach with regards to determining the goals of surgery and use of preoperative therapies. Radiation induced sarcomas should similarly be biopsied with core needle biopsy to exclude recurrent breast cancer.

The following review focuses on surgical resection of the chest wall after radiation therapy. We concentrate mainly on treatment of osteoradionecrosis and radiation induced sarcomas, although we briefly discuss surgical resection of recurrent cancers in the setting of radiation therapy.

Surgical Resection of the Irradiated Chest Wall

In addition to surgical resection for osteonecrosis and radiation induced sarcoma (discussed below), surgical resection of recurrent breast and chest wall sarcoma after radiation therapy is sometimes necessary.[12-14] Loco-regional recurrence of breast cancer in the chest wall occurs in approximately 9% of patients undergoing breast conservation therapy.[14] Multi-modality treatment including chemotherapy, radiation, and surgery is typically employed. Although there is some controversy regarding the benefit of surgery compared with systemic therapy and radiation therapy in estrogen receptor-negative breast cancer, surgical resection is often carried out after radiation therapy has already been administered to the chest wall. In general, resection margins should encompass all skin with radiation changes to ensure proper wound healing. Surgical margins should be appropriately wide. Although we recommend and routinely use intraoperative frozen section analysis, margin determination can be challenging at bony margins where frozen section is not possible. In addition, frozen section analysis of breast cancer at soft tissue margins can sometimes miss infiltrating breast

cancer cells that are identified on permanent pathology.[15-17] Reconstruction of the chest wall is described elsewhere. Soft tissue coverage should factor in the size of the defect, the radiation field, and the quality of the soft tissue at any potential flap vascular pedicle. Rotational myocutaneous flaps, such as latissimus dorsi flaps, are commonly used but close attention should be directed to whether the vascular pedicle was included in the radiation field and if so whether the vessels are patent and what the quality of the soft tissue surrounding those vessels is.[18] This can affect the blood flow to the flap after reconstruction even when vessels are patent through kinking of the pedicle when rotated through fibrotic tissue. Similarly, free flaps should be implanted into vessels free of radiation whenever possible. Use of the omentum, which is tunneled subcutaneously, provides excellent soft tissue coverage in an irradiated field and is covered with skin grafting. The downsides of omental flaps are the need for laparotomy (or laparoscopic harvest), risk of symptomatic ventral hernia, and inferior cosmetic result. Finally, the omentum may not provide sufficient coverage in very thin patients. Selection of coverage should be individualized based on the size of the defect, extent of radiation changes, and body habitus. [19]

Osteonecrosis of the Chest Wall

Aside from skin changes and soft tissue edema, chest wall necrosis is rare with standard doses of radiation therapy (typically between 4,000-5,000 cGy). Although there is not a large amount of evidence on the factors contributing to chest wall osteoradionecrosis, delivery of high dose radiation, either planned or unplanned, due to incorrect planning, dose calculation, or machine calculation is likely to be responsible.[20] Patients typically present with slowly worsening skin ulceration and full thickness necrosis that involves pathologic rib fractures, which cause discomfort and chest wall instability. Tissue necrosis often progresses with time due to a combination of ongoing microvascular compromise, inflammation, and infection. Localized infection in the skin, soft tissue, and bone is common because of the loss of the normal skin barrier and compromised microvascular circulation, which prevents an effective immune response. When allowed to progress without treatment, loss of necrotic soft tissue and ribs will expose the thoracic viscera, which results in empyema. Both soft tissue infection and empyema may result in septicemia, which may be fatal if left untreated. Quality of life is poor due to fatigue from chronic wound infection, foul smell, which often accompanies infection, and body image issues related to the nature of the wound.

It is important to biopsy the edges of the wound to rule out recurrent cancer. At times, it can be difficult to distinguish osteoradionecrosis from recurrent cancer, and both may be present. Imaging with chest CT and PET/CT are important to evaluate for systemic disease, however imaging is not diagnostic to distinguish between these two entities. While both recurrent disease and osteoradionecrosis are typically treated surgically, recurrent breast cancer in the chest wall is associated with poor prognosis and systemic therapy prior to surgical resection may be indicated. Moreover, surgical margins should be wider when recurrent chest wall disease is present.

