Non degenerative cervical radiculopathy: a pictural review

Poster No.: C-1807
Congress: ECR 2013
Type: Educational Exhibit
Authors: H. Derbel¹, H. Fourati¹, W. Feki¹, K. Cherミ¹, M. Bradai¹, Y. Hentati², E. Daoud¹, Z. Mnif¹; ¹Sfax/TN, ²TN
Keywords: Metastases, Infection, Haematologic diseases, Diagnostic procedure, MR, CT, Conventional radiography, Trauma, Oncology, Musculoskeletal spine
DOI: 10.1594/ecr2013/C-1807

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Learning objectives

The cervical radiculopathy is a quite common disease in clinical practice. It is dominated by degenerative causes like disc herniation, posterior facet joints arthritis, and unco-vertebral osteophytes. This frequency should never ignore the presence of other etiologies certainly rarer but more serious. These etiologies are represented mainly by tumor pathology, infectious, inflammatory and less frequently trauma and malformation.

In this educational exhibit and through a 37 patient’s series, we propose to:

1. Illustrate the spectrum of etiologies of non-degenerative cervical radiculopathy.
2. Outline theirs different radiological aspects.
3. Establish adequate diagnostic approach in front of such clinical situations.
Background

Background:

PATHOGENESIS

Cervical radiculopathy results from foraminal encroachment on the spinal nerves secondary usually to degenerative changes of the spine. In contrast to disorders of the lumbar spine, herniation of the nucleus pulposus is responsible for only 20% to 25% of cases. However, it is distinctly uncommon for cervical radiculopathy to be the initial manifestation of many pathologic processes dominated by tumoral, infectious, inflammatory diseases and cervical trauma. The onset of radicular pain may be caused by irritation, involvement or compression of the dural sack or nerve roots, from either tumor mass, edema, or bony collapse.

CLINICAL FEATURES

The information gathered through the patient history, physical examination, and plain radiographic images helps to discriminate those potential patients with one of these rarer causes from those patients with more common spondylotic pain symptoms.

Symptomatic cervical radiculopathy is characterized by certain clinical and biological features:

- Patients who are younger than 20 or older than 50
- Patients with neoplastic, infectious or trauma history
- Patient’s immunocompromised state
- Inflammatory pain: Pain with no clear association with activity, night pain, progressive pain despite treatment
- Signs of infection
- Perturbation of biological tests (sedimentation rate acceleration, elevated leukocyte count, elevated C-reactive protein, elevated tumors markers...)

DIAGNOSTIC APPROACH AND IMAGING PROTOCOLS: (Fig 1)
Conventional high-quality, plain-film radiography is still the first imaging modality to consider in patients with suspected rare causes of back and radicular pain. Standard anteroposterior and lateral radiographs provide the most information, although oblique views of the spine can better visualize facet joints and the pars interarticularis.

Cross-sectional imaging is indicated even if the plain radiographs are normal. In suspected cases of malignancy or infection, an injection of iodinated contrast (CT scan) or gadolinium (MRI) is required. The administration of gadolinium-based contrast material results in enhancement proportional to soft-tissue vascularity and is helpful for differentiating cystic lesions from cystlike solid masses. It is also useful for biopsy in that it allows differentiation of enhanced viable tumor from areas of non-enhanced necrosis. In addition, gadolinium-based contrast material is frequently used to better demonstrate epidural extension. Contrast material enhancement is best evaluated on fat-saturated T1-weighted MR images.

In the case of whiplash with suspected fracture or severe sprain, a volume rendering reformatted on CT scan is recommended.

**ETIOLOGIES**

1- **Tumors:**

It is true that primary spine tumors generally involve one vertebra, whereas metastatic lesions, myeloma, and tuberculosis involve many.

