Percutaneous Combined Therapy for Painful Sternal Metastases: A Radiofrequency Thermal Ablation (RFTA) and Cementoplasty Protocol

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Abstract. *Background: Radiofrequency thermal ablation (RFTA) has recently been introduced for the treatment of painful bone metastases. We report the outcome of one combined protocol session of percutaneous RFTA and cementoplasty on a painful sternal breast cancer metastasis of a 66-year-old patient. Patients and Methods: A sternal lesion was identified at a repeated CT scan during the oncological follow-up. Due to severe chest pain, the patient was treated percutaneously to obtain pain relief and bone stabilization. Percutaneous RFTA was performed using a 15-gauge needle electrode (MIRAS TX-120) coaxially introduced through a 13-gauge bone biopsy needle. The lesion was heated up to 80˚C for 3 minutes. A percutaneous injection of 1 cc polymethylmethacrylate in the central part of the lesion was performed immediately after the RFTA procedure. Results: Immediate symptomatic improvement was documented. Conclusion: Combined percutaneous therapy showed feasibility and effectiveness and can be considered as an alternative for the treatment of painful bone metastases.*

Bone metastases are common in cancer patients, most often in breast, lung or prostate cancer (1-2). In fact, bone metastases from such tumors are demonstrated up to 85% post-mortem autopsies (3). The most common symptom associated with bone metastases is severe pain that can dramatically affect a patient's quality of life (1-3). Because of the usual advanced stage of disease at the time of presentation, current treatments are aimed at pain palliation and/or at complications prevention and hospital admission reduction. Standard treatments include radiation therapy, chemotherapy, hormone therapy and analgesic medications (4-5). Radiation therapy (RT) may be effective for pain relief and is the treatment of choice for painful bone metastases. Nonetheless, up to 20-30% of patients treated with RT do not respond to the treatment. Furthermore, patients who experience pain recurrence at a previously irradiated site might not be suitable for further irradiation due to dose limits in normal tissues (6).

Radiofrequency thermal ablation (RFTA) uses a high-frequency alternating current producing a focal thermal injury of tumor cells (7-8). The technique has been tested in several organs, for treatment of both benign and malignant tumours. With regard to musculoskeletal diseases, it has been used for osteoid osteomas, chondroblastomas, epithelioid hemangioendotheliomas, chordomas and spinal metastases (9). Recently, a combined therapy of RFTA and cementoplasty for painful bone metastases was introduced (10).

Patients and Methods

A 66-year-old woman with a medical history of endocrine-responsive right breast cancer treated with neoadjuvant chemotherapy followed by breast conservative surgery plus adjuvant chemotherapy and radiotherapy was put on long-term hormonal therapy with anastrozole.

After two years of follow-up, a fluorine-18 fluorodeoxyglucose positron-emission tomography/computerized tomography (FDG PET-CT) scan showed pathological radioactive tracer uptake in the right breast, mediastinal lymph nodes and corpus sterni (Figure 1). The same oblate lesion was evidenced at bone scintigraphy. A gemcitabine-cisplatin based chemotherapy was started as first-line treatment for metastatic disease and after three months of therapy a complete radiological regression was demonstrated in all metastatic sites but the sternal one.

As severe anterior chest wall pain still persisted, even with optimal systemic analgesia treatment, a course of radiation therapy

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Key Words: Bone metastases, radiofrequency thermal ablation, cementoplasty, breast cancer.

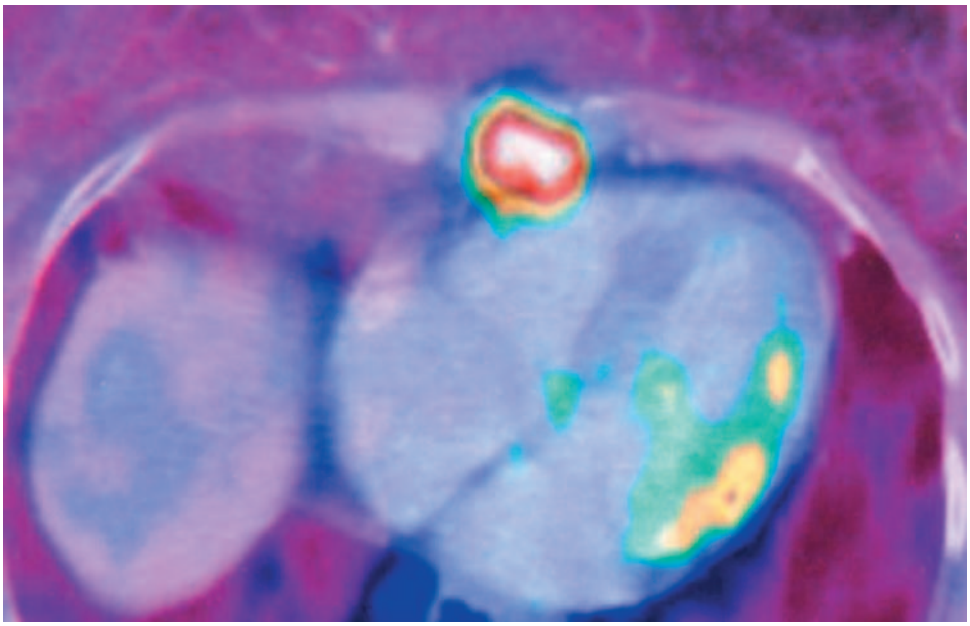

Figure 1. *PT/CT scan of sternal metastasis.*

to the sternal region was delivered. After 6 weeks, no symptom improvement was noted and a percutaneous treatment of the localised metastasis was proposed. Informed consent was obtained. Before the procedure a repeated CT scan confirmed a 23 mm osteolytic sternal lesion at the 2nd-3rd rib articulation level.

