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Vacuum Disc Phenomenon Turned Gassy Disc Herniation: A Case Report

Esther Benedetti de Marrero, MD, Tho Chi Le, MD, Bradley Jones, MD, Andres Missair, MD, Edmond Benedetti, MD, and Alejandra Mayorga, MD

Background: The vacuum phenomenon is a radiologic finding that results from gas accumulation within degenerated discs, joints, or vertebrae. This gas can herniate, causing back pain and/or radiculopathy. Asymptomatic imaging abnormalities can be coincidental and/or non-concordant with clinical presentation therefore warranting close evaluation.

Case Report: This 45-year-old man, previously diagnosed with lumbar facet arthropathy, returned to the clinic for left-sided axial low back pain. Imaging revealed that a gas filled mass in the right lateral recess was affecting the traversing right L5 and S1 nerve roots. Given the exclusive axial symptoms consistent with lumbar zygapophyseal joint arthropathy, the patient was treated with a repeat L3-4 medial branch and L5 dorsal ramus radiofrequency ablation and experienced subsequent near-complete pain resolution.

Conclusions: Careful consideration must be taken when conducting clinical evaluation, imaging, diagnosis, and treatment of patients with low back pain given the significant frequency of abnormal, often nonconcordant, radiological findings.

Key words: Pneumorrhachis, vacuum disc phenomenon, low back pain, case report

BACKGROUND

This case study describes a patient who presented with solely axial left-sided low back pain despite imaging findings demonstrating well confined extruded gas within the patient's spinal canal, which appeared to affect the right L5 and S1 nerve roots. Based on these images, clinicians expected a radicular etiology and presentation for the patient's symptoms, which resulted in inappropriate management of the patient's spinal condition. However, after evaluating the patient's history and physical exam, clinicians observed that the purely axial complaints are concordant with a facet joint origin of the pain. The patient then received treatment for such and experienced sustained pain relief post-intervention. The vacuum disc phenomenon experienced by this patient is common and may present asymptomatically despite large-sized accumulations affecting neural structures. Given the significant frequency of radiological findings discordant with patients' symptom presentation, this case highlights the importance of carefully evaluating a patient's imaging results while simultaneously collecting their historical information and evaluating available clinical data.

CASE

A 45 year-old man presented to the pain clinic for a virtual follow-up regarding chronic low back pain secondary to lumbar spondylosis. He was last seen approximately 3 years prior when he underwent a bilateral L3, L4 medial branch, and L5 dorsal ramus radiofrequency ablation after which he experienced sustained pain relief. About 9 months after the proce-

From: [1]Bruce W. Carter Department of Veterans Affairs Medical Center, Miami VA Healthcare System, Miami, FL; [2]Eastern Virginia Medical School, Norfolk, VA

Corresponding Author: Edmond Benedetti, MD, E-mail: edmondbenedetti@gmail.com
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dure, the patient experienced a return of his low back pain with the added complaint of the pain radiating to the right lower extremity, without sensory or motor deficits. Repeat medial branch radiofrequency ablation was recommended and scheduled at that time. Unfortunately, the patient was lost to the lack of follow-up for the next 2 years due to the COVID-19 pandemic. Upon re-establishing care with the pain clinic, the patient complained of severe left-sided low back pain with radiation into the ipsilateral buttock. The patient denied further radiation or the presence of any right-sided symptoms. The patient experienced no sensory or motor deficits, and clinicians found no neurologic red flag signs upon physical examination.

A recent noncontrast lumbar magnetic resonance imaging (MRI) was available for review at the time of this visit. It demonstrated a posterior right paracentral T1/T2 hypointense signal abnormality, measuring approximately 1.6 x 1.7 x 1.1 cm (Cranial-Caudal x Transverse x Anterior-Posterior dimensions), associated with deformity of the right anterolateral aspect of the thecal sac. This signal abnormality affected the traversing right L5 and right S1 nerve roots (Figs. 1 and 2) and correlated with gas attenuation observed on a recent abdomen/pelvis computed tomography (CT) scan of the patient (Fig. 3). These findings, however, are not expected to produce right-sided radicular pain.

Nevertheless, given that the axial nature of the patient's symptomatology was consistent with lumbar zygapopheseal joint arthropathy, a left L3-4 medial branch and L5 dorsal ramus radiofrequency neurolysis was performed. The patient reported 90% pain relief for 4 months post-procedure with concurrent improvement in functional status, which allowed for increased mobility. Thus, the patient was able to discontinue using muscle relaxants and antineuralgics.

After this period of improvement, the patient returned to the clinic reporting right-sided low back pain similar in quality, intensity, exacerbating, and alleviating factors to that previously experienced on the left side prior to undergoing the left-sided rhizotomy. The patient continued to deny any symptoms in the lower extremities. Therefore, the patient underwent a right-sided L3-4 medial branch and L5 dorsal ramus radiofrequency ablation after which he experienced sustained and near-complete resolution of pain.

