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Case Report

CT-guided percutaneous cryoablation of an osteoid osteoma of the rib[☆]

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ABSTRACT

An osteoid osteoma is a benign bone tumor that arises from osteoblastic dysfunction and usually presents as nonspecific, nocturnal pain located in the diaphysis of long bones, with <1% occurring in the ribs. It is most commonly treated with nonsteroidal anti-inflammatory drugs or merely observed; when these treatments do not prove efficacious, either open surgery or interventional ablation are pursued. Herein, we report a rare case of an osteoid osteoma located in the rib of a 19-year-old male that was histologically diagnosed through computed tomography (CT)-guided biopsy. Using CT guidance, the tumor was ablated by creating an artificial pneumothorax in order to induce a margin of space safe enough for cryoablation. It is important to be aware of the possibility that an osteoid osteoma may be present in the ribs, as the differential diagnosis includes costochondritis, pneumonia, osteoblastoma, enchondroma, osteosarcoma, cyst, and Brodie abscess. In addition, we have shown that CT-guided cryoablation can be an effective and less invasive treatment when compared to open en bloc resection, highlighting the role of interventional radiology in bone tumor ablation.

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Introduction

Osteoid osteoma (OO) is a benign osteoblastic bone lesion, first described by Dr. Henry L. Jaffe in 1935. It is characterized by a nidus of osteoid tissue (unmineralized bone matrix) and con-

stitutes up to 10% of all benign bone tumors [1]. This tumor is most commonly found between the ages of 7 and 25 years and has a predilection toward males [2]. OO is distinct in presentation in that it usually affects the long bones, typically the femur or tibia, and is accompanied with nocturnal pain alleviated by salicylates or nonsteroidal anti-inflammatory drugs (NSAIDs) [3]. Depending on location and severity, treatment options vary ranging from conservative medical management

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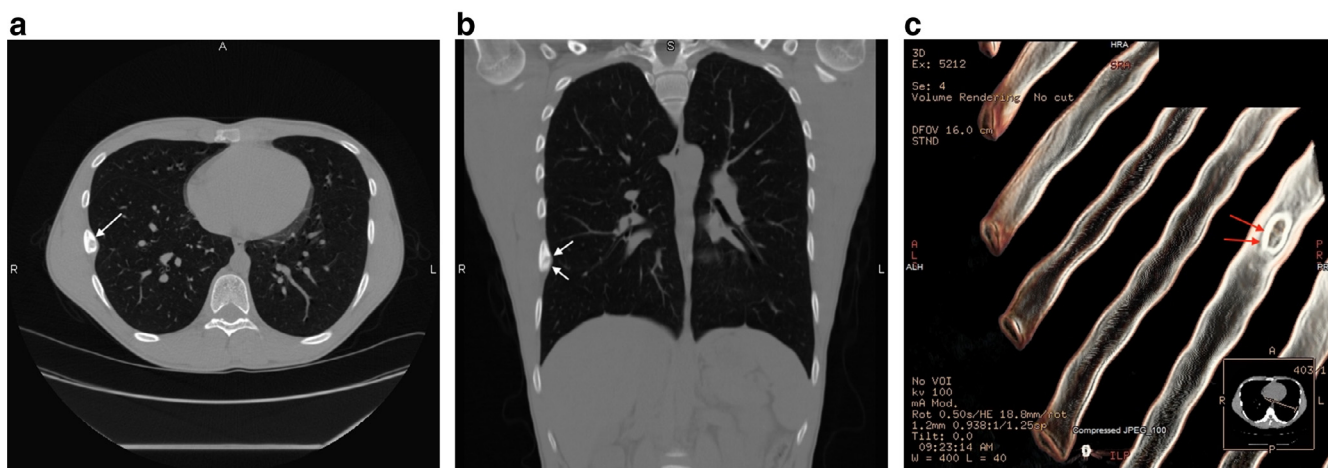


Fig. 1 – Axial (a), coronal (b), and 3D reconstruction (c) CT showing a right seventh rib with a 7 mm intracortical radiolucency with overlying cortical thickening and sclerosis.

