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Review Article

Postoperative complications with cryotherapy in bone tumors

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ABSTRACT

The technique of cryosurgery has been used to control local recurrence in a variety of benign and malignant bone tumors. Early studies revealed significant complication rates (25%) that included fracture, infection, and soft tissue injury. Our method of cryosurgery has yielded excellent tumor control with improved complication rates. The objective of this study is to determine the characteristics of postoperative complications after pouring liquid nitrogen into curettaged bone defects, and to review our current indications and surgical technique in bone tumor management.

We reviewed charts in over 200 patients who received cryoablation for bone tumors from 1994 to 2015. Imaging studies were evaluated in all patients diagnosed with a complication. All patients receiving cryotherapy had soft tissue management intraoperatively that included warm saline directed to the structures. Liquid nitrogen was poured into the bone defect and in some cases, additional spraying with a cryogun into the defect was performed.

The majority of cryotherapy was used in cases of active or aggressive benign tumors. Our low complication rate of 2.34% included 1 post-operative fracture, 3 infection, and 1 paraesthesia. Bone graft or cementation was used in the majority of patients, all of which fully incorporated.

Cryoablation is an excellent from of adjuvant therapy for active and aggressive benign tumors and may be used in malignant tumors as well. Soft tissue protection is critical to avoid skin necrosis and wound breakdown. We recommend the use of cryotherapy in active and aggressive bone tumors as an adjuvant treatment prior to bone grafting or cementation.

1. Introduction

The technique of cryosurgery has been used to control local recurrence in a variety of benign and malignant bone tumors. Cryotherapy was initially instituted in seventeenth century originally by the Greeks, and adapted for dermatological use in 1850 for its anesthetic and vasoconstriction effects [1]. Since then, cryotherapy was put toward other uses in neurosurgery, gynecology, and eventually orthopaedics. The first reported use of cryosurgery for metastatic bone tumors was by Marcove who described an open system “direct pour” method using liquid nitrogen to aggressively fill the tumor cavity several times [2]. Repeated exposure of the curettaged area to extreme temperatures below 20 °C created ice crystal formations that were later shown to produce osmotic disturbances and bone necrosis [3].

The initial study with cryotherapy by Marcove revealed a high complication rate (51%) that included fracture, skin necrosis, infection, and neuropraxia [4]. The use of curettage alone was shown to be associated with a high recurrence rate but minimized complications [5]. The high complication rate with cryotherapy led to other adjuvant modalities such as phenol, peroxide, and aggressive burring in the treatment of bone tumors. However, refinement and experience with the technique helped reduce complication rates over time [6]. Recent studies have revealed that cryosurgery could be a recommended treatment for benign-aggressive and malignant bone tumors with little bone loss or long standing functional complications [3,7].

The purpose of this study was to describe our surgical technique used in cryoablation and to evaluate the complication rate using cryosurgery as an adjuvant in treating bone tumors.

2. Materials and methods

We retrospectively reviewed charts in patients who had been treated with cryoablation between 1994 and 2015. Follow up varied with the tumor type or until complete healing was seen radiographically. 5 patients had three freeze/thaws 207 patients had two freeze thaws and 2 patients had cryoprobe treatment. Surgical technique using

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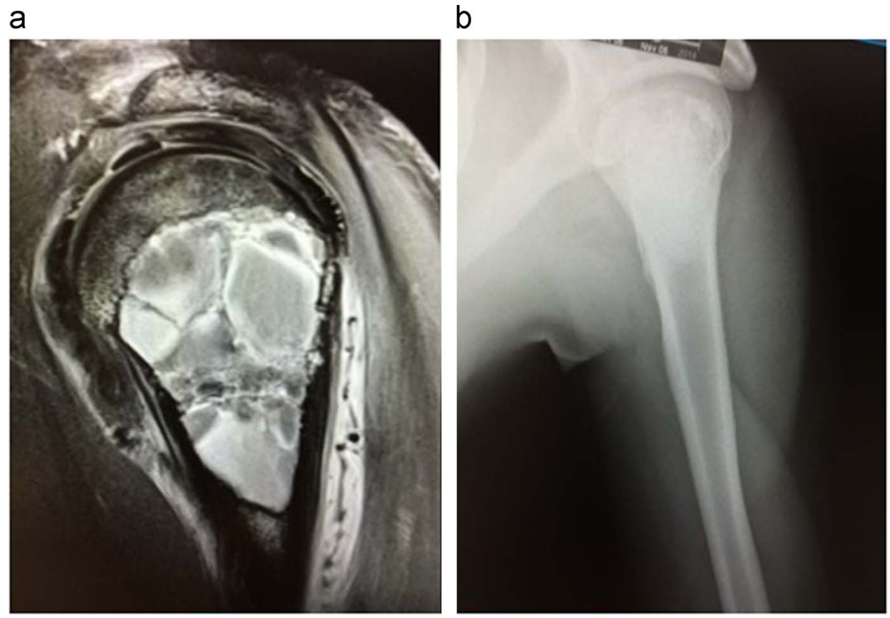

