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Radiation-Induced Liposarcoma of the Groin in a Patient with Prior Vulvar Cancer: A Case Report and Literature Review

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Abstract

Radiation-induced sarcomas (RIS) are rare but severe long-term complications of radiotherapy (RT). They typically arise years after exposure to ionizing radiation used to treat primary malignancies and complicate patient outcomes. Determining the risk associated with these radiation-induced cancers is challenging due to confounding factors such as lifestyle and genetic predisposition. Liposarcomas, which are the most common type of soft tissue sarcomas, originate from adipose tissue and can develop as a late complication of RT. Although they account for a significant portion of soft tissue sarcomas, radiation-induced liposarcomas are still considered rare, making them a noteworthy diagnostic and therapeutic concern. In this report, we present a rare case of radiation-induced dedifferentiated liposarcoma arising 12 years after RT for vulvar cancer. The patient presented with a mass in the groin, which was initially suspected to be a local recurrence. Imaging studies revealed a suspicious lesion on PET/CT, while MRI showed no significant findings. Histopathological evaluation confirmed the diagnosis of dedifferentiated liposarcoma. Surgical resection was performed with a focus on achieving negative margins. A literature review identified nine similar cases, with five being pleomorphic liposarcomas. The average time to presentation was 15 years (interval 3 - 47 years), with a mean radiation dose of 62 Gy. This case highlights the importance of long-term follow-up for cancer survivors and the need for vigilance in diagnosing secondary malignancies following RT.

Keywords

Radiation-Induced Neoplasms, Liposarcoma, Radiotherapy, Vulvar

Neoplasms

1. Introduction

Radiotherapy (RT) is a cornerstone of cancer treatment, widely used to target and destroy malignant cells. Despite its therapeutic benefits, the emergence of new tumors within previously irradiated fields poses a diagnostic challenge. When a tumor appears in an area that received radiation, the differential diagnosis can be complex and may include a local recurrence of the original cancer, radiation field effects, a new primary malignancy, or a secondary cancer induced by prior radiation exposure. Assessing the risk of these radiation-induced malignancies remains challenging as multiple confounding factors, such as lifestyle habits and genetic predisposition, can influence outcomes. This uncertainty makes determining the true risk associated with RT a subject of ongoing debate. In this report, we describe a rare case of radiation-induced dedifferentiated liposarcoma following treatment for a squamous cell carcinoma of the vulva and summarize the nine other reported cases in the literature of liposarcoma following radiotherapy.

2. Case Report

A 76-year-old woman with a significant past medical history of stage III vulvar squamous cell carcinoma of the left Bartholin's area treated in 2012 with chemotherapy and radiotherapy presented in 2024 with a six-month history of a slowly growing mass in the right groin. Physical examination revealed a firm nodule measuring 2 cm in diameter in the right inguinal region. The surrounding skin had post-radiotherapy changes with no signs of inflammation. No other masses were noted on examination and the lymph node survey was negative. In 2012, she had received concurrent weekly chemotherapy with cisplatin at a dose of 40 mg per metered squared during her external bean radiation therapy. The patient's previous radiation treatment fields from her 2012 vulvar cancer therapy were reviewed to assess overlap with the location of the current mass. In 2012, intensity-modulated radiotherapy (IMRT) with 6 MV photons delivered a total dose of 47.6 Gy to the pelvis in 28 fractions (1.7 Gy per fraction), either once or twice daily. A targeted boost of 13.6 Gy to the bilateral groins brought the cumulative dose to 61.2 Gy. The patient then received a high-dose-rate (HDR) brachytherapy boost to the vagina using a shielded cylinder of 16 Gy. These fields are displayed in **Figure 1**, illustrating the correlation between the irradiated areas and the site of the newly detected mass.

Routine annual surveillance imaging from 2012 through 2023 of pelvic MRIs and CT scans of the abdomen and pelvis had not shown evidence of recurrent disease or new masses. After the development of the 2024 nodule, a PET-CT showed a moderately intense 9 mm right groin cutaneous lesion. Additionally, the PET-CT identified a separate area of mildly increased metabolic activity associated

with a soft tissue density in the left external iliac region, which had been previously noted in earlier imaging studies since 2012. This left inguinal activity was stable over the years and had been attributed to post-treatment changes rather than new or recurrent disease. No abnormal metabolic activity was identified elsewhere, confirming the absence of distant metastatic disease. Interestingly, the MRI results were unremarkable, showing no abnormal mass or soft tissue changes in the groin area.

