Differential diagnoses for disc herniation

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Abstract

Disc herniation is a frequent pathology in the radiologist's daily practice. There are different pathologies that can imitate a herniated disc from the clinical, and especially the imaging point of view, that we should consider whenever we report a herniated disc. These lesions may originate from the vertebral body (osteophytes and metastases), the intervertebral disc (discal cyst), the intervertebral foramina (neurinomas), the interapophyseal joints (synovial cyst) and from the epidural space (hematoma and epidural abscess).
Keywords: Herniated disc, Spondylosis, osteophyte, bone metastasis, discal cyst, neurinoma, synovial cyst, epidural hematoma, epidural abscess.

Introduction

Disc herniation is one of the most frequent diagnoses in the radiological practice of spine pathology. However, we must consider in the differential diagnosis other pathologies that can imitate disc hernias, especially in some sequences or planes when reading an MRI. Herniated discs, are frequently in contact with the intervertebral disc, and are located in the extradural intrathecal space. Occasionally they may extend to the intervertebral foramen or even in an extraforaminal situation. They may have an ascending or descending component, located behind the vertebral body and occupying the central spinal canal or lateral recesses. On computed tomography imaging they are visualized as an extradural intrathecal mass, adjacent and isodense to the intervertebral disc which takes up the spinal canal or lateral recess, displacing the dural sac. In magnetic resonance imaging, their appearance is highly variable. They are often visualized as low-signal lesions in T2-weighted images compared with the intervertebral discs, but may be isointense or hyperintense with respect to the intervertebral disc which makes it difficult to see them in conventional MRI images. After administration of the contrast medium, they generally present peripheral enhancement, with a "fried egg" appearance. We should make the differential diagnosis of the herniated disc with other lesions that, although less frequent, can lead to a misdiagnosis. These lesions can originate in neighboring structures such as the vertebral body, intervertebral disc, intervertebral foramen, interapophysiary joint or epidural space. We will consider that the lesions that can originate from the vertebral body are osteophytes and metastases; from the intervertebral disc - the discal cyst; from the intervertebral foramina - the neurinomas; from the interaphysiary joints to the lateral recesses - the synovial cyst; and from the epidural space - the hematoma and the epidural abscess (Table 1).

Vertebral body

1. Osteophytes

Spondylosis is defined as a noninflammatory process that occurs primarily due to degeneration of the intervertebral disc. Disc degeneration and the development of spondylosis are part of the normal process of aging. The presence of osteophytes is very frequent, predominantly affecting adults, its incidence increases with age, being observed in up to 80% of 75-year-old patients[1].

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Table 1.
A. Vertebral body
Osteophites
Metastasis
B. Intervertebral disc
Discal cyst
C. Intervertebral foramen
Neurinoma
D. Interapohyisiary articulation
Synovial cyst
E. Epidural space
Epidural hematoma
Epidural abscess

These degenerative changes have the potential to decrease the amplitude of the spinal canal and eventually compress the neural elements, producing myelopathy or neuropathy[2].

Osteophytes that are directed posteriorly can compress the spinal cord or the emergence of the ventral nerve roots. As the osteophytes are directed towards the intervertebral foramina they can cause radicular compressions (Figure 1a, b).

Osteophytes are easily visible on simple radiographs, especially on lateral projection (Figure 2). The study of choice to visualize osteophytes at the level of the spine and its three-dimensional relation with the other structures is computed tomography that allows an adequate visualization of the amplitude of the central canal, lateral recesses and intervertebral foramen.

In magnetic resonance imaging the osteophytes appear with low signal intensity in all sequences (Figure 3). Often in magnetic resonance imaging, especially in those of the cervical spine, it is very difficult to differentiate the disc herniation from a prominent osteophyte, for which we must complement the study with computed tomography. This differentiation is fundamental at the time of surgery, since the resection of a soft structure like an intervertebral disc is totally different from a very dense structure like an osteophyte, especially at the level of an intervertebral foramen.

Whenever we visualize a herniated disc we must ask ourselves if there is an associated bone proliferation.

2. Metastasis

The spine is the most common bone site of secondary implant location[3], and the third location after the pulmonary and hepatic secondary implants. Secondary implants may be the first sign of neoplastic disease and may compromise any location in the spine such as the vertebral bodies, epidural space (Figure 4a, b), leptomeninges or less frequently in the spinal cord[4].

Neoplasms of the breast, prostate, thyroid, kidney and lung are primary tumors most commonly associated with bone metastases.

The study of choice is magnetic resonance, because of its multi-planar properties and different sequences.

Bone focal lesions frequently appear hypointense in T1-weighted sequences and hyperintense in T2-weighted sequences. Occasionally they may have a T2 hypointense border on the periphery of the lesion known as “halo signs”.

Sequences with fat saturation such as STIR are of great importance, because in TSE or FSE T2 images many of these lesions are indistinguishable from normal bone marrow.

Sclerotic lesions appear hypointense in T1, T2 and T2 gradient sequences. The bone marrow signal may be diffusely abnormal. The T1 images with fat saturation and paramagnetic contrast allow the ex-