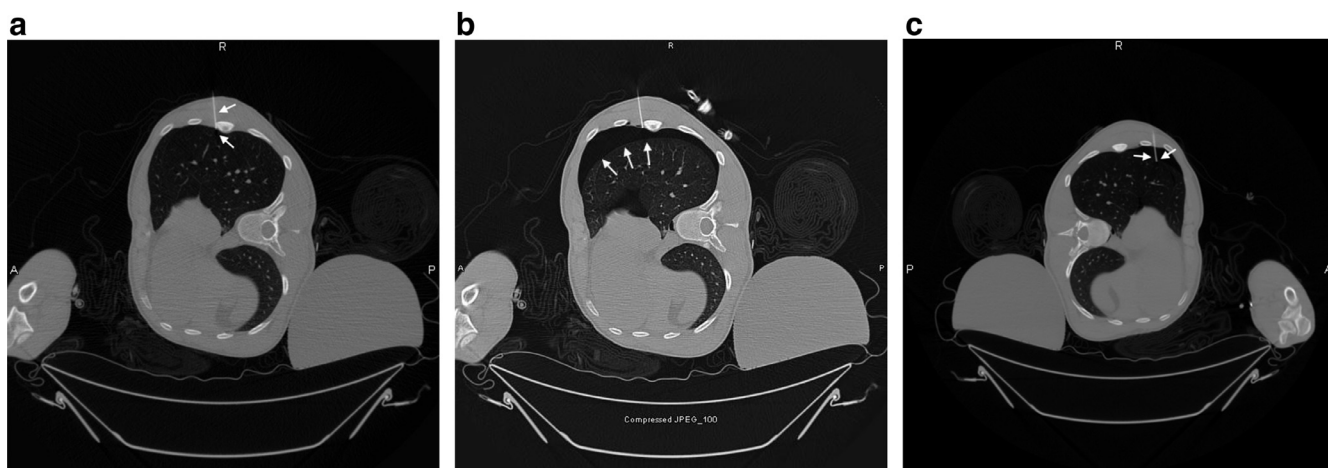


Fig. 2 – CT showing a 22-in. gauge needle inserted into the pleural space (a) that was used to create a pneumothorax (b). A Yueh needle was also inserted to allow for proper drainage of the pleural space (c).

to surgical resection [4]. Location within a rib is rare, accounting for <1% of all OOs, with only 12 cases currently published in the literature [5]. Here, we present a case of an OO of the rib successfully treated with computed tomography (CT)-guided percutaneous cryoablation.

Case report

A 19-year-old male presented to his primary care physician with 8 months of constant, predominantly aching, right lateral chest wall pain that was most severe at night and relieved with NSAIDs. He denied a history of trauma, shortness of breath, cardiac symptoms, or sternal pain. An initial chest x-ray was normal, but after 2 months of unresolved symptoms a CT scan was performed revealing a 7 mm, well-circumscribed, cortical lucency at the lateral seventh rib. The lesion contained

an intracortical calcified nidus, and was surrounded by sclerosis, raising the possibility of an OO (Fig. 1). The patient subsequently was prompted to visit a thoracic surgeon who then referred the patient to our interventional radiology clinic. Based on the above clinical scenario and CT appearance a likely diagnosis of OO was established, and the patient was scheduled for a CT-guided biopsy and cryoablation under general anesthesia.

Before the procedure, general anesthesia was initiated utilizing single-lumen intubation and 1% lidocaine solution was injected into the surrounding tissues for local anesthesia. First, using CT guidance, a 22-gauge needle was gently advanced into the pleural space with the aim of creating a pneumothorax that would establish a safe margin between the rib and right lung (Fig. 2a and b). The needle was positioned just superficial to the parietal pleura and then slowly advanced while gently injecting saline. When an abrupt decrease in resistance of the saline injection was felt approximately 10 cc of

