Treatment of Symptomatic Intraosseous Pneumatocyst Using Intraoperative Navigation

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abstract

Intraosseous pneumatocysts are benign air-containing lesions that are most often found in the spine and pelvis and are nearly always treated nonoperatively. Although rarely clinically symptomatic, studies have shown pneumatocysts to be present in up to 10% of computed tomography (CT) scans of the pelvis and spine. Radiographic characteristics of these lesions include a localized collection of gas with a thin sclerotic rim, no bony destruction, no soft tissue masses, and no medullary abnormalities. Computed tomography is the diagnostic study of choice, with Hounsfield units ranging from -580 to -950, showing a gas-containing lesion. Few studies have described the management of symptomatic pneumatocysts, and all reported cases concern underwater divers, presumably because of greater pressure cycling and barotrauma encountered while underwater diving. The goal of this report is to describe the intraoperative CT-guided navigation and percutaneous injection of calcium sulfate-calcium phosphate composite bone graft substitute material for the treatment of a symptomatic pneumatocyst in the ilium of a Navy dive instructor. The patient reported a 1-year history of increasing buttock pain with increased depth of diving, consistently reproduced by diving past a depth of 20 to 30 feet. To the authors’ knowledge, this is the first description in the English literature of the operative treatment of an intraosseous pneumatocyst of the ilium. The use of intraoperative CT guidance permitted accurate percutaneous localization, decompression, and filling of the lesion with synthetic bone graft substitute, with complete early relief of symptoms. At 6-month follow up, the patient had reached diving depths of 170 feet without pain. [Orthopedics. 2015; 38(3):e244-e247.]
Intraosseous pneumatocysts are gas-containing lesions that are most commonly found in the spine and pelvis. This type of lesion is an uncommon benign finding that is not well described in the orthopedic literature. They are usually found incidentally, are most often asymptomatic, and are treated nonoperatively. The literature on the subject largely concerns radiographic recognition of this entity, and there are few reports of operative management of symptomatic intraosseous pneumatocyst lesions.

This article describes a modern technique using intraoperative computed tomography (CT)-guided navigation to locate and percutaneously inject synthetic graft material into a symptomatic intraosseous pneumatocyst of the ilium in an active duty male Navy dive instructor who had pain in the pelvis while diving. The patient provided written informed consent for print and electronic publication of the case report and images.

**CASE REPORT**

A 32-year-old active duty male Navy dive instructor presented to the authors’ facility with a 1-year history of increasing buttock pain with increased depth of diving. This pain was consistently reproducible by diving past a depth of 20 to 30 feet and was reliably alleviated by returning to the surface. He had no history of trauma or symptoms of infection. The patient was referred to the authors after plain radiographs and magnetic resonance imaging (MRI) showed an intraosseous lesion in the posterior pelvis (Figure 1). A CT scan was subsequently ordered to better delineate the osseous involvement of the lesion. It showed a well-circumscribed lesion in the right posterior ilium measuring approximately 1.8×1.1 cm in diameter, without lobulations or fluid levels (Figure 2). Because the patient had lifestyle and job-limiting symptoms in the distribution of this lesion, he underwent percutaneous decompression and grafting of the cyst under intraoperative CT-guided navigation.

The patient was positioned prone on a radiolucent table. After standard sterile field preparation, 2 threaded 4-mm half-pins were placed in the iliac wing to secure the navigation array. After intraoperative CT scan for navigation orientation, 2 cannulas were placed percutaneously under navigated guidance (O-arm Surgical Imaging System with StealthStation System navigation; Medtronic Inc, Louisville, Colorado). Two cannulas were placed to allow injection of the lesion and to ensure complete decompression by permitting egress of the gas and synthetic graft. Saline irrigation and liquid contrast were sequentially injected to confirm placement of both cannulas within the lesion (Figure 3). This was followed by injection of calcium sulfate-calcium phosphate composite bone graft substitute material (PRO-DENSE; Wright Medical Technology, Inc, Arlington, Tennessee; approved by the US Food and Drug Administration for this use) to fill the defect. The lesion was deemed filled (approximately 5 mL) when flow of synthetic bone graft substitute out of the second cannula was observed (Figure 4). The patient recovered without incident and was discharged from the hospital the next day. At 6 weeks, the patient returned to full duty and was asymptomatic while performing diving activities below 20 to 30 feet. At the most recent 6-month follow-up, the patient had continued complete relief of symptoms and has dived to 170 feet without pain.
**Discussion**