Fig. 1. Aggressive chondroblastoma with an aneurysmal bone cyst of the proximal humerus seen on MRI treated with curettage, cryotherapy and bone graft substitute. a) Initial evaluation; b) Post-operative outcome.

the freeze/thaw technique included initial extensive curettage of the lesion through a 1.5–3.5 cm defect in the bone made with an 8 mm drill and followed by increasing the size of the cortical defect with curettes. The tumor was excised using a combination of angled curettes and large bore Frazier tip suction under fluoroscopic guidance. A high speed burr was not used. Once the lesion was removed, warming the overlying tissue prior to pouring in the liquid nitrogen was performed. The liquid nitrogen was poured into the defect through a metal funnel under direct vision. If the liquid nitrogen began freezing the overlying tissue, warm saline would be judiciously applied to prevent freezing damage to the skin, subcutaneous tissue and in some cases the muscle. After the liquid nitrogen was poured into the defect, the limb would be manipulated to achieve maximum freeze throughout the defect. Once the intralesional ice ball thawed, a second and or third freeze thaw cycle would be repeated. If a portion of the defect could not be adequately frozen, additional freezing using a cryogun spray would be administered. The defect was then filled with either bone grafting, bone graft substitute, or polymethyl methacrylate (PMMA) cement to return mechanical support (Fig. 1). Tourniquet was used if the tumor surgery was distal to the proximal humerus and femur.

A second technique implemented included the use of cryoprobes. The tumor size was evaluated, the size and number of cryoprobes were determined to achieve a complete freeze, and the probes were inserted percutaneously under fluoroscopic guidance. Two freeze thaws were performed and the probes were removed.

3. Results

There were 232 cases where cryotherapy was used in 214 patients between 1994 and 2015. There were 96 male and 118 female. The age of patients ranged from 4 to 95. All patients had undergone imaging studies for evaluation. A majority of cases consisted of active or aggressive benign tumors. The most common tumor types included enchondroma (75), giant cell tumor (42), aneurysmal bone cyst (20 primary); (15 secondary), metastatic disease (19) and chondroblastoma (16). Complications included superficial infections (2), deep infection (1), fracture (1) and paraesthesia (1) (Table 1). 12 cases of local recurrence requiring additional surgery was noted primarily in aggressive giant cell tumors and chondroblastoma with secondary ABC. A majority of patients received bone graft or PMMA cementation, with all

Table 1
Patients presented with the following subtypes of bone tumor. Secondary Aneurysmal bone cyst present in 6 chondroblastoma, 3 fibrous dysplasia, 6 giant cell tumor and were not counted as separate cases,.

Types of Tumor included in current study	
Chondroblastoma	16
Chondromyxoid Fibroma	7
Osteoblastoma	1
Nonossifying Fibroma	8
Enchondroma	75
Chondrosarcoma (Low Grade)	1
Aneurysmal Bone Cyst, Primary	20
Giant Cell Tumor	42
Unicameral Bone Cyst	7
Lipoma	2
Fibrous Dysplasia	3
Eosinophilic Granuloma	1
Other Metastatic	19
Malignant Tumor	9
Other	3
Total Patients	214
Repeat Surgeries	18
Aneurysmal Bone Cyst, Secondary	15
Total Cases	232

bone fillers incorporating. There were no restrictions postoperatively in our cases involving benign tumors.

4. Discussion

The common local adjuvants with curettage include phenol, cryotherapy, laser, and cement. Cryotherapy agents include carbon dioxide and liquid nitrogen. However, liquid nitrogen is favored for its rapid freezing capabilities (−196 °C) for a potentially large area necrosis.

Previous studies show that cryosurgery may be as effective as wide resection for therapeutic treatment of benign-aggressive, low grade, and malignant bone tumors [2,6,8]. A slow freeze and quick thaw can preserve cells, but a quick freeze and slow thaw is repeated to induce cell death [9,10]. Exposing the curettaged area to a quick freeze below −20 °C creates ice crystals that disrupt cell osmolality which leads to apoptosis [11,12]. A minimum of 2 freeze thaw cycles is needed to