RFTA was performed percutaneously under CT guidance. The patient was posed in the supine position and the thorax was prepared and draped in the usual sterile fashion. The lesion was identified using the CT pointing system and 1% lidocaine local anesthesia was administered through the skin. A small blade incision was made and a hand-modified 13-gauge bone biopsy needle was directed into the sternum. Under CT guidance, the needle was gently advanced into the lesion. After diagnostic cyto-aspiration, the 15-gauge RFTA needle (MIRAS TX-120, Invatec Italia, Concesio, Italy) was placed through the biopsy needle and the 3 spiral tines deployed up to 1 cm from the needle sheath (Figure 2). A multi-tine expandable probe was used in order to obtain entire lesion coverage. Correct placement of needle and tines was CT confirmed. Ground pads were placed in the supraclavear space to avoid the cardiac electrical axis and then connected to the electrical circuitation.

The procedure was performed with a 40 W energy peak raising the temperature up to 80˚C for 3 minutes. A bone lesion RFTA protocol commonly used for vertebral lesions less than 3 cm in diameter was carried out. The procedure started with a 10 W energy output, maintained up to three minutes in order to reduce the local tissue impedence to 50-60 Ohm and then 10 W each further minute up to a 40 W generator output and 80˚C homogeneous temperature at the thermocouple tips. These settings were maintained for about 3 minutes, in order to obtain entire lesion coagulative necrosis. In the first 120-180 seconds, using such a low energy, it is possible to optimize radiofrequency flowing at the tissue-electrode interface without charring, distributing radiofrequency homogeneously while reducing burning pain. The elapsed time for the entire procedure was 15-20 minutes.

A post-procedure CT scan confirmed the presence of gas bubbles inside the bone lesion, which are commonly interpreted as the immediate coagulation sign. Gas formation is due to intracellular fluid evaporation after membrane disrupture after extensive radiofrequency ionizing friction heating. Bubbles are entrapped mainly in the outer soft tissue margins in face to periosteum burdens.

Tines were then retracted and the needle removed from the patient after a 2 minutes cool-down period.

Percutaneous injection of polymethylmethacrylate (PMMA) (~1 cc) for bone stabilization using the biopsy needle as a guide (Figure 3) was subsequently performed.

The patient was hospitalized for one night. No complication occurred. Antibiotics were administered one day before and three days after the procedure.

Results

The procedure was uneventful and patient experienced an immediate pain relief.

Discussion

Metastatic cancer is the most common malignant bone disease. Every year more than a half of the estimated 1.2 million new cases of cancer diagnosed in United States will probably exhibit skeletal metastases (11).

Breast, lung and prostate cancer are responsible for more than 85% of bone metastases (12). The most frequently reported symptom of such lesions is pain. It may be excruciating and so bring about a decrease in the patient's quality of life. Because of the advanced disease at the time

