Cardiovasc Intervent Radiol (2008) 31:669–672
DOI 10.1007/s00270-007-9223-2

CASE REPORT

# Percutaneous Cryoablation and Vertebroplasty: A Case Report

**Salvatore Masala · Mario Roselli · Guglielmo Manenti · Matteo Mammucari · Dario Alberto Bartolucci · Giovanni Simonetti**

Received: 17 April 2007 / Accepted: 1 August 2007 / Published online: 14 November 2007


**Abstract** A 70-year-old man with a painful vertebral metastasis was treated with combined percutaneous cryoablation and vertebroplasty therapy (CVT) in one session. The patient was suffering from diffuse visceral metastasized cholangiocarcinoma. After several weeks of back pain, magnetic resonance imaging documented a single L2 bone metastasis. In consultation with the oncologists, palliative combined CVT was administered with the aim of obtaining pain relief and bone stabilization. In our experience this combined treatment is safe and effective for immediate pain relief in painful bone metastases when other standard palliative treatments have failed.

**Keywords** Bone metastasis · Percutaneous cryoablation · Vertebroplasty

## Introduction

Few patients with secondary bone tumors are surgical candidates. Current therapies are aimed at palliation of pain. Standard treatments include radiation therapy (RT), chemotherapy, hormone therapy, and analgesic medication. RT is considered the treatment of choice, but 20–30% of patients are non-responsive. Furthermore, patients with recurrent pain at a previously irradiated site may not be suitable for further irradiation, due to the dose limits in normal tissue [1]. Several therapeutic options have recently been introduced for the treatment of painful bone metastases. These consist of image-guided percutaneous ablative techniques of secondary lesions, mainly radiofrequency thermal ablation (RFTA) and most recently cryoablation.

Percutaneous cryoablation is a minimally invasive technique in which freezing is used to destroy selected tissues. This innovative procedure allows the destruction of malignant tissues in situ, without surgical removal, and may be used instead of invasive and painful techniques which are often useless in cancer patients.

S. Masala · G. Manenti · M. Mammucari ·
D. A. Bartolucci (✉) · G. Simonetti
Department of Diagnostic Imaging, Molecular Imaging, Interventional Radiology and Radiotherapy, "Tor Vergata" University General Hospital, V.le Oxford 81, 00133 Rome, Italy
e-mail: el3arto@gmail.com

M. Roselli
Department of Medical Oncology, "Tor Vergata" University General Hospital, V.le Oxford 81, 00133 Rome, Italy

## Case Report

A 70-year-old man had been diagnosed with cholangiocarcinoma. Contrast-enhanced CT staging of the tumor showed liver-limited disease. Bone scintigraphy was negative for extension of the disease to bone. Between April 2006 and October 2007, the patient underwent chemotherapy. Magnetic resonance imaging (MRI) of the lumbar spine performed in March showed tumoral seeding of the L2 vertebral body with a severe vertebral compressive fracture (40% L2 vertebral body compression with disruption of the anterior and posterior walls). Due to the persistence of the single bone lesion after chemotherapy, targeted radiotherapy was performed. Because of continuing pain and worsening of the patient's performance status, percutaneous cryoablation and vertebroplasty therapy (CVT) of the metastasis was considered. Informed consent to proceed was then obtained.

CT scans confirmed the presence of a 30 mm osteolytic lesion inside the L2 body, with disruption of the anterior and posterior walls. A two-phase procedure was carried out, in which positioning of bone biopsy needles in the vertebral body was followed by insertion of coaxial cryoprobes.

The patient was placed in the prone position with the spine extended. The patient's back was prepared in the usual sterile fashion and 1% lidocaine local anesthesia administered up to the periosteum. Two small skin incisions were made to access the pedicles. Under CT guidance, two 13G biopsy needles were introduced transpedicularly into the lesion (Fig. 1A). The combined approach to the metastasis was aimed at freezing the entire circumference of the lesion.