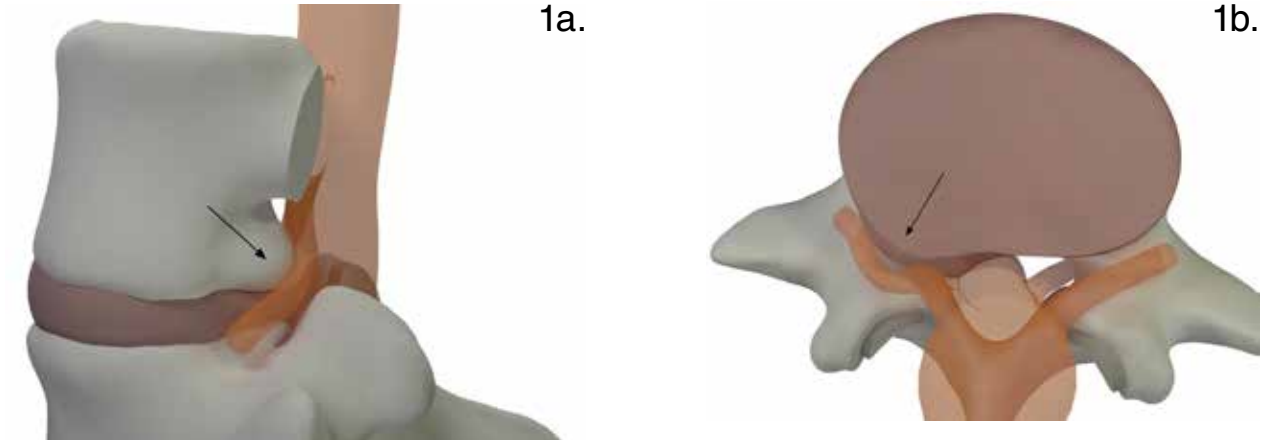

Figure 1. *Representation of a posterolateral osteophyte and right foraminal that together with a protrusion of the disc produces a displacement of the emergent root. The lateral view (1a) shows a posterior displacement of the root (arrow). In the top view (1b) there is a participating disc component (arrow).*

Figure 2. *Lateral radiograph of the cervical spine showing posterior osteophytes (arrow) that on MRI completely resemble a herniated disc.*

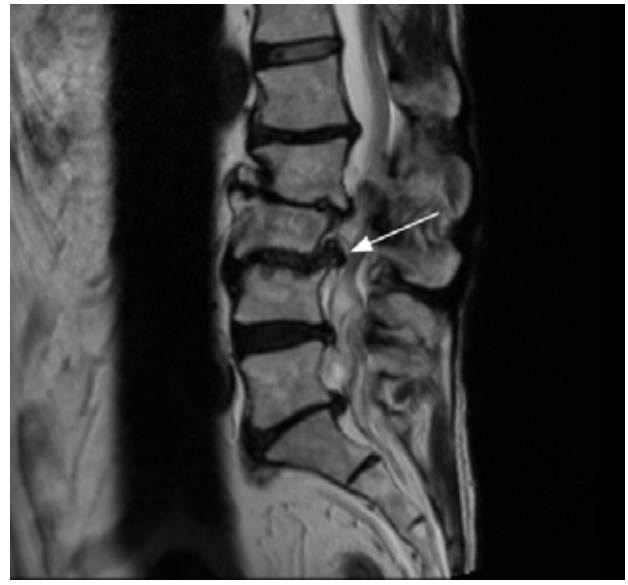

Figure 3. *Sagittal T2-weighted magnetic resonance image. Anterolisthesis of L3 is observed. An osteophyte and posterior disc material (arrow) that decrease the amplitude of the spinal canal.*

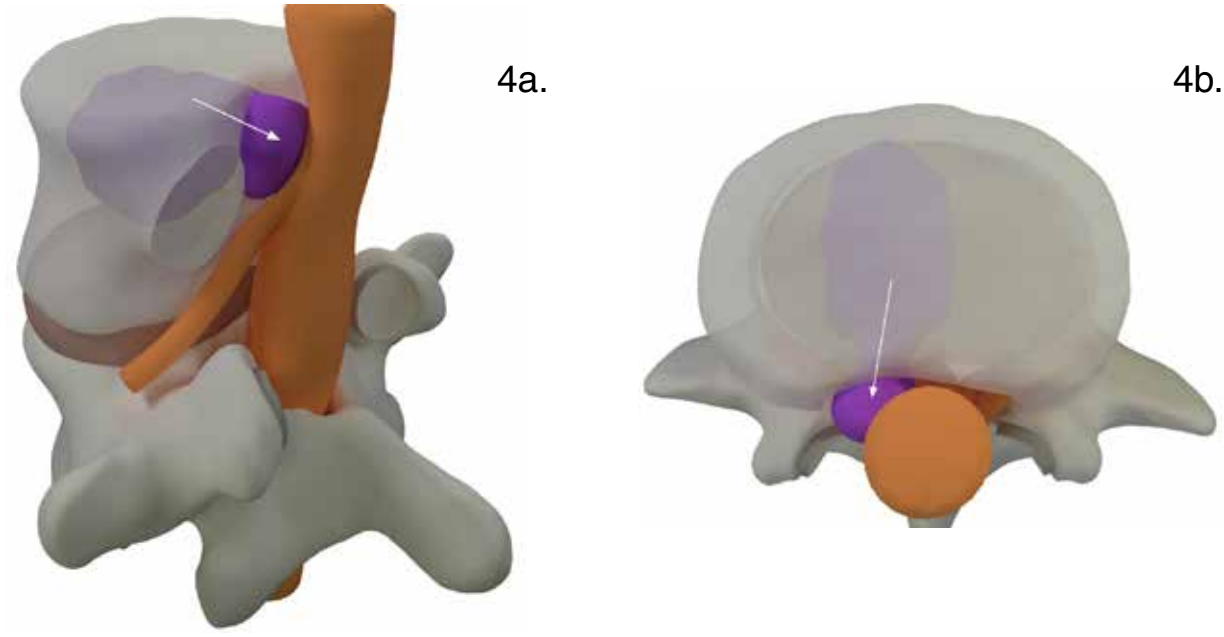

Figure 4. *Representation of a metastasis of the superior vertebral body that breaks through the posterior cortical of the vertebral body and extends to the anterior epidural space below the level of the disc (not shown). These lesions can easily imitate a herniated disc. In the left posterolateral view (4a), root compression is observed at the level of its origin (arrow). In the top view (4b) the tumor is visualized by transparency in the inside of the body and its anterior epidural extension (arrow).*

tension of the lesion and the compromise of adjacent structures such as the epidural space, intervertebral foramen and paraspinal region, to be defined.