1- **Spine metastasis:** *(Fig 2)*

The location of a lesion seen on plain-film radiography gives clues regarding differential diagnoses. Metastatic disease and primary malignant spine tumors have a predilection for the vertebral body and pedicles (anterior elements) versus benign tumors, which more commonly affect the posterior elements. This predilection for malignancy to involve the anterior elements reflects the rich vascular red marrow supply to these areas. Osteolytic lesions are associated most often with lung cancer and less commonly with breast cancer. Sclerotic lesions, most commonly seen in prostate cancer, also are seen in breast cancer, gastrointestinal cancer, and lymphoma. Multiple myeloma lesions are typically quite osteolytic and therefore not identified by bone scanning because of the lack of osteoblastic activity.

Usually, a lytic mass will replace normal spongiform bone tissue such as trabeculae; the resultant lesion (which may be very small, with low visibility) can be seen with better delineation on CT than on plain films. Sometimes, necrosis and, more rarely, calcifications can be seen as well as cortical or pedicular destruction, epidural
involvement or a paravertebral mass. Following intravenous contrast-media injection, CT can demonstrate soft-tissue masses in two-thirds of cases.

2- **Lymphoma, myeloma:**

a- Lymphoma: *(Fig 3)*

Spinal involvement in lymphomas results much more frequently from late metastatic dissemination of Hodgkin disease and non-Hodgkin lymphoma. Spinal involvement may manifest as paraspinal, vertebral, and epidural involvement, either in isolation or in combination. Vertebral involvement results more frequently from hematogenous spread than from osseous invasion from adjacent lymph nodes.

Vertebral lesions may have a sclerotic, lytic, or mixed appearance. The sclerotic (ivory vertebra) and mixed patterns are more common in Hodgkin disease.

On MRI, spinal lymphoma commonly appears as a T1 and T2 low-signal-intensity lesion spreading over multiple levels with possible extension into the epidural and prevertebral spaces, but without extension through the intervertebral disk. Contrast-enhanced fat-saturated T1-weighted MR image shows heterogeneous enhancement of the lesion.

b- Myeloma: *(Fig 4)*

Predominant radiographic abnormalities include diffuse osteolysis and may resemble osteoporosis. Absence of reactive sclerosis surrounding lytic lesions is typical and therefore invisible to bone scanning. Multiple myeloma typically affects the vertebral body, sparing the posterior elements. Paraspinous and extradural extension may occur as well.

Marrow disease in the presence of multiple myeloma is identifiable at MR imaging as areas of heterogeneous decreased fat and increased signal intensity within the marrow on T1-weighted images. STIR and T2-weighted imaging are the most sensitive sequences for depicting these changes. When contrast-enhanced imaging is performed, untreated lesions demonstrate diffuse contrast enhancement.

3- **Intra spinal ductal tumors:**

a- Spinal cord tumors: *(Fig 5 and 6)*

Tumors arising from the spinal cord or directly surrounding tissues are rare.

The most commonly encountered spinal cord tumors are with decreasing frequency: astrocytoma (50%), ependymoma (10%), hemangioblastoma (10%), other tumors are
extremely rare (lymphoma, metastasis, lipoma, dermoid, teratoma and cavernous angioma)

Radiologic imaging of the intramedullary tumors may demonstrate widening of the interpediculate distance secondary to spinal canal expansion, with occasional erosion and thinning of the pedicles. The lateral projection is often normal. CT myelography may demonstrate cord expansion with block of contrast flow. MRI is the imaging modality of choice; however, edema in the spinal cord can make lesion borders difficult to delineate. MRI reveals a fusiform enlargement of the spinal cord, which is iso intense to hypo intense on T1-weighted images and hyper intense on T2-weighted images; there is uncharacteristic enhancement after the injection of gadolinium.

b- Intradural extra medullary tumors: (Fig 7 and 8)

Intradural extra medullary tumors arise outside the spinal cord but within the dura. The two most frequent are meningioma (50%) and schwannoma or neurofibroma (35%). The others etiologies are rarer (sarcoma, dermoid, epidermoid, angioma, lymphoma and metastasis). Meningioma and neurofibroma/schwannoma are benign, slow-growing tumors.