Two 17G cryoprobes (IceRod, Galil Medical, Yokneam, Israel; IceSeed, Galil Medical, Yokneam, Israel) were then introduced coaxially, up to the distant border of the lesion, immediately behind the L2 anterior wall (Fig. 1B). The biopsy needles were then retracted slightly to obtain a better exposure of the tip of the freezing cryoprobes. We used two different cryoprobes models. The IceRod, with its double-chambered gas expansion, allows wider iceball formation (16 mm $\times$ 41 mm ellipsoid at $-40°C$) in comparison with the IceSeed (10.5 mm $\times$ 19 mm ellipsoid at $-40°C$) which has a single gas chamber on the exposed tip. Compressed argon gas passes through the cryoablation needle, cooling the tip and forming the iceball (Joule-Thomson effect). A double freeze/thaw cycle is required to ensure cell destruction at high subzero temperatures, which must be $-40°C$. At this temperature 100% of cells are destroyed by extra- and intracellular ice formation, based on the cooling rate [2].

Freezing cycles (10 min each) are interspersed with a 5 min passive thaw in order to release probes and defrost surrounding tissue for polymethylmethacrylate (PMMA) injection. A double freeze/thaw cycle increases the statistical probability of intracellular ice formation and cell damage. Cells surviving the primary insult of freezing will die because of structural damage and ischemia [3].

After each freezing step, a CT scan revealed the presence of "kissing" iceballs within the lesion (Fig. 1C–E), visualized as hypodense areas arising from the probe tips enveloping the greater part of the lesion and a small surrounding area, sparing the wall of the vertebral bone.

During the last thaw phase the PMMA was prepared, combining liquid monomer and powder cement polymer. PMMA loaded into the dedicated device was injected into the vertebral body under CT guidance. Sequential CT scans showed the distribution pattern of the cement, filling the hypodense areas representing the iceballs (Fig. 1F).

After extraction of the needles the incisions did not require suturing and the patient was instructed to remain in bed, in a supine position, for the following 4 hr. The patient