The epidural space may be a primary site for neoplastic disease, but more frequently it corresponds to an extra-osseous extension of a metastasis of the vertebral body or posterior arch (Figure 5).

In the epidural space it can imitate a herniated disc and exert mass effect on the spinal cord and nerve roots. In the intervertebral foramen it can imitate a foraminal disc herniation (Figure 6).

From the epidural space the lesion can spread to the adjacent vertebral bodies via the venous route.

B. Intervertebral disc

3. Discal cyst

The discal cyst is a very rare lesion and causes lumbar and / or radicular pain. Its natural history and management is not well known[5].

In 1997, Toyama[6] used this term to describe an anterior epidural cystic image in relation to the intervertebral disc that is impregnated in its intravenous post gadolinium periphery.

Kono, in 1999[7], described a well-defined, homogeneous extradural intra-spinal cyst, localized ventrolaterally, with displacement of the dural sac and communication with the intervertebral disc (Figure 7 a, b).

The discal cyst was defined as an entity by Chiba in 2001[8]. He describes the clinical presentation, characteristics in the images and the histopathological findings of the discal cysts.

Magnetic resonance imaging shows a low-signal spherical lesion in T1-weighted images and high signal in T2-weighted images, consistent with a cystic lesion of fluid content, totally different from the content observed in patients with a herniated disc (Figures 8, 9). The degree of disc degeneration is generally mild, with minimal loss of the disc nucleus signal[9], consistent with the findings of the discography.

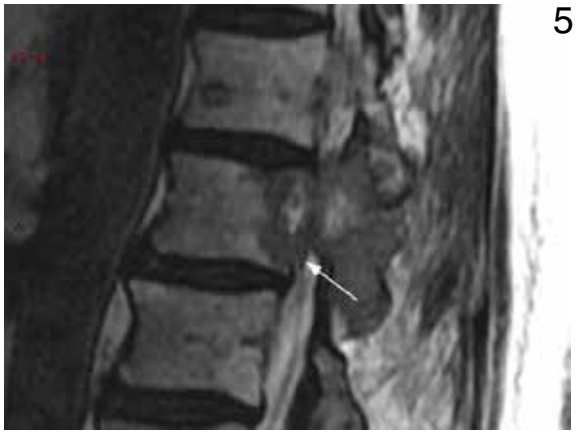

Figure 5. *Sagittal T2-weighted MRI showing a bone lesion of the posterior area of the vertebral body and anterior epidural extension (arrow) which is located behind the vertebral body, adjacent to the inferior intervertebral disc which can imitate a herniated disc.*

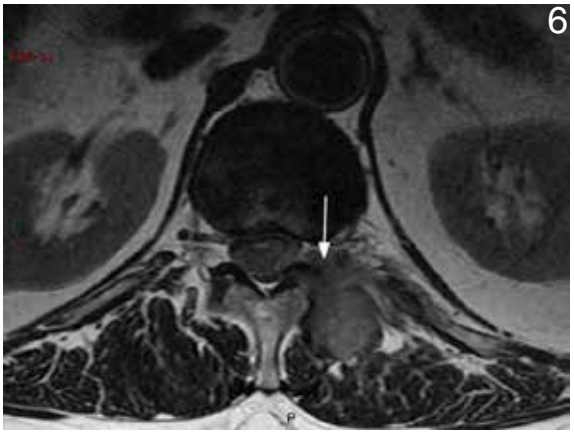

Figure 6. *T2-weighted transversal magnetic resonance image showing a mass in the left vertebral foramen (arrow) that comes from a bone mass of the pedicles and left articular laminas. Clinically they may completely appear like symptoms of a herniated disc.*

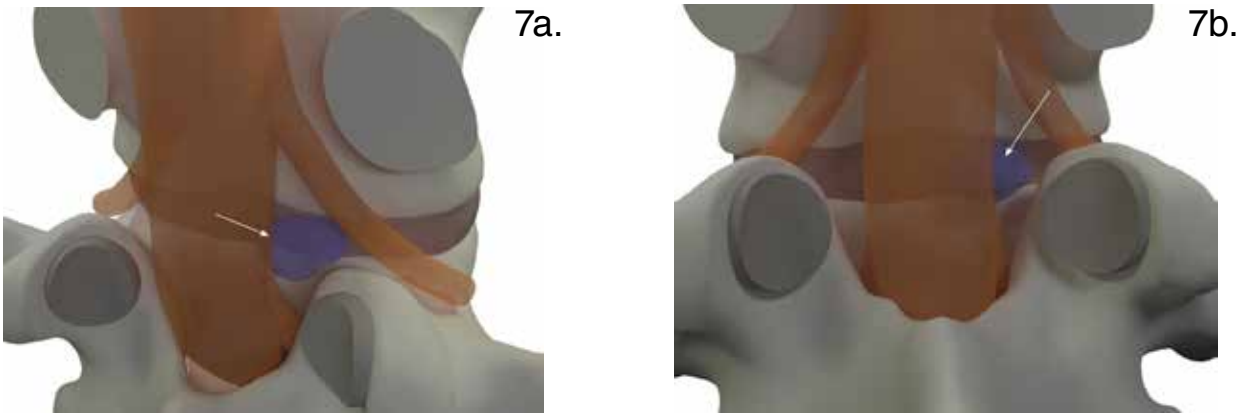

Figure 7. *Representation of a right posterolateral discal cyst, as a blue cystic lesion adjacent to the intervertebral disc that protrudes into the epidural space and deforms the dural sac and origin of the underlying right root. In the right posterolateral view (7a) it is observed that the cyst deforms the dural sac and the origin of the underlying root (arrow). In the posterior view (7b) it is observed that the cyst is at disc level (arrow).*

In 2006, Lee et al[10] gave details of the characteristics of the discal cyst: 1- Ventrolateral extradural cyst anchored to the lumbar disc. 2- Reinforcement ring with contrast in magnetic resonance and 3- Occasional extension in the lateral recess. Discography and CT discography demonstrate a channel between the cyst and the disc, differentiating this with a disc herniation or other intra-spinal cyst.