MRI is the imaging modality of choice for revealing well-circumscribed lesions, which are isointense or mildly hypointense on T1-weighted images and variably hyperintense, or rarely, hypointense on T2-weighted images. After Gadolinium injection, the enhancement is usually intense and homogeneous for meningioma, less intense in case of neurofibroma/schwannoma.

4- Other primitive spine tumors:

a- Malignant tumors:
Ewing sarcoma, solitary plasmocytoma, osteogenic sarcoma, chordoma…

b- Benign tumors:
Hemangioma, osteochondroma, osteoblastoma, giant cell tumor....

5- Pancoast Tobias syndrome: (Fig 9)

Quite commonly, Pancoast Tobias syndrome is caused by non-small cell carcinomas that originate in the lung apex or superior sulcus. Its manifestations may include pain in the shoulder girdle and arm, as well as Horner syndrome, which is characterized by
ipsilateral anhidrosis of the face, miosis, and ptosis with narrowing of the palpebral fissure secondary to paralysis of the Müller muscle.

On plain radiographies, superior sulcus tumors are difficult to detect because of their location in the lung apices. The tumor often appears as a subtle soft-tissue mass that may be confused with benign apical pleural thickening. The presence of associated rib or vertebral body destruction may be difficult to ascertain on the basis of radiographs.

CT is the best modality for depicting bone abnormalities adjacent to the primary mass, such as rib and vertebral body erosion, information that may influence the surgical approach taken and the extent of the resection. MR imaging is superior to CT in depicting tumor invasion of the chest wall, extension into the neurovertebral foramina and spinal canal, and involvement of the brachial plexus.

II- Infectious disease: spondylodiscitis: (Fig 10 and 11)

Infectious spondylodiscitis is an infection of the intervertebral disc and the adjacent vertebral bodies due to the introduction of a pyogen or a specific germ (Koch bacillus, brucellosis), usually by the haematogenous route.

The radiologic appearance of spine infection differs from that of tumors, even though they can be relatively indistinguishable. Involvement of the intervertebral disc and adjacent vertebral body end plates suggests an infectious cause, whereas tumors tend to preserve the disc and end plates.

Abnormalities on computed tomography are visible from the first 2 weeks of infection in half of all patients. An assessment of signs will look for early disc involvement that manifests as reduced bone density. Areas of osteolysis, bone erosion, or vertebral endplate geodes can be easily identified. CT scanning also allows the clinician to make a much more precise assessment of the extent of bone destruction (especially in the posterior vertebral arch), as well as being able to detect involvement of the vertebral canal, which is not visible on standard radiography.

MRI is the examination of choice, as it detects edema within the trabecular bone very early, before the onset of destruction. It appears as a trabecular bone high signal intensity on T2-weighted images, low signal intensity on T1 as well as thickening of the paravertebral soft tissue and/or involvement within the vertebral canals. The intervertebral disc is still involved instead of tumor etiologies in which it is spared. It is
characterized by a loss of disc height producing high signal intensity on T2 and low signal intensity on T1.

Injection of a contrast medium with fat signal saturation improves detection and visualization of the spread of infection in the soft tissue and epidural space. Contrast uptake is homogenous where there is phlegmon, while peripheral and ring-enhancement is seen in abscesses, as only the capsule takes up gadolinium.

Other signs can be seen in the vertebral body: cortical bone loss in the vertebral endplates, which is a characteristic finding and is better visualized on T1-weighted sequences, or involvement of the posterior arch, which is more common in tuberculous spondylodiscitis.

Imaging can also be used to guide a needle aspiration to investigate the infective agent.

III- **Inflammatory diseases: Rheumatoid arthritis and Ankylosing spondylitis: (Fig12)**

Spinal joints, intervertebral spaces, and tendinous and ligamentous insertions can be inflamed in inflammatory disease especially in rheumatoid arthritis (RA).