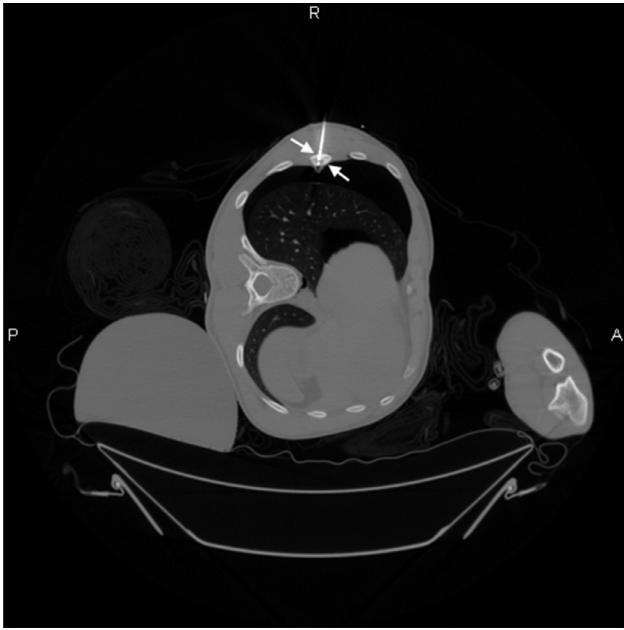


Fig. 3 – Intraoperative CT imaging showing a 10 gauge Cook biopsy needle inserted directly into the nidus of the osteoid osteoma, a 13 gauge biopsy needle was then inserted for sampling.

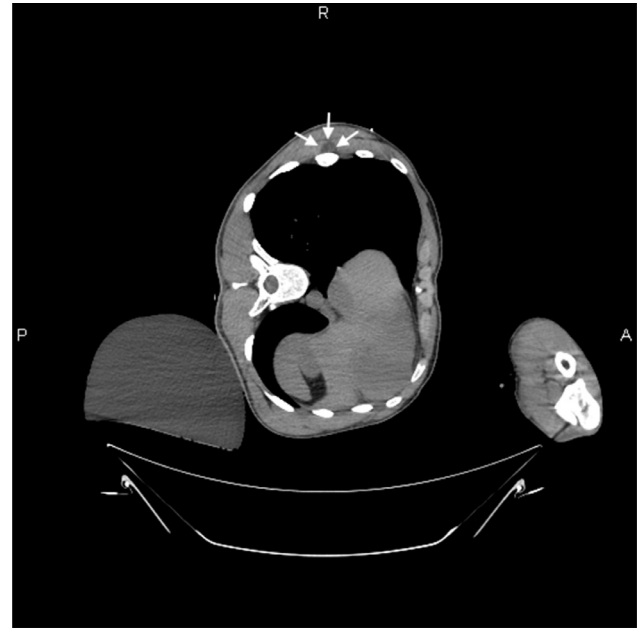


Fig. 4 – Intraoperative CT imaging showing a hypodense 2 cm ice ball with distinct margins after the first freeze-thaw cycle.

atmospheric air was injected. A CT scan at this time showed a sliver of pleural air, confirming good position of the needle within the pleural space. 60 cc of air was then injected until there was enough separation of the lung from the chest wall to place a 19 gauge Yueh needle (Fig. 2c). A total of 600 cc of air was then injected to achieve an approximately 1.5 cm margin. A 10 gauge Cook bone biopsy needle was then advanced into the rib lesion from a lateral approach and a 13 gauge core biopsy was then obtained using coaxial technique (Fig. 3). The core sample was then handed to the pathologist and histologic analysis showed dense trabecular bone with subjacent osteoid and osteoblastic activity, consistent with a diagnosis of OO (Fig. 6). Once the diagnosis was confirmed, the 10 gauge cannula was left in place and a 14 gauge BTG IcePearl 2.1 CX Family cryoablation probe was then advanced into the lesion with the tip positioned at inner cortex of the rib. Cryoablation was then initiated with cycles of a 4-minute freeze, 2-minute thaw, and then 3.5-minute freeze to create an ice ball of approximately 2 cm (Fig. 4). The pneumothorax was then evacuated; however, the amount of air aspirated was greater than the amount injected. A CT confirmed a slowly enlarging right pneumothorax for which an 8 French chest tube was placed. On postprocedure day 1, the patient reported a significant reduction in pain and serial follow-up chest x-rays confirmed resolution of the right pneumothorax (Fig. 5). The chest tube was removed and the patient was discharged home. Follow-up on the patient 3 months after the procedure showed no chest wall pain nor other previous symptoms associated with the OO.