The pathogenesis of the discal cyst is unclear. The resorption of a preexisting disc herniation and a hematoma associated with disc prolapse is suggested.

Tokunaga et al[11] confirmed the presence of cartilaginous tissue in the cyst wall and it is thought that the discal cyst may have arisen from the resorption of a herniated disc. Chiba[8] proposes that the discal cyst arises from underlying damage of the intervertebral disc that causes a fissure of the fibrous ring in the posterior region of the intervertebral disc. Pathological studies show fibrous connective tissue with hemosiderin deposits on the walls of the cyst[5].

C. Intervertebral Foramen

4. Neurinoma

Neurinomas (Schwannomas) are commonly benign neoplastic lesions accounting for approximately one-third of all spinal primitive tumors[12]. The average age is found in the fourth decade of life and they are more frequent in the lumbosacral region[13]. Neurinomas in the lumbosacral foramen are also relatively uncommon. According to Western studies, the incidence of spinal neurinomas varies between 0.3 and 0.5/100,000 people per year, so in our country we could have approximately 70 cases per year. The most frequent neurinomas are the intradural, followed by the extradural and then the intra- and extradural at the same time. The tumors have a regular shape, oval (Figure 10 a, b) or in the form of an hourglass. They may have a thin capsule with cystic content[13]. The foraminous neurinomas may generally show a widening of the intervertebral foramen. Herniated discs may appear to be a neurinoma on CT and MRI, even with scalloping of the vertebral body[14].

Figure 8. *Sagittal T2-weighted MRI showing a small right posterolateral discal cyst(arrow), immediately above the intervertebral disc.*

Figure 9. *T2-weighted transversal image showing a small left posterolateral discal cyst (arrow) that is in contact with the dural sac.*

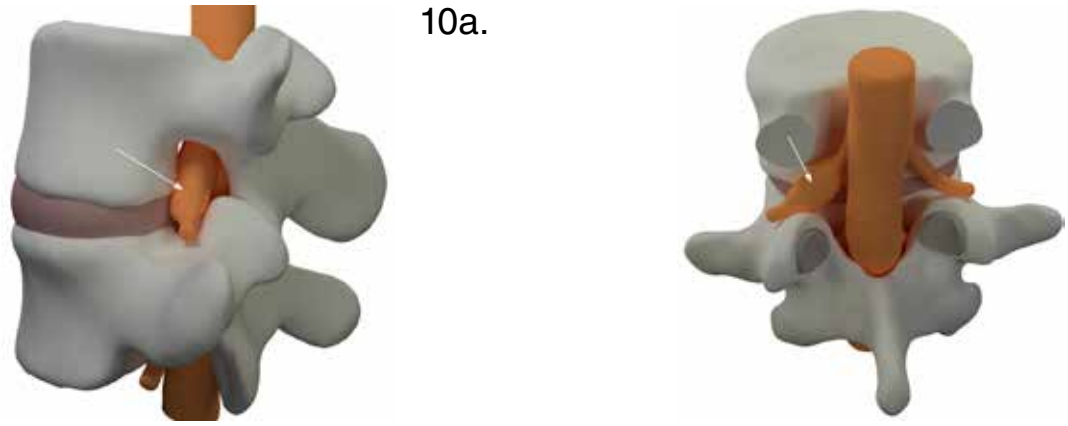

Figure 10. *Representation of a neurinoma of the emergent left root in the lower part of the foramen. This lesion may mimic a foraminal disc herniation. In the left lateral view (10a) it can be seen that the root dependent mass is in contact with the intervertebral disc (arrow). In the posterior view (10b) its root origin is clearly shown (arrow).*

The most common symptom is radiculopathy, with pain and paresthesia. Symptoms have been reported between 6 months and 15 years, with an average of 5.5 years[15]. From the clinical point of view, the absence of a specific symptom makes it impossible to differentiate this pathology from a herniated disc[15]. In computed tomography they are well-defined, rather homogeneous tumors with widening of the vertebral foramen. Computed tomography cannot always differentiate the neurinoma from a herniated disc[15]. Magnetic resonance imaging shows that the lesion has a high signal on T2 (Figure 11) and is homogeneously impregnated with gadolinium. MRI images on the sagittal and coronal planes are very useful for evaluating the relationship between tumor and disc, and the extent of the tumor in the intervertebral foramen (Figure 12)[15]. Occasionally, computed tomography and MRI of the herniated discs can mimic a tumor or cyst[16].

Treatment is surgical with symptomatic tumor resection.

D. Interapophysiary Articulation

5. Synovial cyst

Synovial cysts, juxtafacet cysts or ganglion cysts are relatively rare and correspond to a of synovial proliferation in the proximity of the interapophysiary joint (Figure 13a, b), which was first described by Baker in 1885[17].

Only after 1950 was it described that they could be the cause of radiculopathy[18].

