Novel use of epidural catheter: Air injection for neuroprotection during radiofrequency ablation of spinal osteoid osteoma

ABSTRACT

Osteoid osteoma (OO) is a benign bone tumor, with a male-female ratio of approximately 2:1 and mainly affecting long bones. Ten percent of the lesions occur in the spine, mostly within the posterior elements. Treatment options for OO include surgical excision and percutaneous imaging-guided radiofrequency ablation (RFA). Lesions within the spine have an inherent risk of thermal damage to the vital structure because of proximity to the neural elements. We report a novel use of the epidural catheter for air injection for the neuroprotection of nerves close to the OO of the spine. A 12-year-old and 30 kg male child with an OO of the L3 vertebra was taken up for RFA. His preoperative examinations were within normal limits. The OO was very close to the L3 nerve root. Under general anesthesia, lumbar epidural catheter was placed in the L3-L4 space under imaging guidance. Ten ml of aliquots of air was injected under imaging guidance to avoid injury to the neural structures due to RFA. The air created a gap between neural elements and the tumor and served as an insulating material thereby protecting the neural elements from damage due to the RFA. Postoperatively, the patient did not develop any neurological deficit.

Key words: Epidural, osteoid osteoma, radiofrequency ablation

Introduction

Osteoid osteoma (OO) is a benign bone tumor of childhood and adolescence. Males are twice more likely to be affected than females. It most commonly affects the long bones (femur and tibia account for more than 50% cases). OO comprises 10% of all benign bone tumors and is associated with pain, which classically worsens at night and responds well to salicylates.[1-2] Ten percent of the lesions occur in the spine, mostly within the posterior elements. Treatment options for OO include surgical excision and percutaneous imaging-guided ablation; most spinal lesions are managed surgically. For years, lesions within the spine were considered untreatable with radiofrequency ablation (RFA) because of the inherent risk posed by proximity to the neural elements.[3] We present a novel nonanesthetic and nonanalgesic use of the epidural catheter for air injection and for the neuroprotection of the nerves close to the OO of the spine.

Case Report

A 12-year-old, 30 kg male child with an OO of the L3 vertebra was taken up for RFA. He was an American Society of Anesthesiologist class I. His clinical examination, airway, and spine anatomy revealed no abnormality. His preoperative laboratory investigations were within normal limits. The

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OO was very close to the L3 nerve root. He was taken to the interventional radiology room and monitors were attached. Anesthesia was induced with fentanyl, propofol, and atracurium and trachea was intubated with 6 mm of ID tracheal tube. Anesthesia was maintained on sevoflurane in oxygen and nitrous oxide mixture (30:70). To avoid injury to the neural structures due to RFA (heat generated), we inserted an epidural catheter after the induction of general anesthesia, one space lower (L3-4) than the tumor under computed tomography (CT) guidance. We injected aliquots of 10 ml of air through the epidural catheter under radiological guidance till an air pocket was seen between the neural structures and the osteoma. A total of 30 ml of air was needed to create a gap between neural elements and the tumor [Figure 1]. This air pocket served as an insulating material thereby protecting the neural elements from damage due to the RFA. The RFA electrode (RITA Medical Systems Inc., Model 1500X) was introduced in a lateral position under CT guidance and heated for 3 cycles of 90° Fahrenheit each till the target temperature was achieved. Postprocedure, he was kept in the recovery room for 4 h and then discharged after removal of the epidural catheter. Postoperatively, the patient was followed up for 6 months and was asymptomatic for the disease without any neurological deficit.

Discussion

OO is a benign bone tumor of childhood and adolescence in which males are twice more likely to be affected than females. RFA has emerged as the most widely accepted method for both palliative and curative procedures. RFA works by converting radiofrequency energy into heat. Electrodes are placed within the tumors percutaneously using imaging guidance such as ultrasound, CT, or magnetic resonance imaging.[4] An alternating current is passed from an electrode tip into the surrounding tissues, generating sequential changes in the direction of locally charged ions. This results in an ionic agitation and localized increase in the temperature to around 90°C.[4] This in turn causes frictional heating, which causes tissue desiccation and produces a localized area of coagulative necrosis. RFA is able to destroy tumor tissue and only a small rim of normal tissue around the edges of the tumor because healthy tissue can withstand heat better.

