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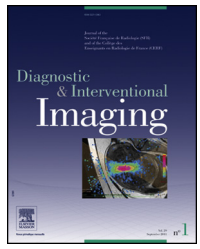

ORIGINAL ARTICLE / *Musculoskeletal imaging*

Standardization of selection criteria for percutaneous image-guided cryoablation of recurrent soft-tissue sarcomas

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KEYWORDS
Soft tissue sarcoma;
Local recurrence;
Cryoablation

Abstract
Purpose: Percutaneous image-guided cryoablation has not been validated for local management of recurrence of soft tissue sarcoma (STS) of the trunk or limbs. This study aims to identify selection criteria for cryoablation in order to standardize indications of this treatment.
Patients and methods: Between 2000 and 2010, 46 patients (57 tumors) presenting local recurrences of STS of the trunk or limbs and treated following standards of care were selected from our institutional database. Eligibility for cryoablation was assessed by two radiologists according to predefined criteria: maximal diameter size of the tumor $\leq$ 10 cm, distance to skin >5 mm, distance to neurovascular structures 3 mm at least, absence of articular involvement and planned cryoablation covering the entire lesion volume. Characteristics and outcomes were compared.
Results: There was nearly perfect agreement for all criteria (k coefficient ranging from 0.83 to 0.98) between both readers. A subgroup of 13 patients was identified as eligible for cryoablation. Locations to the trunk, pelvic girdle or shoulder were significantly more present in the cryoablation group ($P = 0.002$). In this group, tumors were mainly located deeply ($P = 0.002$) with great axes $\leq$ 5 cm ($P = 0.044$). High local tumor aggressiveness ($P = 0.016$) and differentiated myxoid liposarcoma or myxofibrosarcoma ($P = 0.007$) were more frequent in the eligible group.

Abbreviations: CT, computed tomography; GE, gradient echo; Gd, gadolinium; MR, magnetic resonance; ROI, region of interest.

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Conclusion: Based on these criteria, two groups of patients with local relapse of STS can be identified. These results may improve the standardization of selection of patients who could be candidates for cryoablation.
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Introduction

Local management of recurrence of soft tissue sarcoma (STS) of the trunk or limbs is still a challenge and depends principally of the prognosis of the disease [1]. Treatments depend of stages proposed by the American Joint Committee on Cancer (AJCC) and the International Union against Cancer (UICC) in addition of tumour size and depth or tumour resectability. In cases of good prognosis (i.e. late or low-grade recurrence), a new curative treatment may be proposed, while in cases of poor prognosis (i.e. early or high-grade recurrences or with metastases), a palliative option must be considered. Therefore, according to ESMO Clinical Practice Guidelines [2], surgery is still the standard-of-care for limited disease whereas chemo- or radiotherapy can be discussed in case of extensive disease or recurrences.

Recently, percutaneous image-guided procedures such as radiofrequency or cryoablation have been proposed in several soft tissue tumors as alternatives to surgery [3]. These techniques are discussed case-by-case because they offer less invasive alternatives for locoregional treatment of primary or secondary tumors, especially for patients who are poor surgical candidates, irrespective of the reasons. Due to its minimally invasive nature and real-time control of ablative volume and margins, cryoablation has been recently performed in soft tissues for the treatment of benign tumors such as desmoid tumors [4,5] or vascular malformations [6,7], and for soft tissue metastases [8]. Performed under ultrasound (US), computed tomography (CT) or magnetic resonance imaging (MRI) guidance, these studies have reported low morbidity, excellent tolerance and adequate local control.

As the literature about the indication and feasibility of cryoablation in the management of STS is scarce [9,10], the purpose of this retrospective study was to identify selection criteria for cryoablation of local recurrence of STS of the trunk and the limbs in order to standardize indications of this treatment.

Patients and methods

Patients

Institutional review board approval was obtained for this retrospective study. Medical records of all patients diagnosed with a local recurrence of soft tissue sarcoma of the limbs or trunk wall in our institution between 2000 and 2010 and explored with MR or CT imaging were retrospectively selected from our prospectively maintained institutional database and reviewed. In addition, thorough review of all medical or pathological records, treatments, follow-up and complications were compiled for all patients.

Then, forty-six patients (30 male, 16 female) with 57 tumors were selected from the institutional database and included in this study (Fig. 1). Mean age was 64.9 years (range: 23.4—84.2). Thirty-four presented co-morbidities (73.9%) and 10 were ASA 3 (21.7%). Among all tumors, the pathology diagnosis ware unclassified/myxofibro sarcomas for 24 (52.2%), liposarcomas for 15 (32/6%) and other for seven (15.2%). Mean size was 64 mm (10—178). Tumor grades were 2 for 10 tumors (21.7%) and 3 for 21 (45.7%). Multiple tumors were observed in seven patients (15.2%) and metastatic disease was reported for 27 patients (58.7%). Surgery was performed alone in 16 patients (34.8%) or combined with other therapeutic modalities in 24 patients (52.2%), as radiotherapy or brachytherapy-only for 11 (23.9%), chemotherapy-only for 5 (10.9%), or both for 4 (8.7%). Four patients had surgery associated with isolated limb perfusion associated ($n = 3$) or not ($n = 1$) with other therapeutic option, such as chemotherapy ($n = 1$) or radiotherapy ($n = 2$). Three patients received palliative chemotherapy-only due to locally advanced disease and contraindications to surgery, two were managed with exclusive isolated limb perfusion and one was managed with best supportive care. After surgery, final results were resection R0 for 23 patients and R1 for 17. The median duration of hospital stay after surgery of the local relapse was 10.5 days (range 2—45 days), and there was no 30-day mortality. The median follow-up after treatment for recurrence was 42.8 months [95%CI: 24.6—61]. Twenty-eight patients were still alive (60.9%) and 18 have died, 16 deaths being related to the disease (34.8%). New recurrences have been observed in 24 patients (52.2%) and were local in nine patients, located in lymph nodes in one and metastatic in 14 patients.

Image analysis

All selected cases were reviewed to identify patients who could be eligible for percutaneous cryoablation as a curative option according to predefined selection criteria based on surgical recommendations [1], results of previous studies on the topic [5,8] and our own experience on soft tissue tumors cryoablation including cases presenting STS [4,6,9,11]. Therefore, selection criteria were: maximal diameter size of the tumor smaller than 10 cm, planned cryoablation must cover the entire lesion volume, no possible problem for the positioning of the cryoprobes, distance to skin at least 5 mm, distance to neurovascular structures at least 3 mm, absence of articular involvement.

Two radiologists (N.L. and F.C.), blind to pathology results, reviewed independently the CT or MR images on picture archiving and on the communication system workstation in order to determine the feasibility of cryoablation following these selection criteria. After the independent

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