Figure 11. *Sagittal T2-weighted magnetic resonance image showing a small, rounded, hyperintense, intraspinal mass, posterolateral to the vertebral body (arrow) corresponding to a neurinoma.*

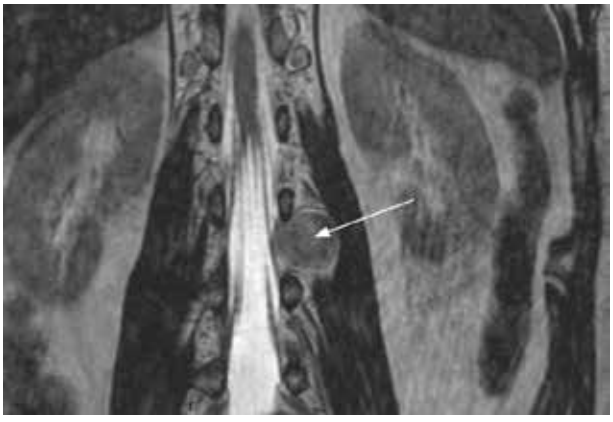

Figure 12. *Coronal T2-weighted image showing a posterolateral, foraminal and left extraforaminal mass (arrow) which occupies virtually all of the foramen and is in contact with the underlying root.*

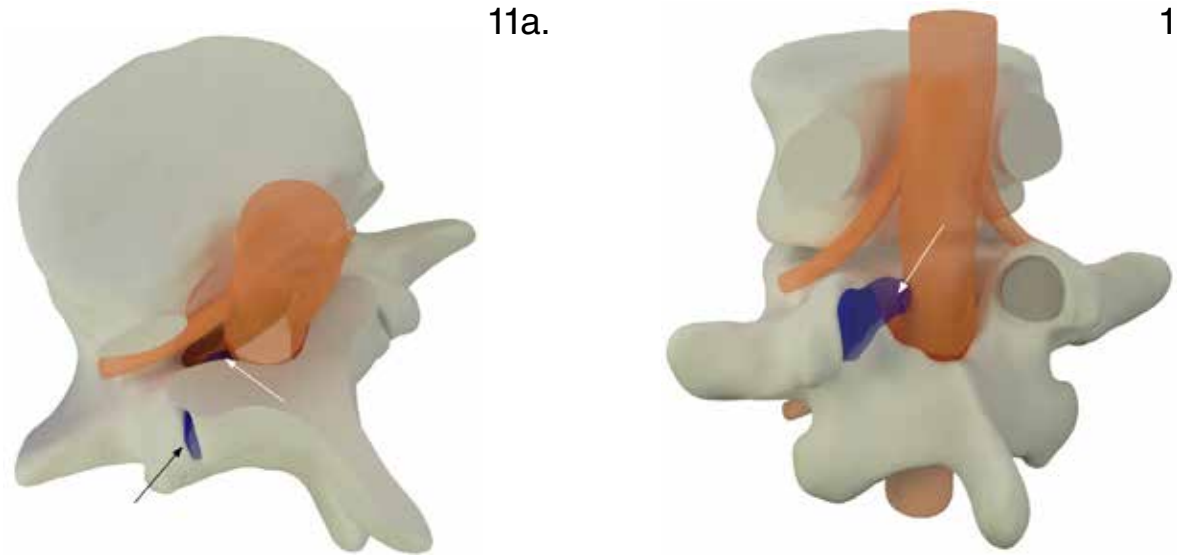

Figure 13. *Representation of a synovial cyst originating from the left interapophysiary joint and extending anteriorly in contact with the dural sac. In the posterior view (13a) it is observed that it originates from the interapophysiary joint (black arrow) and extends to the posterior epidural space (white arrow). In the left posterolateral view (13b) with no superior laminas, the cyst is seen extending anteriorly deforming the dural sac (arrow).*

Reports of synovial cysts have increased in international literature[19], possibly due to the advancement of imaging techniques.

Patients are frequently found in the sixth decade of life, with a slight predominance in women. They are rarely detected before the age of 30[20]. They may be asymptomatic and found incidentally. However, if they increase in size they can cause compression of the neural structures and secondary symptoms[21].

The most frequent symptoms are radicular pain and neurological deficit of a specific territory. It is believed that their incidence is less than 0.5% of patients with these symptoms.

The most frequent level corresponds to the level L4-L5, since it is the site with maximum mobility (Figure 14). Cysts can be uni or bilateral, and be found on more than one level.

Figure 14. *Sagittal T2-weighted magnetic resonance image showing a small anterior synovial cyst (arrow) adjacent to the interapophysiary joint L4-L5.*

It is assumed that the cysts originate and commonly can be found connected with the interapophysiary joint[22]. Cysts may extend from the interapophysiary joint anteriorly, to the spinal canal (Figure 15), or posteriorly, to the soft periarticular parts. The posterior cysts are three times more frequent than the anterior ones. Anterior cysts in 70% of cases are associated with radiculopathy[23].

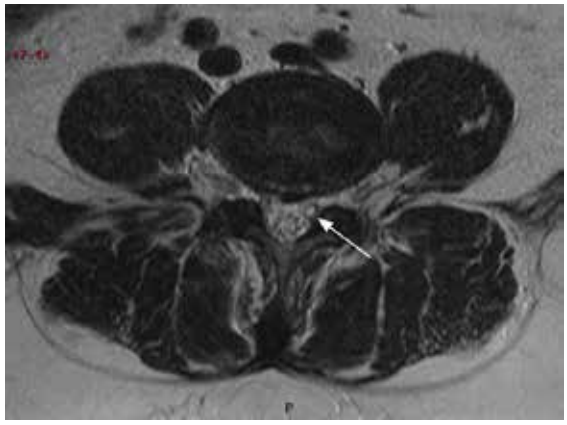

Figure 15. *T2-weighted transversal image showing a small anterior synovial cyst (arrow) occupying the left lateral recess and compressing the underlying root at the lateral recess level.*

Their etiology is still unclear; however, focal instability, spondyloarthrosis, and spondylolisthesis have a strong association with the formation of synovial cysts. It is also described that joint traumas may be related to the formation of cysts[22]. Although they have also been described in patients with rheumatoid arthritis and calcium pyrophosphate deposition disease[24]. Computed tomography, and especially magnetic resonance imaging, allow an adequate diagnosis of this type of lesions[25].