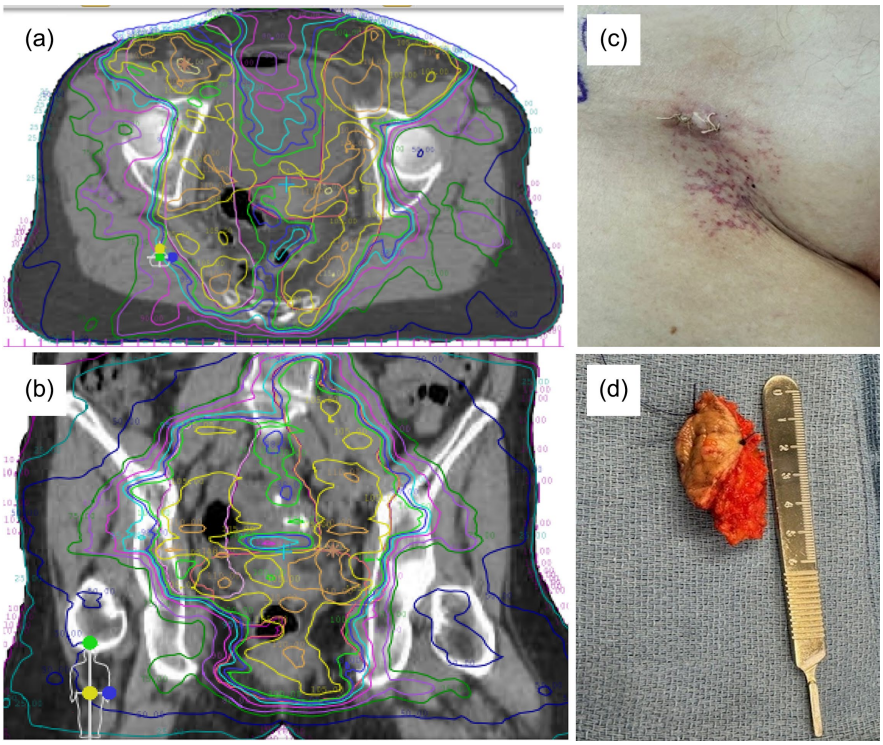

Figure 1. Comparison of 2012 Radiation Fields with 2024 Liposarcoma in Right groin. (a) 2012 Radiation Field Axial View. (b) 2012 Radiation Field Coronal View. (c) Pre-Excision evaluation. Suture seen from previous office biopsy. Note the presence of skin changes secondary to radiotherapy. (d) Radical Wide local excision specimen.

An office biopsy was performed, and histopathological analysis revealed a tumor comprised of spindled cells with scattered atypical, enlarged, hyperchromatic nuclei and numerous mitotic figures. Mature adipocytic cells were identified at the edge of the spindled area (**Figure 2**). The tumor cells stained strongly positive for MDM2 and negative for MNF116, S100, desmin, caldesmon, and STAT6. H3K27me3 was preserved. Nuclear expression of c-MYC was identified in approximately half of the tumor nuclei. Fluorescence in-situ hybridization showed amplification of the MDM2 gene (MDM2/CEP12 ratio: 8.4), supporting the diagnosis of dedifferentiated liposarcoma. The final pathology ruled out the possibility that this was a recurrence of squamous cell carcinoma.

Given the localized nature of the disease and the absence of metastasis, the patient underwent a radical wide local excision of the mass with a 2 cm margin and

excising down to the femoral vessels. Figure 1(d) shows the physical appearance of the tumor at the time of surgery. The patient recovered well from the surgery, with no immediate postoperative complications. At six months of follow-up, the patient remained asymptomatic with no evidence of recurrence noted on MRI and PET scans.

On histological examination of the surgical specimen, scant residual microscopic foci of dedifferentiated liposarcoma were identified in association with previous biopsy site changes. The dedifferentiated component was completely excised. The background showed fatty tissue with expanded septae and rare/scattered atypical cells, suggestive of involvement by well-differentiated liposarcoma extending to the specimen surface. By immunohistochemistry, scattered tumor cells were positive for MDM2, CDK4, HMGA2 and p16. See Figure 2.