Figure 2. *The RF needle has been positioned.*

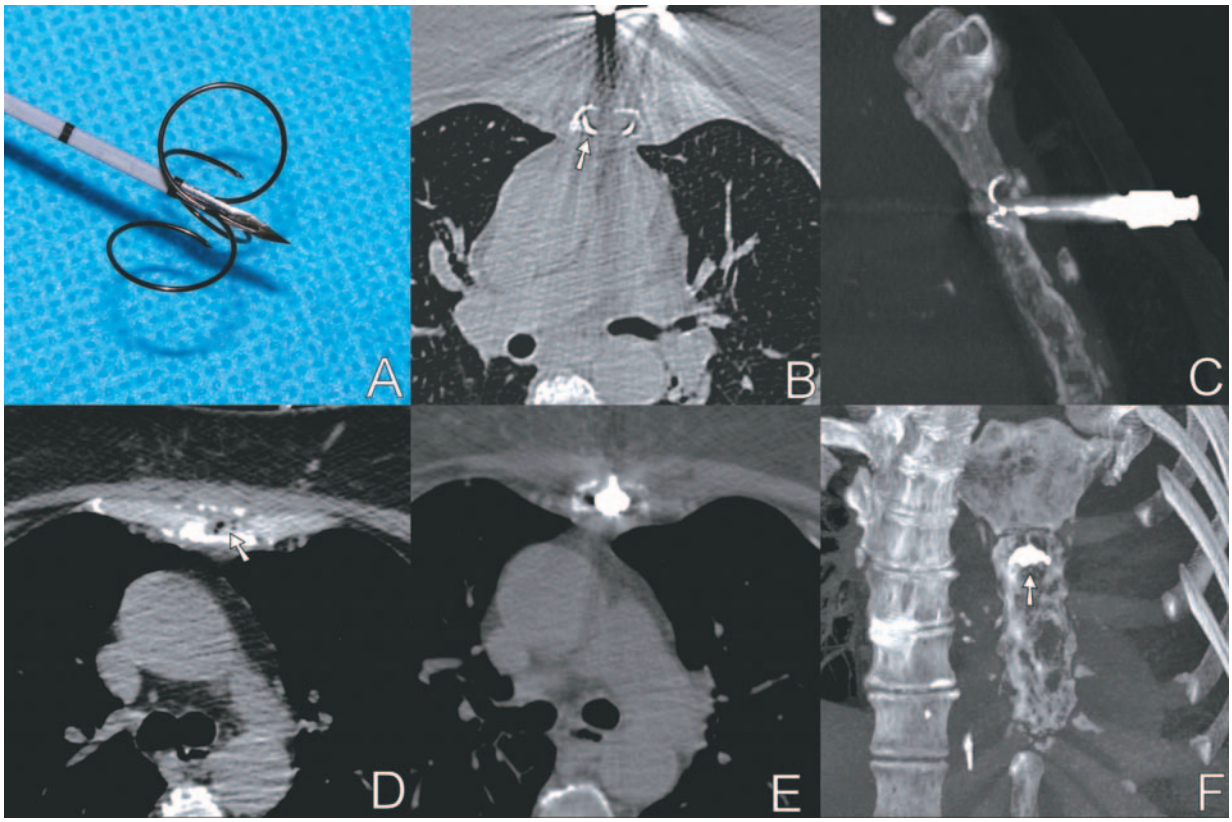

Figure 3. *A) RF needle with partially deployed tines. B) RF needle positioning using CT control. Only tines are visible (arrow). C) MIP reconstruction: RF needle with deployed tines positioned in the lesion. D) Gas bubbles (arrow) in the upper side of the lesion some minutes after the RFTA procedure. E) Polymethylmethacrylate (PMMA) introduction after RFTA. F) MIP reconstruction: PMMA distribution in the lesion at the end of the procedure.*

of presentation, current treatments are pain palliation, aimed at preventing treatment complications and reducing the hospital stay. Radiation therapy, chemotherapy, hormone therapy and analgesic medications are all included in standard palliation protocols. Currently, radiation therapy is recognized as the most effective treatment, however 20-30% of patients with painful bone metastases are non-responders. Furthermore, patients who have recurrent pain in a previously irradiated site may not be suitable for further irradiation due to dose limits in normal tissue (7-8).

Percutaneous image-guided RFTA uses a high-frequency alternating current that produces a focal thermal injury to tumour cells. RFTA allows the destruction of tumor cells without surgical removal and may be used instead of more invasive, expensive and complicated techniques, often unnecessary for patients with a short life expectancy. Pain decrease is probably due to local sensory terms destruction and cytokines being released as a result of the intense heat of RFTA (13). This technique has been used to treat both benign and malignant conditions in several organs. In the musculoskeletal system, it is used to treat osteoid osteomas, chondroblastomas, epithelioid hemangioendotheliomas, chordomas and spinal metastases (9).

The integrity of the periosteum is of paramount importance when RFTA is used for osteolytic bone lesions. After the procedure is completed, thermal ablation continues as heat is kept inside the insulating periosteum. In a cool-down period following the retraction of the tines, heat is irradiated from the charring tip producing tissue necrosis nearby the needle track. This cool-down period, with the energy output off, is variable among the different bone lesions, mainly depending on cell density and lesion diameter, as we previously found in swine.

To date, RFTA combined with cementoplasty is used on the spine or other bearing bones with excellent results in terms of long-term pain relief (14). RFTA and cementoplasty are mutually enhanced because of the homogeneous distribution cement of the inside the heated tissue and the bone burdens.

As far as we know, there is no data in the literature on the use of cementoplasty for sternal lesions. We aimed to give a combined effect of pain relief and bone stabilization of the osteolytic lesion. RFTA can be performed with no sedation and in patients who would not be suitable for more invasive surgical procedures because of their age, performance status or disease extension. The main advantages of this protocol are the restricted range of damage and the immediate pain relief that is reached with a single-application therapy, while in contrast, RT has to be extended for weeks. In our experience, mechanical or thermal damage to the adjacent organs and structures such as the pericardium, heart and major vessels were the most important concerns. An accurate and repeated CT scan control during needle positioning is the way to guarantee a complication-free treatment. The position of the grounding pads is another important aspect. In the case reported here the supraclavear space was preferred for positioning in order to avoid electrical flow to the heart area.

The RFTA and cementoplasty combined therapy appears to have a real efficacy against oncological pain and can be considered as a true alternative to other palliative therapies. The most important features of this approach are its rapid action against pain and the limited duration of the procedure.

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Received July 24, 2007
Accepted August 6, 2007