The primary goals of surgical treatment for osteoradionecrosis are to eliminate infection, to excise all damaged tissue, and to provide stability to the chest wall during reconstruction. When infection of ulcerated skin is present, a combination of systemic antibiotic therapy, localized wound debridement, and vacuum-assisted closure (VAC) therapy (KCI, San Antonio, TX) is often indicated. VAC therapy accelerates wound healing by applying negative pressure, removing edema fluid and bacteria. This improves resolution of infection and decreases time to formation of granulation tissue. [21] It is important to reduce the bacterial load of the soft tissue as much as possible before definitive surgical resection, as prosthetic chest wall reconstruction provides the most effective stabilization of the chest wall. The extent of debridement varies by the extent of wet necrosis. Options for debridement include mechanical (surgical) debridement, enzymatic debridement, and maggot debridement therapy (MDT). For extensive chest wall wounds, we have used MDT with excellent results. [22] Enzymatic debridement, such as collagenase SANTYL ointment, typically must be used in combination with mechanical debridement and is not very effective for most chest wall wounds on its own.

Surgical resection should involve a plastic reconstructive surgeon for soft tissue coverage. As previously mentioned, the use of rotational myocutaneous flap, most often a latissimus dorsi flap, is based on the field of radiation, the quality of the vascular bundle supplying the flap, the quality of the tissues surrounding the vascular bundle, the patient's body habitus, and the size and location of the defect. Omental flap is an excellent and versatile option but it involves intrabdominal surgery and the cosmetic outcome may be less appealing compared with myocutaneous flap coverage.

Surgical resection should encompass all skin and soft tissue that grossly appears to be compromised by radiation therapy. Resection of chest wall should continue to healthy bleeding tissues. Resection of underlying lung is occasionally necessary when it is adherent to the chest wall because of radiation associated adhesions. Options for chest wall resection are discussed elsewhere in detail, but briefly include no reconstruction, prosthetic reconstruction, and biological reconstruction. We favor reconstruction for all anterior chest wall defects, except in small chest wall defects involving one rib or short segments of two ribs. Reconstruction provides improved chest wall stability and improves quality of life. Rigid prosthetic chest wall reconstructions provide the best mechanical support for the chest wall. We most commonly use Marlex mesh with methyl methacrylate patch as these material create a reconstruction that provides rigid reconstruction that can be shaped or molded as needed and is inexpensive. Others use a combination of rib plating devices (osteosynthesis) and mesh, although this approach is substantially more expensive. One of the risks of implanting a prosthetic device is infection, and in a contaminated wound these risks may be substantially higher. The use of biological meshes decreases the risk of infection but provides inferior mechanical support compared to rigid prosthetic reconstruction. Several biological meshes are available, but most are rather thin and do not provide the stability needed in chest wall reconstruction. To our knowledge, SurgiMend bovine acellular matrix is the thickest biological patch (4mm thickness) available for reconstruction. We have used this patch for chest wall reconstruction in the setting of infection with good result.

Here we present a case of osteoradionecrosis to illustrate some of the challenges associated with treatment of this problem.