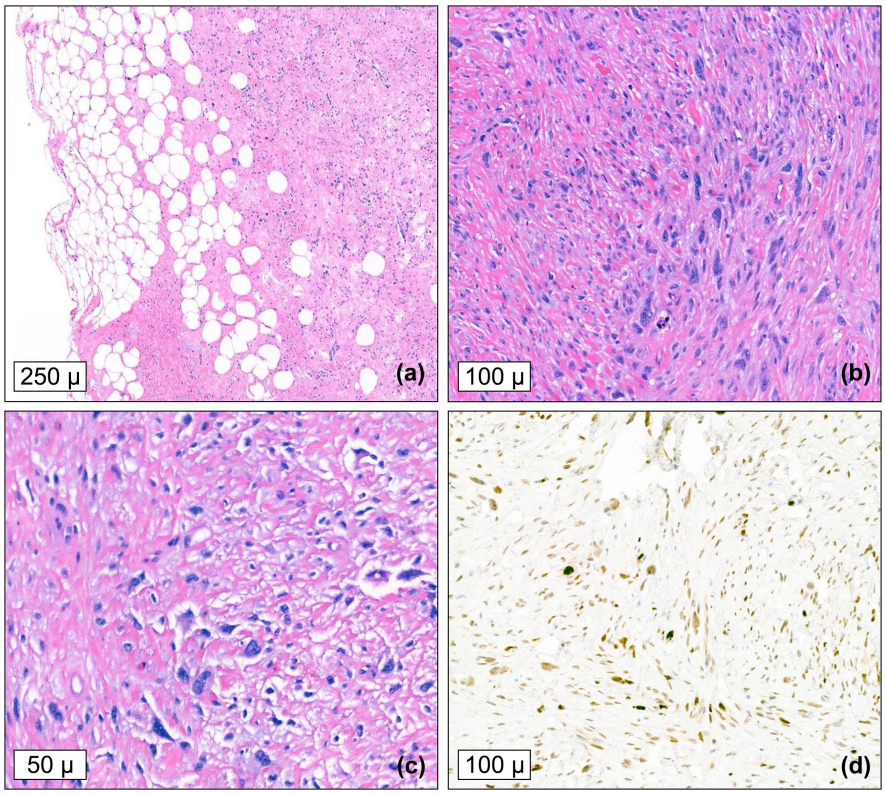

Figure 2. Dedifferentiated liposarcoma of the right groin. (a) The tumor is characterized by an abrupt transition from well-differentiated liposarcoma to high-grade pleomorphic sarcoma. (b) and (c) Tumor cells are predominantly spindle with some atypical, enlarged, hyperchromatic nuclei and numerous mitotic figures. (d) Diffuse nuclear expression of MDM2 is present.

3. Discussion

We describe the first reported case of a patient with a dedifferentiated liposarcoma in the radiated groin 12 years after curative concurrent chemotherapy and radiation for a Stage III squamous cell carcinoma of the vulva. Radiation-induced malignancies (RIM) are a rare and late complication of radiotherapy. These tumors

have different histological types, tend to exhibit more aggressive behavior, have limited treatment options, worse prognosis, and appear long after receiving radiotherapy. The diagnosis of radiation-induced malignancy (RIM) is established based on the modified Cahan's criteria, which include: 1) the malignancy must have developed within the previously irradiated field; 2) a sufficient latency period, ideally longer than four years, must have passed between the initial radiation therapy and the development of the secondary tumor; 3) both the original tumor and the suspected radiation-induced malignancy must be confirmed through biopsy, with distinct histologies for each; and 4) the tissue in which the secondary tumor arose must have been metabolically and genetically normal prior to radiation exposure [1]-[3].

The pathogenesis of radiation-induced malignancies (RIM) involves complex biological mechanisms triggered by ionizing radiation, which can cause genetic damage and alterations in cellular behavior. Ionizing radiation generates free radicals and induces DNA damage through direct and indirect interactions within cells. This damage can lead to mutations, chromosomal aberrations, and alterations in gene expression, which may initiate the malignant transformation of cells. The cumulative effect of such damage, particularly in tissues with high turnover rates or those undergoing rapid cell division, increases the risk of developing secondary malignancies years after radiation exposure. In addition to direct DNA damage, radiation exposure can also disrupt cellular repair mechanisms and influence the tumor microenvironment, favoring chronic inflammation and oxidative stress [4].