Intraosseous pneumatocysts are nearly always incidental, innocuous findings. This report is the first to describe CT-guided navigation to locate and inject bone graft substitute into a symptomatic lesion of the ilium. To the authors' knowledge, no cases in the English literature have reported the treatment of these lesions in the pelvis, and nearly all reported cases have concerned underwater divers.\(^1\,^2\) A Norwegian case report described CT-guided puncture and decompression of the lesion under local anesthesia in a diver.\(^1\) A French case report described fluoroscopically guided percutaneous filling of a pneumatocyst of the ilium in a diver.\(^2\) The authors found only 1 report in the English literature describing a symptomatic pneumatocyst, again in a diver, although no treatment was described.\(^3\)

Although intraosseous pneumatocysts are uncommonly encountered, evidence suggests that they may be seen in up to 10% of CT scans obtained for other reasons. A study of 369 pelvic CT scans found intraosseous pneumatocysts in 38 (10.3%) patients. A review of 89 spinal CT scans found pneumatocysts in 8 (9.0%) patients.\(^4\,^6\) A recent review of this topic found that of 152 reported cases, the sacroiliac joint was most commonly involved (101; 66.4%), and the ilium rather than the sacrum was involved in the majority of cases (62 of 32), with 1 found bilaterally and 6 indeterminate cases.\(^4\) The increased incidence in the ilium may be explained by the comparably thicker cartilage of the sacrum.\(^7\)

The characteristic radiographic features of a pneumatocyst, as described by Monu et al,\(^6\) include: “localized collection of gas in the iliac bone, usually adjacent to the sacroiliac joint; thin sclerotic rim; no bony destruction; no soft tissue mass; and no other medullary abnormalities.” The findings on MRI are nonspecific, and CT scan is the study of choice for definitive diagnosis, with Hounsfield units of -580 to -950 showing a gas-containing lesion.\(^8\,^9\)

Pneumatocyst has several putative etiologies, including subchondral extension of intra-articular gas as a result of cortical erosion from trauma, congenital, or degenerative changes, and involvement of intraosseous ganglia or mucoid cysts.\(^4\,^8\,^9\) The differential diagnosis includes intraosseous lipomas, solitary bone cysts, osteonecrosis, osteomyelitis, neoplastic collapse, and posttraumatic and postoperative changes.\(^7\,^8\,^9\) The natural history of pneumatocysts is uncertain, with reports showing interval growth, involution, and stability of cyst size over time.\(^12\,^13\)

The unusual symptoms described by the authors’ patient, similar to those in previous reports, likely stem from his occupation as a diver who experienced significant pressure cycling on a regular basis. For each descent of 10 m (32.8 feet), the body experiences a pressure elevation of 1 atm. Boyle’s law states that pressure and volume are inversely proportional at a fixed temperature. Therefore, symptoms may occur with increased atmospheric pressure from underwater descent, creating a compression-vacuum phenomenon within the relatively unyielding, noncompliant osseous structure and causing internal mechanical stress and pain. Thus, as a diver ascends from an underwater dive and atmospheric pressure decreases, the gas contained in the pneumatocyst re-expands to its baseline volume and provides symptomatic relief.

**Conclusion**

Intraosseous pneumatocysts are benign lesions that are almost always treated nonoperatively. When symptomatic, both the current case and the few previously reported cases involved repetitive barotrauma as a result of diving.

This case describes a Navy diver who had pain in the distribution of his pneumatocyst lesion secondary to barotrauma that significantly affected his ability to perform his duties. Modern intraoperative navigation allowed percutaneous decompression and therapeutic injection of calcium sulfate-calcium phosphate composite graft material into the lesion, providing the patient with complete relief of symptoms and the ability to expeditiously return to his diving duties. However, intraoperative CT-guided navigation may not be familiar to all surgeons or available at all institutions. Therefore, multiplanar fluoroscopy localization may be a viable option, although the 3-dimensional morphologic features of the pelvis can make accurate localization difficult. An open approach and greater soft tissue dissection may be needed. Another option is CT-guided interventional radiology, but this may be precluded by the general anesthesia requirements for the use of large trochars to allow placement of bone void filler. In addition, prone-lateral positioning may be needed, depending on the location of the lesion.

**References**