Case Presentation

A 48 year old woman was diagnosed with ER+/PR+/Her2+ left breast cancer four years prior to presentation. She delayed her treatment and opted to receive high dose radiation treatment to the breast and chest wall over a 7 month time period several years later. Soon after completion of her treatment, she developed dyspnea and was found to have pulmonary metastases. She was started on systemic chemotherapy followed by tamoxifen. At that time she developed a chronic chest wall wound which was periodically treated with oral antibiotics and the patient required narcotics for pain control. The wound became progressively deeper, purulent, and malorodous and at that point she transferred her care to our institution. The ulceration was approximately 14×16cm with exposed necrotic ribs visible and extensive yellow necrotic fibrinous material lining the wound (Fig.1). The edges of the wound were darkened and thickened and extended about 3cm in all directions. Punch biopsy of adjacent skin showed no evidence of carcinoma. PICC line and antibiotic therapy was initiated, and maggot debridement therapy was initiated by the dermatology service. Trastuzumab (Herceptin) was initiated by the treating oncologist for the metastatic disease. After six weeks of IV antibiotics and maggot therapy, the patient underwent surgical resection. The ulcerated portion of the chest wall and all skin changes were excised. Portions of ribs 2-5 and a portion of the sternum were resected. A wedge resection of the left upper lobe was also performed because of adherence to the chest wall (Fig.3). The chest wall was reconstructed with 4mm thick Surgimend (Fig.4). The plastic surgery service then performed latissimus dorsi and serratus anterior muscle flaps with split-thickness skin grafting to cover the soft tissue defect (Fig.5). Unfortunately the latissimus dorsi muscle flap developed partial necrosis, and the patient was taken back to the operating room and an omental flap was harvested via laparotomy and transposed subcutaneously to cover the defect (Fig 6). Split thickness skin graft was harvested to cover the omental flap. The patient then had an uneventful recovery (Fig 7). She is alive with stable disease more than two years after her operation.

Radiation Induced Soft Tissue and Bone Cancers of the Chest Wall

Sarcomas make up approximately 1% of all cancers. Different factors have been linked to their formation, including viruses, genetic predisposition, chronic edema, chemotherapy and radiation therapy. Ionizing radiation exposure is only linked to 3-5% of all sarcomas [23, 24]. 70% of these tumors are soft-tissue in nature, while the other 30% develop in bone [24]. Radiation-induced sarcomas (RIS) can be of a variety of histologies. The most frequent being (1) *undifferentiated pleomorphic sarcoma*, previously termed malignant fibrous histiocytoma [25] and (2) *angiosarcoma*, primarily occurring among women treated with XRT for breast cancer [24]. The most common type of RT-induced bone sarcoma is *osteosarcoma* [23].

The frequency of RIS is less than 1% [4], although the incidence is just above 1% in children previously treated with radiation[26]. RIS are primarily a complication of high-dose

therapy; and are rarely seen after low doses [27]. Tucker and associates found that patients with a history of radiation therapy had a 2.7-fold increased risk and a sharp dose-response gradient reaching a 40-fold risk after doses to the bone of more than 6000 rad[28].

RIS of the chest wall are typically related to radiation for breast cancer or Hodgkin's disease but may occur secondary to lung cancer radiation as well [25, 29, 30] [31]. In their prospective, descriptive study, Penel et al evaluated 658 patients with soft tissue sarcomas. Ten of the 22 (45%) RIS observed were in breast cancer patients and the next most frequent primary cancer was in Non-Hodgkin lymphoma patients (4 patients; 18%) [32]. The mean interval from the first cancer treatment to diagnosis of RIS was about 10 years. Souba and colleagues retrospectively evaluated 16 patients who presented with sarcomas of the chest wall at a site where a prior malignancy had been irradiated. Ten (63%) of the 16 patients had prior breast cancer while 4 (25%) had Hodgkin's disease. The latency period between irradiation and the development of the chest wall sarcoma ranged from 5 to 28 years with a mean of 13 years. Among these 16 cases, 6 were osteosarcomas – 4 sternal and 2 clavicular/scapular - and 7 were MFHs - one sternal, 2 lateral chest wall and 4 supraclavicular. There was 1 lateral chest wall malignant mesenchymoma. The mean survival of patients after diagnosis of the secondary tumor was 13.5 months [25].