The occipito-atlanto-axial joints are involved frequently and early. Careful analysis of this area is indicated. Instability and subluxation are dreaded complications of RA in the cervical spine. The rheumatoid pannus in the cranio-cervical junction arises from the C1-C2 synovial lining around the odontoid. It is caused by a chronic instability of the atlanto-axial segment and is influenced by active motion.

Rheumatoid pannus appears on MRI as a thickening of peri odontoid soft tissue with low signal intensity on T1 weighted images, iso or low signal intensity on T2 weighted images with homogeneous enhancement after Gadolinium (Fig12).

Vertical and anterior atlanto-axial subluxations can be assessed with the use of commonplace measurement methods. However, note that subluxations may become visible only during dynamic plain radiographies (flexion and extension). Therefore, MR imaging is indicated in all cases of suspected involvement of the spine.

**IV- Cervical spine trauma (Fig13, 14 and 15)**

For injuries of the axial skeleton, the tasks of the radiologist include:
• Confirming the diagnosis of an injury using appropriate diagnostic methods.
• Diagnosing bony, chondral, ligamentous, articular, and any possible neural injuries as well as associated injuries to the neighboring soft tissues.
• Establishing whether an injury has affected the stability of the spine.
• Discussing diagnosis and further treatment with all physicians involved.
• Documenting the results of treatment and assessing the course of the healing process.

Depending on the clinical presentation of the patient, 5 plain radiographies should be performed: anteroposterior, lateral, oblique and open mouth.

Flexion and extension films aid in ruling out gross spinal instability using criteria established for the cervical spine.

The assessment of spinal traumatic injuries is better established by the x-ray CT in particular through multiplanar and 3D reformations.

With MRI, the spine and contents of the spine can be directly and noninvasively imaged. This technique plays a decisive role in: (Fig14)

• Assessing the spatial relationship between bony fragments and spinal cord compression.
• Visualizing concomitant intraductal and paravertebral soft tissue and vascular or nerve injuries.
• Visualizing primary and secondary spinal cord changes in the acute and post-acute phases.

The standard sequences used to examine patients with spinal injuries are:

• Sagittal T1-weighted spin echo sequences to evaluate the anatomy.
• Sagittal and axial T2-weighted turbo SE sequences to detect pathological medullary edema.
• Susceptibility-sensitive, blood-sensitive gradient echo sequences that can also visualize the ligaments, distinguish between traumatic vertebral prolapse and osteophytes, and can render spinal cord anatomy and the blood vessels.

V- Other etiologies

1- **Crystal arthropathy:** chondrocalcinosis

2- **Congenital disease:** vertebral block (Fig 16), cervical rib

3- **Vascular disease:** carotid or vertebral artery dissection (Fig 17)
4- **Haematomyelia (Fig 6)**
Fig. 1: Diagnostic algorithm for cervical radiculopathy

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Fig. 2: Cervical spine MRI (Sagital slices in STIR, T1 and T1 fat sat GADO) showing multiples spine metastasis appearing in hypersignal T2, hyposigal T1 with high enhancement after GADO. Note the vertebral collapse of Th1.

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Fig. 3: Cervical spine MRI (Sagital slices in T2, T1 and T1 fat sat GADO): Myeloma with diffuse and multiples spinal localisations. Note the vertebral collapse of Th3.

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**Fig. 4:** Enhanced CT scan and Cervical spine MRI (axial slice in T1 fat sat GADO and sagital in STIR and T1 fat sat GADO): Wide spinal involvement by an infiltrating process appearing in hypo signal intensity T1 and T2, non enhanced after contrast.

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**Fig. 5:** Cervical spine MRI in sagital and axial T2 and axial T2 fat sat GADO: Mixopapillary ependymoma appearin as a cervical cord expansion with multiple cystlike lesions.