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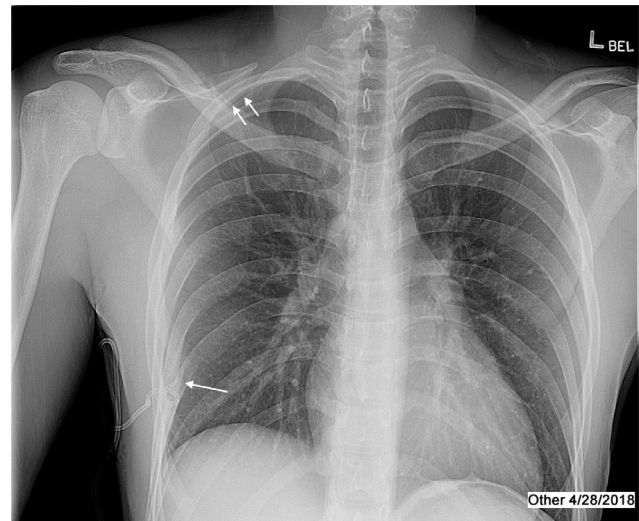


Fig. 5 – Postoperative chest x-ray showing a trace pneumothorax (double arrow) and a chest tube (single arrow) that was subsequently removed.

Discussion

OO is a benign osteoblastic bone lesion characterized by a nidus of vascular osteoid tissue. It constitutes up to 10% of all benign tumors of the bone and is most commonly found in young males between ages 7 and 25 years. Although OO can share histologic and/or clinical similarities with other bone lesions (osteoma, osteoblastoma, enchondroma, osteosarcoma, cysts, and Brodie abscess), there is distinctness in its

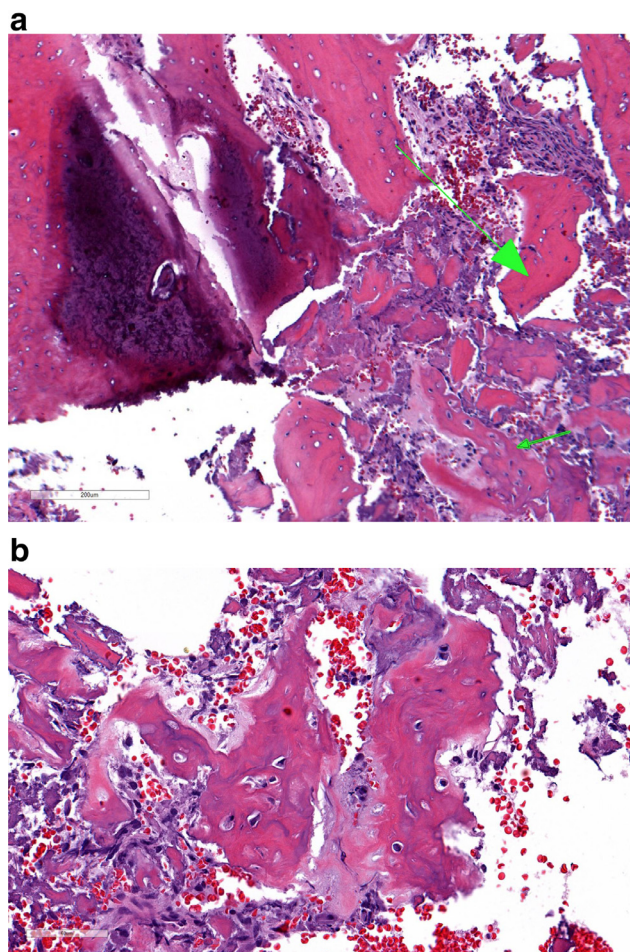


Fig. 6 – Bone curettage (36 x): Sclerotic nonlesional bone (long arrow) with lesional immature bone/ osteoid seams (short arrow) (a). Bone curettage (366 x): Lesional tissue with immature bone/poorly mineralized osteoid seams and background hypercellular stroma (b).

presentation in that it is commonly found in long bones and is accompanied by nocturnal pain only relieved by salicylates or NSAIDs. In addition, patients may have point tenderness and local swelling in the area of the lesion. If the OO is allowed to continue to grow, bony deformities, scoliosis, muscle atrophy, and other chronic complications can occur.