The risk of developing RIM is influenced by various factors, including the dose and duration of radiation exposure, the specific type of radiation, and the genetic predisposition of the individual. The latency period between radiation exposure and the emergence of secondary malignancies can vary, often extending several years or even decades, reflecting the complex interplay between radiation-induced genetic alterations and subsequent tumor development [4] [5].

Radiation-induced secondary malignancies can develop in any area of the body previously exposed to radiation therapy, regardless of the histology of the primary cancer. These malignancies can present with a range of histologies, with sarcomas being the most common. However, carcinomas and, less frequently, hematologic cancers such as leukemia may also arise. Due to their rare occurrence, accurately determining their incidence remains challenging. Snow *et al.* examined the U.S. Surveillance, Epidemiology, and End Results (SEER) database and identified 242 cases of radiation-induced sarcomas (RIS), with breast cancer accounting for the largest share (126 cases) compared to 116 cases from all other cancer sites combined. The relative risk (RR) of developing RIS after breast cancer was 1.21 (CI: 1.01 - 1.45, $p < 0.03$), adjusted for age, gender, and latency [6]. Yap *et al.* analyzed patients diagnosed with primary invasive breast cancer and those who developed subsequent sarcomas between 1973 and 1997 [7]. Among 274,572 patients, 263 developed subsequent sarcomas. Eighty-seven of the 263 patients had received

radiotherapy, for a cumulative incidence of 3.2 per 1000 (SE [standard error] = 0.4) compared to 2.3 per 1000 (SE = 0.2) for those not receiving radiotherapy. In this group of patients, angiosarcoma was the most prevalent type of sarcoma, present in 56.8% of cases [7]. In another single institution study, of 2845 patients diagnosed with sarcoma between 1979 and 2013, two percent (64 patients) developed a RIS with a median interval of 11 years [8].

Mirjolet *et al.* investigated treatment-related factors associated with the risk of developing RIS in breast cancer patients and identified several key risk factors, such as higher radiation doses, larger treatment field sizes, and younger age at the time of treatment, all of which were linked to an increased risk of sarcomas [9]. In this study, the mean dose received in the area where RIS subsequently developed was 47.8 Gy, which is very similar to the doses received by our patient [9]. New radiation therapy techniques, such as Intensity-Modulated Radiation Therapy (IMRT) and Volumetric Modulated Arc Therapy (VMAT), have been introduced, offering advantages in target volume coverage; however, no specific recommendations have been established to mitigate the risk of RIS [10]. Additionally, older patients experienced a shorter interval to RIS development, possibly due to age-related factors such as compromised DNA repair mechanisms and immune system dysregulation [9]. Biomarkers may play a role in identifying patients at risk for radiation-induced complications [11].

The association between chemotherapy and the risk of RIS remains unclear, with studies showing contrasting results. A systematic review of RIS in the breast, covering 24 articles and 1831 patients, found no evidence that chemotherapy contributes to the risk [12], consistent with previous findings [9]. However, another study found an association between treatment with chemotherapy for an index cancer and a shorter interval to development of RIS [13]. Further studies are needed to clarify this relationship, although establishing a clear correlation will be challenging due to the variability in chemotherapy regimens and patient characteristics.

Liposarcomas are malignant tumors originating from adipose tissue and are among the most common soft tissue sarcomas in adults, accounting for approximately 15% - 20% of all sarcomas [14]. They typically arise in deep soft tissues, such as the thigh, retroperitoneum, or groin. Liposarcomas are divided into several histological subtypes, including well-differentiated, dedifferentiated, myxoid, and pleomorphic, with well-differentiated liposarcomas being the least aggressive and pleomorphic types the most aggressive. The exact etiology of liposarcoma is unclear, but certain factors, such as previous radiation therapy, genetic predisposition, and chronic inflammation, have been implicated [15].

Liposarcomas are often slow-growing and may present as painless, enlarging masses. In many cases, the tumor can grow to a significant size before symptoms such as pain, functional impairment, or pressure on adjacent structures occur [15]. Diagnosis is typically made through imaging, such as MRI or CT, followed by a biopsy for histopathological confirmation. In our case, the biopsy and PET-

CT proved to be more useful, showing metabolic activity in the groin mass, which led to the diagnosis of liposarcoma.