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Fig. 8: Sagital medullary MRI (STIR, T1 and T1 fat sat GADO): multiples neurofibroma in a 19 years old young man presenting Von Recklinghausen neurofibromatosis.

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Signs of instability on the front, middle, and back parts of the spine as indications for injury of another part

<table>
<thead>
<tr>
<th>Column</th>
<th>Sign of instability</th>
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<tr>
<td>Front</td>
<td>Teardrop break of the posterior longitudinal ligament</td>
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<tr>
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<td>Compression &gt;50%</td>
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<td></td>
<td>Tilt of the vertebral bodies &gt;11° with respect to neighboring segments</td>
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<tr>
<td>Middle</td>
<td>Irregular contour along the dorsal edge of the vertebrae (&quot;instability line&quot;)</td>
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<tr>
<td></td>
<td>Decrease in height of the posterior wall of the vertebral bodies</td>
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<td></td>
<td>Translation of the dorsal edge &gt;3.5mm</td>
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<tr>
<td></td>
<td>Displacement of the vertebral arch pedicles, or laminae on anteroposterior images</td>
</tr>
<tr>
<td>Back</td>
<td>Displacement and divergence of the spinous process</td>
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<td>Fracture of posterior elements</td>
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<td>Lateral displacement of the articular process</td>
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<td>Facet displacement &gt;5mm</td>
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<td>Facet articulation &lt;50%</td>
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<td>Facet luxation or lock</td>
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Fig. 15

© U. Heinemann, M. Freund / European Journal of Radiology 58 (2006) 76-88 Fig.
**Fig. 16:** Frontal and sagittal spine CT scan: vertebral bloc of C6 and C7

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Fig. 14: Sagital STIR and Gradient Echo spine MRI: A severe cervical sprain with traumatic disc herniation

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**Fig. 12:** Rheumatoid C1-C2 pannus appearing in hypo signal T2 midly enhanced on T1 fat sat GADO

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**Fig. 13:** Plain lateral radiograph and CT scan of cervical spine with frontal reconstruction and oblique VR: instable body and posterior arch C2 fracture.

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Fig. 11: Spine MRI with sagittal and axial T1 fat sat GADO: disc abscess with annular enhancement.

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**Fig. 10:** Cervical spine MRI (sagittal STIR and T1 fat sat GADO): spondylodiscitis appearing as a high signal intensity from the disc and adjacent vertebral body with a significant enhancement of the vertebral endplates and the degenerated intervertebral disc.

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**Fig. 9:** Enhanced chest CT scan showing a superior right pulmonary sulcus tumor with a large rib and spinal lysis.

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Fig. 6: Cervical spine MRI showing an diffuse cervical hematomyelia. The second MRI practiced 2 months later (second T2 sagital slice and axial Gradient Echo axial slice) shows a significative regression of hematomyelia and presence of spinal cavernous angioma.

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Fig. 7: A 52 years old man presents a occipital neuralgiaEnhanced CT scan and sagital T1 weighted MRI: intradural extramedulary process intensively enhanced after contrast located in the foramen magnum.

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Fig. 17: Young man with cervical trauma: CT angiography shows right internal carotid dissection

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Imaging findings OR Procedure details

The different etiologies found were: fractures of the vertebral bodies (n=6), fractures and/or dislocations of the posterior facet joints (n=5), cervical Pott's disease (n=6), bone metastasis (n=8), Hodgkin's disease (n=1), primitive bone tumors (n=2), meningioma (n=1), haematomyelia (n=1), Pancoast Tobias syndrome (n=5), a congenital spinal block (n=2) and a cervical rib (n=2). The diagnosis was suggested on standard radiographs in 12 cases. The use of CT and MRI confirmed the etiology in all cases.
Conclusion

The frequency of degenerative CR should not ignore the possibility of non-degenerative CR indicative of another etiology which is often more severe. This requires the use of a rapid sectional imaging for more accurate diagnosis and thus guides the appropriate urgent therapeutic measures.
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