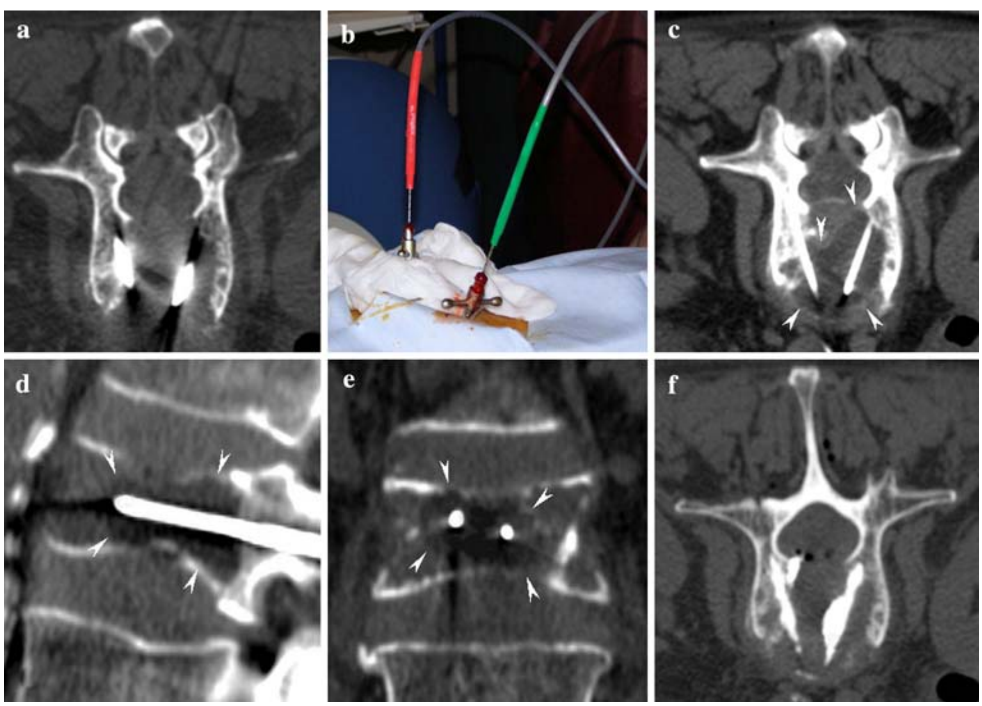


**Fig. 1.** (**A**) Axial image showing positioning of the 13G biopsy needles under CT control. (**B**) Cryoprobes coaxially introduced through the biopsy needles. (**C–E**) "Kissing" iceballs visualized as hypodense areas (arrowheads) in axial, sagittal, and coronal CT reconstructions. **F** Postprocedural axial CT control image of PMMA distribution filling the iceball areas

was hospitalized for 1 night. No complication occurred. Antibiotics were administered 1 day before and 3 days after the percutaneous procedure.

## Discussion

Metastatic cancer is the most common malignant disease of the skeletal system. Approximately 70% of cancer patients have evidence of metastatic disease at the time of their death [4, 5]. Every year more than half of the estimated 1.2 million new cases of cancer diagnosed in the United States will probably exhibit skeletal metastasis.

The spinal column is the most common location among osseous sites for metastatic deposits [6]. Spinal involvement may occur in up to 40% of patients with cancer. Spinal metastasis can arise from the vertebral column (85%), paravertebral region (10–15%) and, rarely, the epidural space. The thoracic spine is the most frequent site of disease (70%), followed by the lumbar spine (20%) and the cervical spine (10%) [7]. The posterior half of vertebral body is usually involved first, with the anterior body, lamina, and pedicles involved later. Multiple lesions and non-contiguous levels occur in 10–40% of cases [8].

Major symptoms of vertebral disease are severe pain and functional limitation, both of which reduce quality of life. Painful bone metastases commonly occur in advanced cancer patients. These are difficult to manage because of pain, reduction of mobility and performance status.

Surgical resection is considered the only potentially curative option for bone metastases but few patients are surgical candidates. Current treatments are aimed at palliation of pain, prevention of complications, and a reduction of the hospital stay.

Chemotherapy may not be suitable because of its toxicity and variable success rates. RT is the treatment of choice, but more than 20–30% of patients with painful bone metastasis are non-responders [8, 9]. In addition, RT may not be an option because of high radiation doses previously delivered. Both RT and chemotherapy require a 2- to 4-week delay to achieve maximum effect. Furthermore, pain relief following RT is not always long-lasting. Steenland et al. found pain recurrence at the initial pain score or higher in 49% of patients in a median of 8–36 weeks [10]. Recently minimally invasive surgical techniques, such as radiofrequency thermal ablation (RFTA) and cryoablation, have been added to the therapeutic armamentarium.

The aim of the combined procedure (CVT) was to destroy the tumor using cryoablation before stabilizing the vertebra through intrasomatic injection of PMMA [11–14]. Cryoablation is a method in which freezing is used to destroy undesirable tissues. It has been applied to treat benign and malignant conditions in several organs, including the prostate, kidney, liver, lung, and breast [15]. Tissue cooling is achieved by rapid gas expansion in an insulated probe tip. First-generation devices were limited to intraoperative use because of their large diameters due to the use of liquid nitrogen for tissue cooling. Recently, the development of thinner probes and the use of argon-helium gas technology has allowed a percutaneous approach.