A comprehensive literature search on PubMed to identify cases of liposarcoma following radiotherapy, utilizing various combinations of the terms "radiation-induced liposarcoma", "liposarcoma", "post-radiation", "radiotherapy", "radiation", and "sarcoma" identified nine additional cases of radiation-induced liposarcoma, of which five were classified as pleomorphic liposarcoma [16]-[24]. The average interval from radiotherapy to the development of liposarcoma was 15 years (interval 3 - 47 years), with a mean radiation dose of 62 Gy. The specific radiation technique used was not reported in most cases. Cases were managed with surgical resection. A summary of these findings is provided in **Table 1**.

Table 1. Reported cases of radiation-induced liposarcoma.

Primary malignancy	Patient's age at first diagnosis (years)	Secondary malignancy	Time to subsequent liposarcoma (years)	Radiation dose (Gy)	Treatment	Reference
Left breast carcinoma	58	Left axillary pleomorphic liposarcoma	10	45	Chemotherapy	[16]
Anaplastic carcinoma of the nasopharynx	10	Myxoid liposarcoma of the thyroid	12	70	Surgical resection	[17]
Benign right parotid lesion	38	Poorly differentiated round cell liposarcoma of the right temporal bone	47	Unknown	Symptomatic care	[18]
Cerebellar medulloblastoma	2	Right scalp pleomorphic liposarcoma	26	40	Surgical resection	[19]
Left calf epithelioid sarcoma	16	Left calf pleomorphic liposarcoma	7	57	Surgical resection	[20]
Undifferentiated malignant tumor of the retropharynx	30	Well-differentiated liposarcoma	10	70	Surgical resection	[21]
Rectal cancer	62	Right buttock pleomorphic liposarcoma	12	Not stated	Surgical resection	[22]
Hodgkin lymphoma (lateral chest wall mass)	60	Liposarcoma (subtype not specified) in the surgical site of the previous lesion	3	110	Surgical resection	[23]
Right breast papillotubular carcinoma	63	Right chest wall pleomorphic liposarcoma	8	42.56	Surgical resection	[24]
Vulvar squamous cell carcinoma	64	Right groin dedifferentiated liposarcoma	12	48	Surgical resection	Present study

The primary treatment for liposarcoma is surgical resection with clear margins, as incomplete removal increases the risk of recurrence. The use of adjuvant radiation or chemotherapy depends on both the tumor's histological subtype, high mutation burden and chronic inflammation in radiation-induced fibrosis. This may create an opportunity to treat RIS with targeted immunotherapy. One study demonstrated that RIS showed different patterns of genomic copy-number variations. There was also increased immune cell infiltration within these tumors, suggesting that PD-1 blockade may add therapeutic benefit with improved response rates and progression free survival [25]. In patients with a history of previous radiation therapy, treatment guidelines are less well-defined, making decisions about further radiation or chemotherapy more complex. Prognosis depends on the subtype and stage at diagnosis, with well-differentiated types generally having a better outcome than high-grade variants.

4. Conclusion

In conclusion, radiotherapy is a widely used cancer treatment modality with the risk of long-term consequences. Radiation-induced liposarcomas are a rare but serious long-term complication of radiotherapy. Although modern radiation techniques, such as IMRT and VMAT, provide improved target coverage and may reduce off-target exposure, no specific recommendations currently exist to lower the risk of secondary sarcomas. This case emphasizes the complexity of the approach to secondary malignancies associated with radiation. Early detection and timely intervention are critical for improving outcomes. Given the potential for late complications, this case reinforces the importance of long-term follow-up for cancer survivors who have undergone radiotherapy, as well as the need for further research into the mechanisms underlying radiation-induced malignancies, as this may help to improve prevention and treatment strategies in the future.

CRediT Author Statement

Munoz Guzman: Conceptualization, writing-original draft preparation, **Manning:** Conceptualization, Writing - review, **Zanfagnin**: Visualization, writing - editing, **Devins**: Visualization, supervision, resources, **Giap**: Visualization, **Russo**: Visualization, resources, **Goodman**: Conceptualization, writing - review, editing, funding acquisition, project administration

Conflicts of Interest

The authors declare no conflicts of interest.

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

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