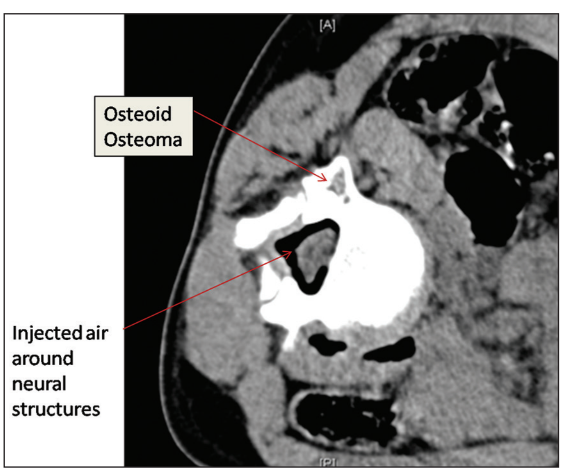

Figure 1: Osteoid osteoma of spine and injected air around neural structures

In spinal OO and other tumors, which are in vicinity of neural structures, when the thickness of cortical bone between the electrode and the periosteum is <5 mm, a safe distance of 10 mm is recommended between the periosteum and the nearest nerve structure.[5] There is always a risk of heat-induced irreversible damage to the spinal cord or a nerve root if the tumor is too close to them (<10 mm). An insulating separation must always be done between the periosteum and neural structures to prevent thermal damage to them during the procedure.

Rybak *et al.*,[3] in a retrospective, multicenter analysis of 17 patients with spinal OO (13 patients at one center underwent laser treatment and 4 patients at other center underwent RFA), showed the efficacy of epidural injection of gas or cooled fluid through spinal needles placed under CT guidance. At the first center, a thermocouple was placed coaxially through an 18-gauge spinal needle into the epidural or perineural space, adjacent to the lesion in nine cases and continuous monitoring was performed to ensure temperatures below the expected neurotoxic threshold (<45°C). At the second center, in four patients, an epidurogram was obtained by the injection of 2-5 cc of air or carbon dioxide (CO_2) through a 22 gauge spinal needle and following which slightly cooled or room temperature 5% dextrose in water was infused through the epidural needle at a rate of 1-2 mL/min during the thermal ablation.

Gangi *et al.*,[1] showed the successful use of epidural catheter insertion for the infusion of normal saline in a retrospective analysis of 12 cases of spine OO, to avoid the thermal damage to the neurologic strictures. The location of these 12 cases of spinal OO was, one cervical; two thoracic; seven lumbar; and two sacral. Nidi were within 8 mm of neural structures in five out of these 12 cases. Klass *et al.*,[6] described successful neuroprotection during RFA in 7 patients with spinal OO by preprocedure bolus injection of 10 ml of sterile water at room temperature, through a 26 gauge spinal needle into the exit foramen and adjacent epidural space. Buy *et al.*,[7] described the successful protection of adjacent vulnerable structures by the use of CO_2 dissection along with continuous thermal monitoring using a thermocouple in 35 patients, including 11 spinal tumors.

In our case, we injected air in aliquots through 20 gauge epidural catheter under CT scan imaging guidance to separate the tumor nidus and adjacent neural structures. This acted as an insulator, successfully preventing thermal damage to the neural structures. If the procedure is prolonged, the epidural catheter can be used for giving top ups of air. Air is a good insulator but has a higher incidence of embolism because of its lower solubility.[8,9] However, there have been no reports of embolism with such minute quantities of epidural air injection under imaging guidance. Filippiadis *et al*.[9] have described gas (CO_2 or air) injection by means of a 22 gauge spinal needle for the insulation of vulnerable structures from the ablation zone. CO_2 is a better insulator than air as the thermal conductivity of CO_2 (14.65 mW/mK at 0°C) is lower than water or air (23.94 mW/mK). However, the use of CO_2 requires special prefilled syringes (which are routinely difficult to get) and is a little cumbersome. Furthermore, thermal insulation by CO_2 dissection cannot be used in the ultrasound-guided interventions as the ring-down artifact from gas completely degrades the images.[8,10]

No local anesthetic or opioid was given through epidural catheter since air would have caused a patchy block and also have interfered with the neurological monitoring of motor power in the postoperative period.

Conclusion

We have successfully used epidural air as an insulator during RFA of spinal OO situated close to the neural structures. Epidural catheters can be used for giving top ups of air into the epidural space under imaging guidance for adequate insulation and neuroprotection.

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Conflicts of interest

There are no conflicts of interest.

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