Magnetic resonance imaging is considered the technique of choice for diagnosis.

Cysts are frequently isointensive to the cerebrospinal fluid in T1 and T2-weighted images[26]. In some cases, they may have a high signal on T1-weighted images and low signal on T2-weighted images, due to the presence of a hemorrhagic or protein content[27]. In T2-weighted images, a hypointense border may be observed, which may correspond to calcification, fibrosis or hemosiderin[26]. The treatment can be percutaneous, with the injection of liquid, anesthetic or corticoid. In cases resistant to conservative therapy, surgical treatment may be considered for radicular decompression. However, there may be relapse of synovial cysts, even after surgical treatment.

E. Epidural space

6. Epidural hematoma

Spinal epidural hematoma is a relatively infrequent extradural intrathecal hematoma (Figure 16a, b) that was described in 1869 by Jackson[28].

The causes are multiple, and its etiology can be established in approximately 70% of the cases[29].

Factors favoring the formation of epidural hematomas, such as coagulopathies, trauma, lumbar puncture and pregnancy have been recognized.

The average age is approximately 50 years, but they can occur at any age, and are more frequent in men[29].

The most frequent sites of epidural hematomas corresponded to C6 (31%) and D12 (22%), with a maximum extension of 6 vertebral bodies[29].

At the time of diagnosis, the patients had a moderate neurological disorder and only in some cases of lumbar epidural hematomas were the patients asymptomatic.

The technique of choice is spinal magnetic resonance imaging (MRI), especially the T1 and T2-weighted images that allow to show the presence of an extradural intrathecal collection, especially behind the vertebral bodies (Figures 17, 18).

In the cases of vertebral trauma, the presence of

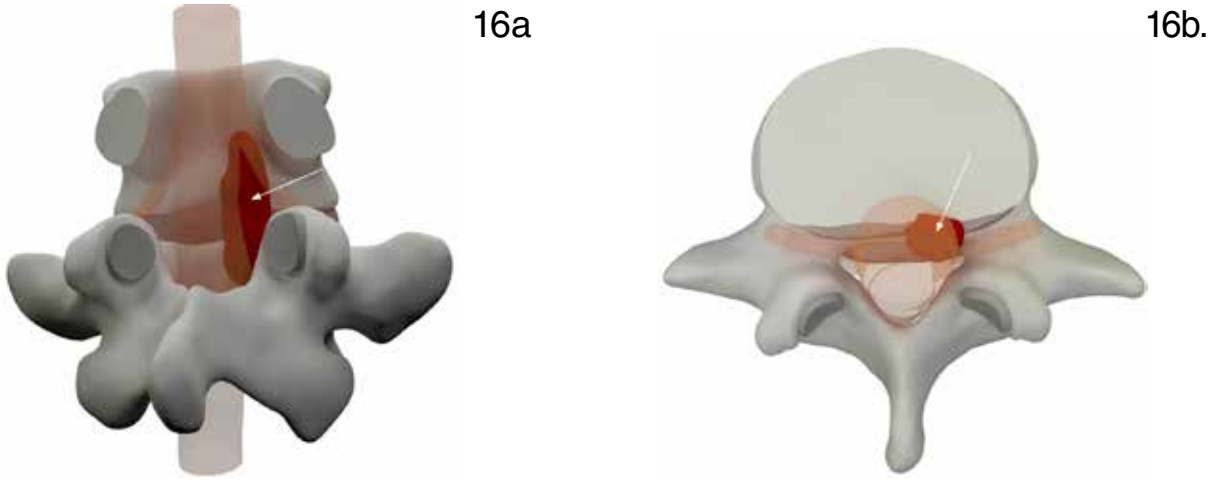

Figure 16. *Representation of an anterior epidural hematoma, lateralized to the right. In the posterior view (16a) it is observed that the hematoma extends beyond the intervertebral disc (arrow), reaching the level of the upper and lower body. In the top view (16b) it deforms the dural sac and the root at the level of its origin (arrow) through its location.*

Figure 17. *Sagittal T1-weighted image showing an anterior, slightly hyperintense epidural collection located behind the vertebral bodies L3, L4 and L5 (arrow).*

Figure 18. *Sagittal T2-weighted image showing the same epidural collection as Figure 17. The hematoma is more difficult to visualize because of its high signal. It is closely connected to the intervertebral disc (arrow).*

an epidural hematoma should be ruled out, which can be very difficult to diagnose[30].

The treatment of choice for epidural hematoma is surgery, and its results are influenced by the clinical and neurological characteristics of the patient; and general status at admission, age and cranio-caudal extention.

7. Epidural abscess.

The epidural abscess is an extradural intrathecal collection that can clinically imitate the pain produced by a herniated disc in some cases (Figure 19a, b).

It was described more than 250 years ago by Giovanni Morgagni. It is uncommon, an incidence is estimated between 0.2-1.2 to 2.5-5 cases per 100,000 hospital admissions[31].

More frequent in men between 50 and 70 years, but it affects all age groups[32].

Risk factors include diabetes mellitus, HIV, spinal trauma or recent spinal surgery, skin or urinary tract infection, etc[33]. Staphylococcus aureus is the most frequently identified pathogen present in 70-90% of cases.

It presents with lumbago, 50% with fever, radiculopathy and sphincteric compromise[34].

Magnetic resonance imaging is the technique of choice in a patient with lumbago with risk factors and eventual fever. On T1-weighted images the disc and adjacent vertebral body are observed with low signal, with loss of the continuity of their margins. On the T2-weighted images, there is a greater signal from the body (Figure 20) and from the compromised disk[35]. It is advisable to use gadolinium (Figure 21), provided it is not contraindicated[36].

Two patterns of gadolinium (Gd) uptake on MRI[37] are described

1. Phlegmon stage: homogenous reinforcement pattern with the use of Gd.
2. Liquid abscess stage: liquid pus, surrounded by inflammatory changes, which are impregnated post Gd.