Even though RFTA is effective in relieving pain, it has some important limitations. Real-time CT monitoring of the RFTA procedure is based on the phenomenon of gas bubble formation, not on visualization of the lesion margins. The use of alternate freeze/thaw cycles allows real-time optimization of the procedure with software control, enabling the sculpting of a precise freeze zone to match the size and shape of the tumor (hypodense elliptical area on pre- and post-contrast CT). RFTA is often a painful procedure due to the action of heat on nearby tissues [16]. In contrast, freezing causes a partial analgesia, reducing nociceptor activity and synaptic transmission, so that patients do not experience pain during the procedure. Finally, percutaneous cryoablation can be performed without general anesthesia when surgery is not acceptable because of the patient's age, general condition or advanced disease.

The efficacy of the procedure was demonstrated by a decrease from 8/10 to 3/10 points on a visual analog scale (VAS) of pain at discharge. The Huskisson VAS is a pain score assigned subjectively by the patient in a range between 0 (absence of pain) and 10 (maximum pain imaginable).

The advantages of the CVT combined procedure are the "surgical" and easily imaged iceball area, the immediate postprocedural pain relief, the painless nature of the treatment, and the achievement of both pain relief and bone stabilization in a single session. Our experience shows that CVT represents an effective and feasible palliation therapy in patients with painful bone metastases. Careful needle positioning and accurate CT monitoring are mandatory for a complication-free treatment.

## References


1. Poullsen HS, Nielsen OS, Klee M, et al. (1989) Palliative radiotherapy in the treatment of skeletal metastasis. Eur J Pain 6:323–330
2. Rubinsky B (2000) Cryosurgery. Annu Rev Biomed Eng 2:157–187
3. Rubinsky B, Pegg DE (1988) A mathematical model for the freezing process in biological tissue. Proc R Soc Lond (Biol) 234:343–358
4. Harrington K (1993) Metastatic tumors of the spine: Diagnosis and treatment. J Am Acad Orthop Surg 1:76–86
5. Klimo P Jr, Schimdt MH (2004) Surgical management of spinal metastases. Oncologist 9:188–196

6. Bohm P, Huber J (2002) The surgical treatment of bony metastases of spine and limbs. J Bone Joint Surg Br 84:521–529
7. Gerszten PC, Welch WC (2000) Current surgical management of metastatic spinal disease. Oncology 14:1013–1024
8. Tong D, Gillick L, Hendrickson FR (1982) The palliation of symptomatic osseous metastases: Final results of the study by the Radiation Therapy Oncology Group. Cancer 50:893–899
9. McQuay H, Collins S, Carroll D, Moore R (1999) Radiotherapy for the palliation of painful bone metastases. Cochrane Database Syst Rev 3:CD001793
10. Steenland E, Leer JW, van Houwelingen H, et al. (1999) The effect of a single fraction compared to multiple fractions on painful bone metastases: A global analysis of the Dutch Bone Metastasis Study. Radiother Oncol 52:101–109
11. Papagelopoulos PJ, Mavrogenis AF, Kelekis AD, et al. (2006) Percutaneous osteoplasty for pelvic and spine metastases. Orthopedics 29:315–323
12. Anselmetti GC, Corrao G, Monica PD, et al. (2007) Pain relief following percutaneous vertebroplasty: Results of a series of 283 consecutive patients treated in a single institution. Cardiovasc Intervent Radiol 30:441–447
13. Gangi A, Sabharwal T, Irani FG, et al. (2006) Quality assurance guidelines for percutaneous vertebroplasty. Cardiovasc Intervent Radiol 29:173–178
14. Masala S, Pipitone V, Tomassini M, et al. (2006) Percutaneous vertebroplasty in painful Schmorl nodes. Cardiovasc Intervent Radiol 29:97–101
15. Callstrom MR, Atwell TD, Charboneau JW, et al. (2006) Painful metastases involving bone: Percutaneous image-guided cryoablation: Prospective trial interim analysis. Radiology 241:572–580
16. Buy X, Basile A, Bierry G, Cupelli J, Gangi A (2006) Saline-infused bipolar radiofrequency ablation of high-risk spinal and paraspinal neoplasms. AJR Am J Roentgenol 186:S322–326