DISCUSSION

The lifetime prevalence of low back pain is approximately 80%, and it is second only to the common cold in those seeking medical attention. Painless radiological spine abnormalities are very frequent (1). Therefore, the radiological presence of disc pathology must be carefully considered in patients who present with low back pain and/or radiculopathy, as they could be merely coincidental.

Although degenerative spine disease has an overall prevalence of 27.3%, the fact that many spondylotic radiological findings are found in otherwise asymptomatic patients (2.7 times greater in those with radiological studies) suggests that the actual frequency of spine degeneration is much higher (2).

Vacuum disc phenomenon is common in adults, with a prevalence of up to 20% in the elderly population (3). This phenomenon was first described by Magnusson in 1937 followed by Knutson in 1942, and it is the result of the accumulation of gas, mainly nitrogen, within fissures of the nucleus pulposus or tears of the annulus fibrosis of degenerated intervertebral discs (4,5). Subsequent disc herniation content can then extravasate, traveling into the epidural and intradural spaces. Boyle and Henry's law of physics explain how dissolved nitrogen is brought to the gaseous state. An enclosed space that expands will increase the volume within that space and as the volume in that space increases, the pressure within it decreases.

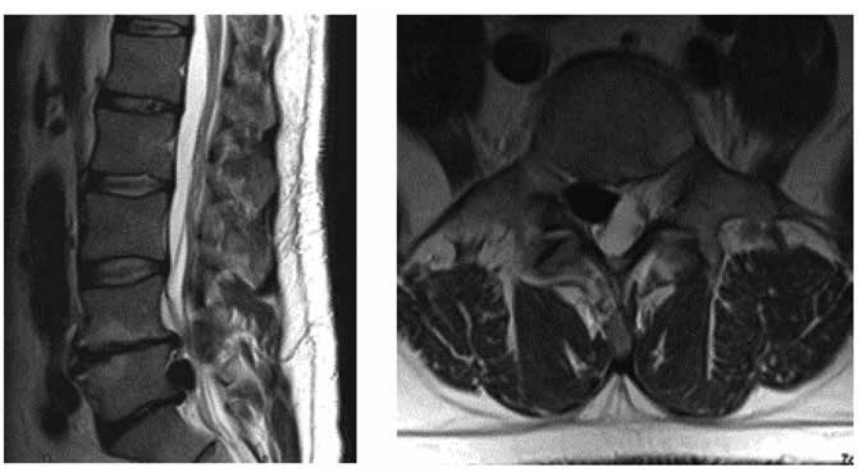

Fig. 1. Lumbar MRI of the T2 weighted image.

While the pressure decreases, as long as the temperature remains stable, the solubility of gas decreases as well. Reduced solubility allows gas to leave solution and expand into the larger space.

Osseous and articular structures can also present the vacuum phenomenon secondary to repeated microtrauma, which can cause erosive defects in the osseocartilaginous endplates (Schmorl nodes), facet joints and juxta facet cysts, and even independently within vertebral bodies (intravertebral vacuum clefts, pneumatocysts).

The intervertebral disc is largely avascular. Nutrients are supplied to the outer annulus by diffusion from the capillaries branching from peripheral sources. Meanwhile, the inner annulus and nucleus pulposus receive nutrients diffusing from the capillaries originating from segmental arteries which penetrate the subchondral end plates underlying the thin layer of hyaline cartilage via ‘marrow contact channels’ (6,7). These channels provide a path from the trabecular bone to the cartilaginous endplate. It has been proposed that small molecules, like oxygen and glucose, rely on diffusive transport, however larger molecules may require fluid flow for transport into and within the disc. The daily exchange of fluid to and from the disc represents 10-20% of the total disc volume (8).

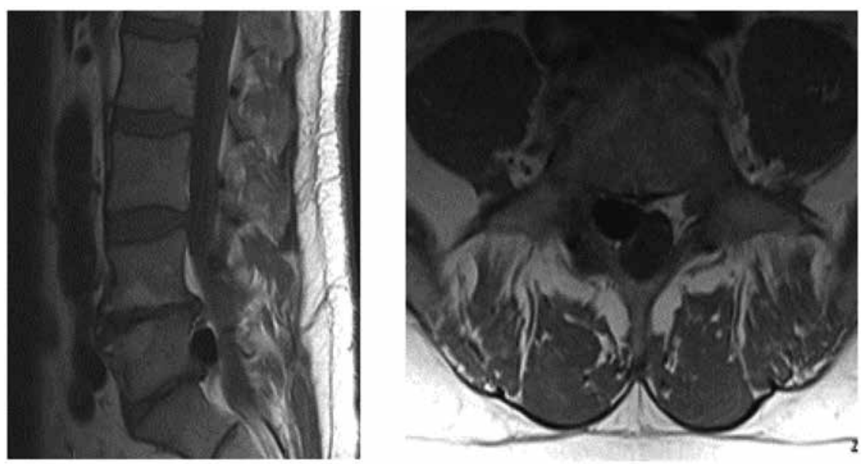

Fig. 2. Lumbar MRI of the T1 weighted image.