Discussion

The herniated disc is a frequent diagnosis in radiological practice, however, we must consider these and other imaging diagnoses that can imitate a herniated disc.

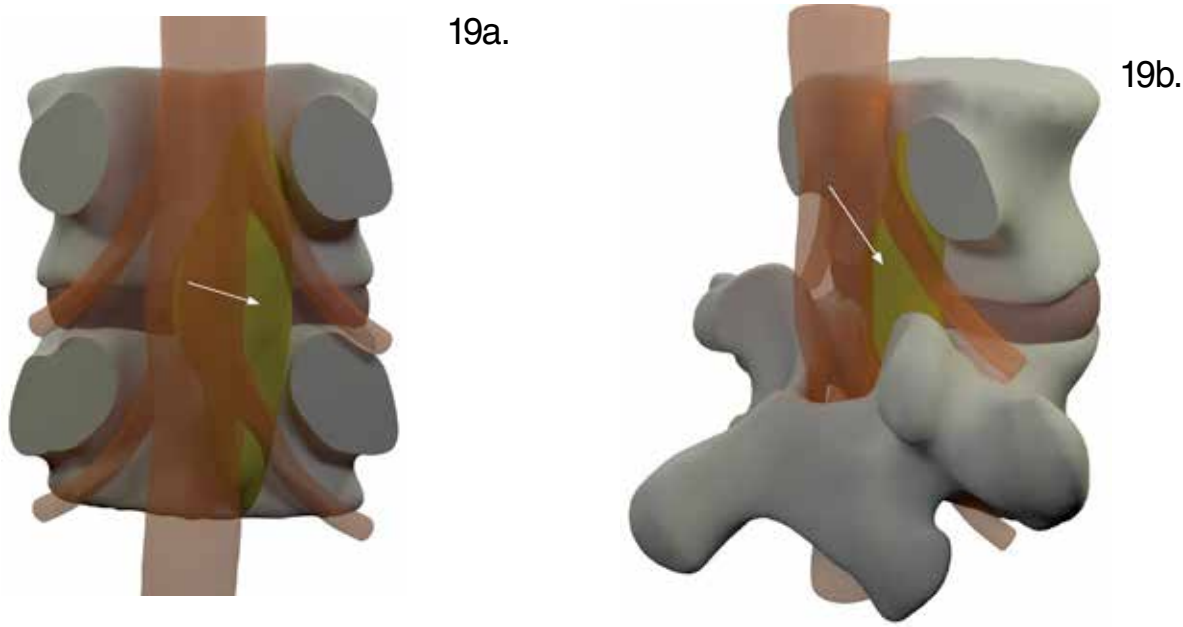

Figure 19. *Representation of an anterior central and right lateral epidural abscess. In the posterior view (19a) it is seen extending behind the vertebral bodies and intervertebral disc (arrow). In the right posterolateral view (19b) it shows that it deforms the dural sac and origin of the roots (arrow).*

Figure 20. *Sagittal T2-weighted image showing stenosis of the spinal canal without clear separation from the anatomic planes. A collection is seen behind the vertebral body (arrow), adjacent to the disc which corresponds to an epidural abscess.*

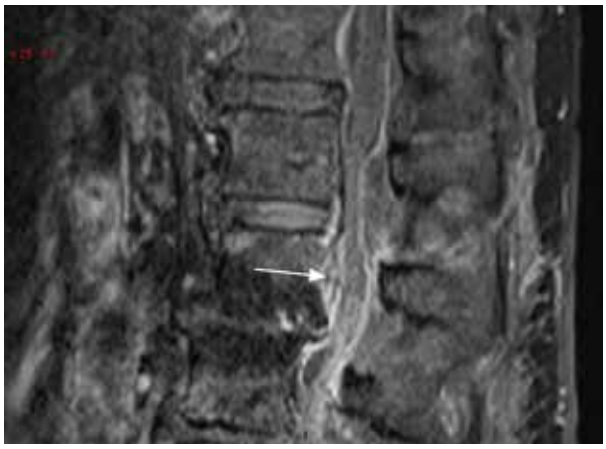

Figure 21. *Sagittal T1-weighted image with post-contrast fat saturation. An ill-defined collection (arrow) with heterogeneous uptake behind the vertebral body and posteriorly displacing the dural sac, can be observed.*