Typically RIS occur near the edge of the radiation field, which is where the radiation dose can be large enough to cause genetic damage but not so great that the cells are killed. It is unclear as to whether there is a lower risk with very high doses or whether there is a plateau in risk [27]. Sarcoma formation in Japanese atomic bomb survivors suggests that there is increased risk of RT-induced sarcomas even with low doses of ionizing radiation [33, 34]. The addition of chemotherapy, especially alkylating agents, may potentiate the effect of previous radiation therapy [28]. Tucker et al evaluated over 9700 survivors of childhood cancers. There were 64 cases of bone sarcomas in their survivors. These cases were matched to those who had not developed a sarcoma. The authors found that after adjusting for RT, treatment with alkylating agents was linked to bone cancer [28]. Other studies also link the use of alkylating chemotherapy to higher rates of secondary sarcomas in children whose primary tumors were treated with radiation [35] [36]. This data is not as clear in adult patients, however.

Diagnosis

Many patients with RIS have a delay in diagnosis because of non-specific symptoms and radiation changes and fibrosis that may make palpation of a mass difficult. In those who have undergone prior radiation and have new bone or soft tissue pain and/or a new mass, appropriate imaging should be performed. An x-ray is typically the first imaging performed, although cross-sectional imaging is necessary to properly diagnose and characterize the mass.

Those with breast or breast skin changes will likely undergo mammography, while most others will under CT or MRI. MRI is preferred by some because of its ability to delineate soft tissue structures. The NCCN suggests that PET may be useful in staging, prognostication, grading and determining response to chemotherapy [37]. A recent meta-

analysis suggests that PET may be a promising tool to help predict survival outcomes of patients with bone and soft tissue sarcomas [38].

It is essential that suspected radiation-induced sarcomas are biopsied for diagnosis and grading. Core needle biopsies are preferred to fine-needle aspiration whenever feasible [39]. Open diagnostic biopsy is rarely required but may be useful if the other techniques are not feasible. It is imperative that the biopsy site, no matter the technique, be completely removed at the time of resection.

Diagnostic criteria

Not all sarcomas that arise after prior radiation are secondary to radiation exposure. Some of these sarcomas will be sporadic even if it arises in an irradiated field. The following criteria for determination whether a sarcoma is secondary to radiation exposure were originally proposed by Cahan in 1948 [40] and later revised by Murray and his colleagues [41]:

1. Radiation must have been given previously and the sarcoma that subsequently developed must have arisen in the area included within the 5% isodose line.
2. There must be no evidence that the sarcoma was present before onset of radiation.
3. Any sarcoma associated with radiation requires histologic confirmation and must be of different histology than the primary tumor.

There is typically a latency period between the treatment of the primary tumor and the appearance of the radiation-induced sarcoma. The usual length of this period is debated. In 1948, Cahan proposed a 5-year latency period [40]. Others have suggested a shorter latency period from as little as 6 months to 4 years [42] [43] [44].

Staging

Staging for both primary and secondary sarcomas of the chest wall is the same. Tumors are characterized by grade and local extension. The American Joint Committee on Cancer (AJCC) 7th edition staging system for soft tissue sarcoma is based on the TNM system. For the T (primary tumor) component, tumors < 5cm are T1, while tumors > 5cm are T2. Both T1 and T2 lesions are then divided into A & B sections based on whether the tumor is superficial (located above the superficial fascia) or not. N is based on regional lymph nodes. N1 depicts regional lymph node metastasis. If there are nodal metastases, the patient is stage III. M1 suggests distant metastasis. Histologic grades are 1-3. The actual anatomic stage is based on T, N, M and grade [37]. For bone cancer the T stage is divided at the 8 cm mark. T1 occurs when the primary tumor up to 8 cm in size and T2 when greater than 8 cm. T3 is noted if the tumor is discontinuous with the primary bone site. N1 again notes regional lymph node metastasis. Distant metastasis is noted as M1. M1a notes metastasis to the lungs. M1b describes metastasis to other sites. G1 is well-differentiated or low grade. G2 is moderately differentiated, while G3 is poorly differentiated and G4 is undifferentiated [37]. The lung is the predominant site of metastases for both soft tissue and bone sarcomas, whether primary or radiation-associated. CT of the chest is typically performed to detect pulmonary metastases in patients with either a soft tissue or bone sarcoma. Positron

emission tomography (PET) or bone scan are recommended for patients with a bone sarcoma.