Recurrent trauma to the bone and cartilage coupled with a reduction in the perfusion of the vertebral endplate due to metabolic and atherosclerotic changes common with aging may contribute to the increased frequency of the accumulation of gas in vertebral structures in the elderly (9). Permeability changes in the cavity walls can ensue from the degeneration of the intervertebral disc and the concurrent erosion of the highly vascular vertebral endplate, which can ultimately result in gas accumulation. This gas is produced by distraction forces which decrease local pressures enough that nitrogen gas, which is normally found in steady-state solution within tissues, reaches a pressure point at which it leaves the solution and enters a gaseous phase.

The motion of the spine can generate enough force to create a pressure gradient that allows gas to travel from the original structure in which it was confined to an adjacent location (10). Thus, intradiscal gas can be contained within the intact peripheral annular fibers of a disc herniation, be collected within a capsule or pseudo-capsule (cyst) or be expelled into the spinal canal through a weak spot in the annulus fibrosus via a

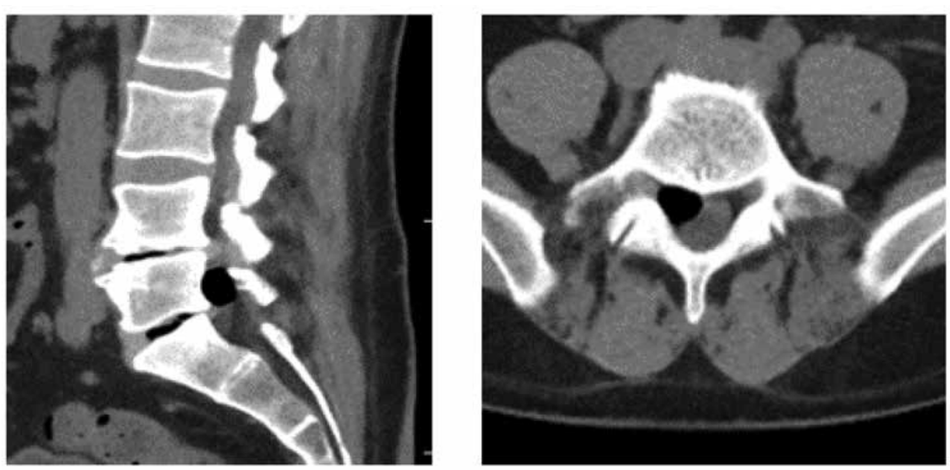

Fig. 3. CT of the abdomen/pelvis without contrast.

ball-valve effect (pneumorrhachis) (11). These confined masses of gas typically cause radicular pain symptoms equivalent to a traditional mass occupying lesions since it produces a comparable compression of the surrounding neural structures. The natural history of intraspinal gas is not well defined but the vanishing of such gas and subsequent symptom improvement has been well documented (12).

Imaging studies are necessary for the diagnosis of the vacuum phenomenon. Radiographs may show lucencies within the vertebral bodies, joints, intervertebral discs, or vicinity, however x-rays are neither sensitive nor specific enough for such diagnosis (13). CT scans are considered the gold standard for diagnosing the vacuum phenomenon since it can show gas attenuation. Gradient-Recalled-Echo MRI (GRE-MRI) is also highly sensitive in detecting the vacuum phenomenon but is not specific and cannot differentiate it from calcification. Therefore, the optimal imaging to determine the presence of gas within the spine is a CT scan.

CONCLUSION

Radiological evaluations do not necessarily correlate with clinical findings. Thus, spine imaging alone might be insufficient to make a correct diagnosis and improve clinical outcomes of patients lacking relevant history (cancer, infection, trauma) or with absent signs of a critical underlying condition. Therefore, careful consideration must be taken when treating patients with low back pain with or without radicular symptoms.

Author Contributions

EBdeM identified the clinical case for submission, obtained patient consent, wrote the initial draft manuscript, revised the draft manuscript, and approved the final submitted manuscript. TL and BJ contributed to writing the initial draft manuscript, revised the draft manuscript, and approved the final submitted manuscript. AM and AM revised the draft manuscript and approved the final submitted manuscript. EB formatted, revised, and approved the draft manuscript, and submitted the final manuscript.

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