Radiographs are usually obtained first and typically show sclerosis and thick periosteal reaction with a lucent nidus located centrally. The imaging modality of choice for diagnosis of an OO is CT, as it is the most accurate in detecting the nidus of the lesion when compared to other modalities [6,7]. It is important to note, however, that magnetic resonance (MR) perfusion has also been shown to be clearly effective in diagnosis and measurement of OO recurrence. MR perfusion can better portray bone marrow edema and offers enhancement patterns that peak within a short amount time and correlate very well with OO-related symptoms [8,9]. Yet another modality used to diagnose OO is radionuclide imaging; studies have shown that when an initial plain radiograph is inconclusive, following up with nuclear studies (such as ^{99m}Tc -methylene

diphosphonate bone scintigraphy) can be a useful tool for further workup. If radionuclide imaging is positive, subsequent CT scans may be a more valuable resource in diagnosis of an OO when compared with MRI; on the other hand, if it is negative, MRI should be used to cover for other possible etiologies [10]. Radiation exposure, however, is a setback to this modality because of its dose equivalent that is significantly higher than plain radiographs.

The first line treatment for an OO is conservative, with NSAID administration relieving a majority of cases. However, in those cases that pharmacologic treatment is inadequate, surgical intervention may prove to be beneficial. Although en bloc resection through open surgery has been a method proven to be effective, it comes with higher mechanical risk to nearby soft tissue, especially if it were implemented in this case due to the anatomic proximity of the OO to the costal neurovascular bundle and adjacent pleural membrane. Consequently, CT-guided approaches have been developed in order to reduce invasiveness and improve postsurgical measurements [11]. One similar method that uses CT-guided Kirschner wire (without removal during resection) has also been implemented, but the proximity to vessels in many procedures and lack of established data prove to be a set-back to its standardization [12].

Currently, radiofrequency and cryoablation have been emerging techniques that result in positive and efficacious outcomes. However, deciding between the approaches confers a challenge. Radiofrequency ablation (RFA) consists of a needle that is connected to a radiofrequency source that transmits medium frequency alternating currents. The source heats the needle to create thermal energy and induces a volume of tissue necrosis and coagulation in and around the target lesion through direct cellular membrane damage. On the other hand, cryoablation uses a needle attached to a source that cools it and pumps pressurized argon gas through subsequently smaller lumens, thus inducing a freezing effect on the nearby tissue. This induces necrosis by mechanisms of both direct and indirect cellular damage through disruption of the cell wall and cellular microenvironment, respectively [13]. In addition, a period of thawing also occurs, which induces edema in the area and causes the cells to swell and burst. When reviewing the literature, we recognized multiple cases of OO in other areas of the body as well as in the rib being successfully treated with RFA [14–16]. However, we chose to use cryoablation instead of RFA for numerous reasons, including the proximity of the pleura and costal vessels to the OO, as well as evidence from previous OO cases reporting diffuse, thermal osteonecrosis of the rib when RFA was used [17]. One advantage of cryoablation over RFA is that the formed ice ball more easily penetrates bone cortex whereas RFA requires a higher energy input in order to properly treat the tumor because of bone's high thermal insulation. This is primarily due to that fact that bone cells are more sensitive to lower temperatures [18]. In addition, the ice ball margins created by the freeze can be more easily visualized on CT and maintains the integrity of the bone more so than RFA [19]. This allows for better tracking of the tumor and preserves nearby structures. One setback to our approach in this case, however, was that the creation of a pneumothorax was still needed because of potential thermal injury to the adjacent pleura. Nonetheless, an adequate biopsy

and resection of the mass was accomplished along with resolution of the symptoms.

Conclusion

In conclusion, this case places importance on being cognizant to the fact that an OO may present within a rib, as not many [12] cases have been reported with a <1% prevalence of occurring in the rib. Furthermore, we find that noninvasive, CT-guided approaches have proven to be more efficacious in relieving symptoms, recurrence, and minimizing postoperative complications when compared to an open en bloc resection. We have also shown that cryoablation may be the safer and more efficient technique when compared to RFA based upon the anatomic location of the lesion and superior visualization of necrotic margins on CT. In the future, when similar cases of OO of the rib are encountered, it would be beneficial for the provider to weigh their options of which approach would be best for their patient. More data on the subject matter is certainly needed in order to provide for set standards of approach in similar presentations.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.radcr.2018.12.010.

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