Prognosis

Gladdy et al evaluated 130 patients with primary radiation-associated soft tissue sarcomas. These patients were matched with sporadic MFH patients. The authors found that the radiation-associated tumors were frequently high grade (83%) and were associated with worse 5 year disease- specific survival (44%) than those with sporadic tumors (66%). They also found that histologic type, margin status, and tumor size were the most important independent predictors of survival in patients with radiation –associated sarcomas [45].

Bjerkeheggen et al similarly performed a case-control study comparing the survival of radiation-induced sarcoma patients (98 patients) with those of sporadic sarcoma patients (239 patients with high-grade malignant sarcomas). They found that the 5-year survival of patients with RIS was 32%, while it was 51% for those with sporadic high-grade malignant sarcomas ($p>0.001$). They found that female gender, central tumor site and incomplete surgical remission were significantly more frequent among the RIS patients than in controls. They also found that incomplete surgical remission, metastases at presentation, microscopic tumor necrosis and central tumor site were significant adverse prognostic factors [46].

Treatment

Surgery with wide local resection is the main treatment for RIS of the chest wall. Chapelier et al evaluated 15 patients who underwent radical resection of RIS of the chest wall. The surgical patients had no evidence of extrathoracic metastases. They were worked up with bronchoscopy, arterial blood gas and spirometry. They performed selective arteriography to assess the blood supply of available muscle or musculocutaneous flaps in those with sternal and anterolateral tumors. 10 of their patients had a history of breast cancer and 5 of Hodgkin's disease. Their median delivered radiation dose to the primary tumor site was 45 gray and the median interval between radiotherapy and diagnosis of sarcoma was 14 years. They had 7 tumors located on the sternum, 3 on the lateral chest wall and five in the thoracic outlet. They performed 4 stenectomies, 3 partial sternectomies, three lateral chest wall resections and 5 resections of tumors in the thoracic outlet. Local recurrence occurred in 7 patients after a median interval of 10 months. 4 underwent a repeat resection. 3 died. They had an overall 5-year survival of 48% and a 5-year disease-free survival of 27% [31]. The study revealed the possibility of long-term survival with surgical resection of RIS and therefore the authors suggest that radical surgical resection is an integral part of the treatment of these tumors.

Operative technique

Chapelier et al perform aggressive wide local resection of invaded skin, subcutaneous tissue, irradiated tissues and scars, including a margin of at least 4 cm of normal surrounding tissue. Resection of sternal tumors are started over the costal margins and include 3 cm of free ribs on each side but spare the unaffected lateral part of the pectoralis major (PM) muscles. A total sternectomy is undertaken for tumors located over the midsternum and for large tumors of the manubrium, including the internal third of the clavicles. For lateral chest wall tumors,

the free margins of the resection are one normal rib above and one below. The pleural cavity is entered far away from any chest wall involvement. Lung and involved mediastinal structures are resected en bloc. Tumors invading the thoracic outlet require a transcervical thoracic approach for radical resection of involved structures including an L-shaped cervicotomy extending into the deltopectoral groove and resection of the internal half of the clavicle. Microscopic evaluation of the margins by frozen section is routinely performed. The authors resect en bloc any resectable involved structure, such as lung, mediastinal vessel, and pericardium. They suggest that involvement of subclavian and brachiocephalic veins be managed by ligation and excision; while involvement of the superior vena cava and the subclavian artery requires prosthetic revascularization with polytetrafluoroethylene[31].

Chapelier et al go on to recommend resection of T1 or C8 nerve roots or the lower trunk of the brachial plexus to obtain tumor-free margins. They recommend stabilization of the chest wall only in patients with large anterior and anterolateral defects, especially after total sternectomy. Soft tissue reconstruction after radical resection of RIS should be accomplished using a muscle or musculocutaneous flap, necessitating the consultation of a plastics and reconstruction surgeon [31].