Bibliography

1. Garfin SR. Cervical degenerative disorders: Etiology, presentation, and Imaging studies. Instr Course Lect 2000; 49: 335-338.
2. Clark CR, Benzel EC, Currier BL, et al. The Cervical Spine, 4th ed. The Cervical Spine Research Society Editorial Committee. Philadelphia, PA: Lippincott Williams and Wilkins 2005.
3. Klimo P Jr, Schmidt MH. Surgical management of spinal metastases. Oncologist 2004; 9: 188-196.
4. Shah LM, Salzman KL. Imaging of Spinal Metastatic Disease. Int J Surg Oncol 2011; 769-753.
5. Hwang J, Park I, Kang DH, Jung JM, Discal Cyst of the Lumbar Spine. J Korean Neurosurg Soc 2008; 44: 262-264.
6. Toyama Y, Kamata N, Matsumoto M, et al. Pathogenesis and diagnostic title of intraspinal cyst communicating with intervertebral disk in the lumbar spine. Rinsho Seikei Geka 1997; 32: 393-400.
7. Kono K, Nakamura H, Inoue Y, Okamura T, Shakudo M, Yamada R. Intraspinal extradural cysts communicating with adjacent herniated disks: imaging characteristics and possible pathogenesis. AJNR Am J Neuroradiol 1999; 20: 1373-1377.
8. Chiba K, Toyama Y, Matsumoto M, Maruiwa H, Watanabe M, Nishizawa T. Intraspinal cyst Communicating with the Intervertebral disc in the lumbar spine: Discal Cyst. SPINE 2001; 26(19): 2112-2118.
9. Gibson MJ, Buckley J, Mawhinney R, et al. Magnetic resonance imaging and discography in the diagnosis of disc degeneration. J Bone Joint Surg 1986; 68B: 369-373.
10. Lee HK, Lee DH, Choi CG, Kim SJ, Suh DC, Kahng SK, et al: Discal cyst of the lumbar spine: MR imaging features. Clinical Imaging 2006; 30: 326-330.
11. Tokunaga M, Aizawa T, Hyodo H, Sasaki H, Tanaka Y, Sato T: Lumbar discal cyst followed by intervertebral disc herniation: MRI findings of two cases. J Orthop Sci 2006; 11: 81-84.
12. Klekamp J, Samii M. Introduction of a score system for the clinical evaluation of patients with spinal processes. Acta Neurochir (Wien) 1993; 123: 221-223.
13. Conti P, Pansini G, Mouchaty H, Capuano C, Conti R. Spinal neurinomas: retrospective analysis and long-term outcome of 179 consecutively operated cases and review of the literature. Surg Neurol 2004; 61(1): 34-43.
14. Emamian S, Skriver E, Henriksen L, Cortsen M. Lumbar herniated disk mimicking neurinoma. Acta Radiologica 1993; 34(2): 127-129.
15. Kato T, George B, Mourier KL, Lot G, Gelbert F, Mikol J.Intraforaminal neurinoma in the lumbosacral region. Neurol Med Chir (Tokyo) 1993 Feb; 33(2): 86-91.
16. Saruhashi Y, Omura K, Miyamoto K, Katsuura A, Hukuda S. A migrated lumbar herniation simulating a dumbbell tumor. Journal of spinal disorders 1999; 12(4): 307-309.
17. Baker WM. Formation of synovial cysts in connection with joints. St. Bartholomews Hospital Reports 1885; 21: 177-190.
18. Kao CC. Lumbar intraspinal extradural ganglion cyst. J Neurosurg 1968; 29(2): 168-172.
19. Boviatsis EJ, Stavrinou LC, Kouyialis AT, Gavra MM,

Stavrinou PC, Themistokleous M, et al. Spinal synovial cysts: pathogenesis, diagnosis and surgical treatment in a series of seven cases and literature review. Eur Spine J 2008 Jun; 17(6): 831-837.
20. Khalatbai K, Ansari H. MRI of degenerative cysts of the lumbar spine. Clinical Radiology 2008; 63: 322e-328.
21. Kouyialis AT, Boviatsis EJ, Korfias S et al. Lumbar synovial cyst as a cause of low back pain and acute radiculopathy: A case report. South Med J 2005; 98: 223-225.
22. Resnick D. Degenerative diseases of the spine. In: Resnick D, editor. Bone and joint imaging. 2nd ed. Philadelphia: W.B. Saunders Company; 1996. p.355e77.
23. Doyle A, Merrilees M. Synovial Cysts of the Lumbar Facet Joints in a Symptomatic Population.Spine (Phila Pa 1976) 2004; 29(8): 874-878.
24. Wybier M. Imaging of lumbar degenerative changes involving structures other than disk space. Radiol Clin North Am 2001; 39: 101e14.
25. Trummer M, Flaschka G, Tillich M et al. Diagnosis and surgical management of intraspinal synovial cysts: report of 19 cases. J Neurol Neurosurg Psychiatry 2001 70: 74-77.
26. Liu SS, Williams KD, Drayer BP, et al. Synovial cysts of the lumbosacral spine: diagnosis by MR imaging. AJNR Am J Neuroradiol 1989; 10: 1239e42.
27. Mahallati H, Wallace CJ, Hunter KM, et al. MR imaging of a hemorrhagic and granulomatous cyst of the ligamentum flavum with pathologic correlation. AJNR Am J Neuroradiol 1999; 20: 1166e8.
28. Jackson R: Case of spinal apoplexy. Lancet 1869, 2: 5-6.
29. Domenicucci M, Mancarella C, Santoro G, Dugoni DE, Ramieri A, Arezzo MF,et al. Spinal epidural hematomas: personal experience and literature review of more than 1000 cases. J Neurosurg Spine 2017 Jun 2: 1-11.
30. van Aalst J, Rijkers K, Postma AA.Teaching NeuroImages: Posttraumatic lumbar epidural hematoma. Neurology 2015 6; 84(1): e7-8.
31. Sendi P, Bregenzer T, Zimmerli W. Spinal epidural abscess in clinical practice. Quarterly Journal of Medicine 2008; 101(1): 1-12.
32. Reihsaus e, Waldbaur H, Seeling W. Spinal epidural abscess: a meta-analysis of 915 patients. Neurosurgical Review 2000; 23(4): 175-204.
33. Darouiche RO. Spinal epidural abscess. New England Journal of Medicine 2006; 355(19): 2012-2020.
34. Adogwa O, Karikari IO, Carretal KR. Spontaneousspinal epidural abscess in patients 50 years of age and older: a 15-year institutional perspective and review of the literature. Journal of Neurosurgery: Spine 2014; 20(3): 344-349.
35. Pradilla G, Ardila GP, Hsu W, Rigamonti D. Epidural abscesses of the CNS. Lancet Neurol 2009; 8: 292-300.
36. Sandhu FS, Dillon WP. Spinal epidural abscess: evaluation with contrast-enhanced MR imaging. AJNR Am J Neuroradiol 1991; 12: 1087-1093.
37. Numaguchi Y, Rigamonti D, Rothman MI, Sato S, Mihara F, Sadato N. Spinal epidural abscess: evaluation with gadolinium-enhanced MR imaging. Radiographics 1993; 13: 545-559, discussion 559-560.