Adjuvant Therapy

Typically full-dose radiation treatment of RIS is not performed because of the prior exposure and increased risk of complications. Hyperfractionated RT with small daily doses, intensity-modulated RT protons and brachytherapy are possible local control options if surgery is not possible or margins are not clear but the elevated risk of repeat radiation must be measured against its potential benefit. Hyperthermia enhances the effect of radiation and/or chemotherapy and is used frequently to boost the relatively low maximally permitted radiotherapy dose in the treatment of recurrences in previously irradiated areas. de Jong et al evaluated the role of reirradiation and hypothermia in the treatment of RIS in the thoracic region. They gave this regimen to 13 patients who had unresectable disease and to 3 patients after surgical resection of the RIS. Their radiotherapy consisted of 32 Gy in 8 fractions given twice per week over a period of 4 weeks or 36 Gy in 12 fractions given 4 times per week. Heat was induced electromagnetically by using externally applied, flexible contact microstrip applicators operating at 434 MHz. For all patients, temperatures were measured on the skin. The target temperature was between 41°C and 43°C for 1 hour. They found a 75% response rate. Six patients remained free of local failure until death or last follow-up. They conclude that reirradiation and hyperthermia for RIS in the thoracic region is feasible as it is associated with a high response rate and the possibility of durable local control [47]. Adjuvant chemotherapy is typically advocated because of the poor prognosis of RIS. There are few primary data addressing the benefit in RIS, however. Lagrange et al compared the survival of 80 patients with RIS. 28 patients underwent surgery only. 18 patients underwent surgery and chemotherapy. 15 patients were only treated with chemotherapy and 14 with just radiotherapy. Overall survival rates at 2 and 5 years, respectively, were 69% and 39% for patients treated with surgery, 10% and 0% for those treated with chemotherapy, and 52% and 35% for those treated with surgery and chemotherapy ($p=0.001$). The 2- and 5-year rates for survival without recurrence were 54% and 32%, respectively [48]. The lack of

convincing data associated with treatment of RIS with chemotherapy suggests that decisions about chemotherapy must be individualized.

In conclusion, radiation-Induced sarcomas of the chest wall occur very infrequently after treatment of breast or lung cancer, Hodgkin lymphoma and other tumor types. The interval to diagnosis is typically greater than a decade after the primary treatment. These tumors are frequently high-grade and associated with poor prognosis. Radical resection with wide tumor-free margins is the only proven treatment for a long survival and potential cure. The role of chemotherapy and radiation is unclear and should be individualized.

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Key Points

- Radiation to the chest wall is common before resection of tumors.
- History of radiation does not necessarily change the surgical approach of soft tissue coverage needed for reconstruction.
- Osteoradionecrosis can occur after radiation treatment, particularly after high dose radiation treatment. Radical resection and reconstruction is feasible and can be life saving.
- Radiation induced sarcomas of the chest wall occur most commonly after radiation therapy for breast cancer.
- The most effective treatment is surgical resection. Tumors not amenable to surgical resection are treated with chemotherapy with low response rates.

Fig. 1.
Image of the chest wall ulceration showing extensive fibrinous exudate, exposed ribs, and radiation changes to the skin surrounding the ulceration.

Fig. 2.
Intraoperative picture after chest wall resection showing bleeding soft tissue wound edges. The heart and left lung are visible in the base of the wound. The soft tissue resection extended into the axilla.

Fig. 3.
Chest wall is reconstructed with 4mm thick Surgimend and secured to surrounding ribs and sternum with interrupted 0-Prolene mattress sutures.

Fig. 4.
Intraoperative picture after latissimus dorsi and serratus anterior rotational flaps are secured for soft tissue coverage.

Fig. 5.
Omental flap was transposed subcutaneously after latissimus dorsi flap necrosis.

Fig. 6.
Postoperative image showing omental flap covered with a split-thickness skin graft harvested from the thigh.

Fig. 7.
Three month postoperative image showing healed skin graft over omental reconstruction.