Original Article

EPIDURAL SPACE CERVICAL SPINE: REVIEW OF TRAUMATIC AND NON-TRAUMATIC EPIDURAL PATHOLOGIES

Razan Alamoudi[1]✉, Hatim Alabsi[2], Azza Reda[3], Rayan Ahyad[4], Yasser Noorelahi[5], Ahmed Alharthy[6], and Arwa Badeeb[7]

[1]The Hospital for Sick Children, University of Toronto, Canada
[2,4,5,6,7]Assisstant Professor, Department of Radiology, Faculty of Medicine, King Abdulaziz University, Jeddah, Saudi Arabia
[3]Department of Radiology, King Fahad Armed Forces Hospital, Jeddah, Saudi Arabia

Corresponding Author

Razan Alamoudi, The Hospital for Sick Children, University of Toronto, Canada
Email:razan.alamoudi@hotmail.com

ABSTRACT

The spinal epidural space located between the dura matter and the vertebral bodies can be affected by various pathologies. Understanding the radiological anatomy and clinical relevance of this space is of crucial importance for diagnostic and interventional therapeutic purposes. The cervical epidural space is particularly important due to its proximity to the cervical spinal cord and exiting nerve roots, where early detection of pathologies can prevent catastrophic neurological complications. In this concise review, we highlight the anatomy of the cervical epidural space and its boundaries and content as well as normal variants that mimic pathology on imaging. We discuss common etiologies that affect this space including traumatic and non-traumatic causes and their radiological appearance. Furthermore, the utility of computed tomography (CT) and magnetic resonance imaging (MRI) will be highlighted. Among the most common diseases affecting the cervical epidural space anteriorly is herniated discs and posteriorly facet degenerative changes. Infections and neoplastic processes integral to the cervical epidural space will be discussed in detail.

Keywords: Artifacts, MRI, CT, Epidural Space, Cervical, Spine

How to cite this article (Vancouver): R. Alamoudi. Epidural Space Cervical Spine: Review Of Traumatic And Non-Traumatic Epidural Pathologies. Saudi Journal of Radiology. December, 2025

14

1. BACKGROUND

1.1 Anatomy

The epidural space is located between the dura mater and the vertebral body with no communication between the cervical and intracranial epidural space [1]. The anterior boundaries of the epidural space are the posterior longitudinal ligament, posterior part of the vertebral bodies and the intervertebral discs. Posteriorly, ligamentum flavum, lamenae and the joint capsules of the facet joints. Laterlly, the pedicles, neural foramina and space of Okada (Fig.1).
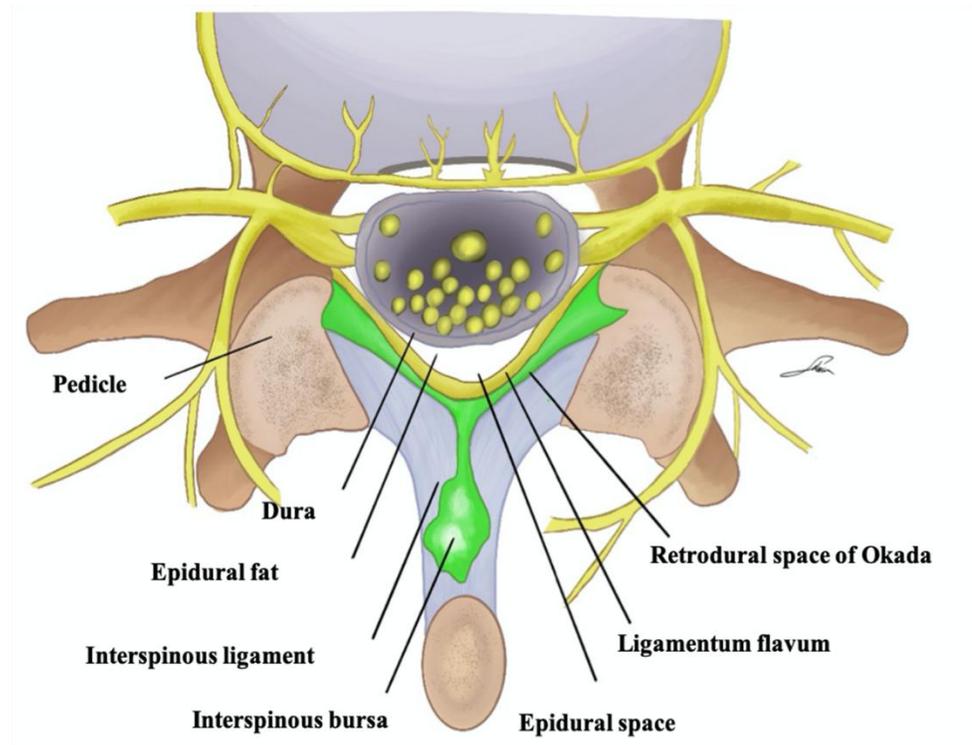

Figure 1. Illustration of the cervical spine at axial plane showing normal anatomy of the epidural space and retrodural space of Okada.

The space of Okada was first described in the cervical spine [2]. It spans approximately 5 mm in coronal plane at a single level connecting the facet joints, neural foramina, paraspinal musculature and the spinous process bursa on the same cervical level acting as a potential channel for spread of inflamatory processes and even injected materials (e.g. contrast and injectable steriod). In case of pars defect, potential spread from one level to another (above or below), might happen (Fig.2) [3]. The space of Okada is visible when contrast is injected in the involved area of the epidural space.
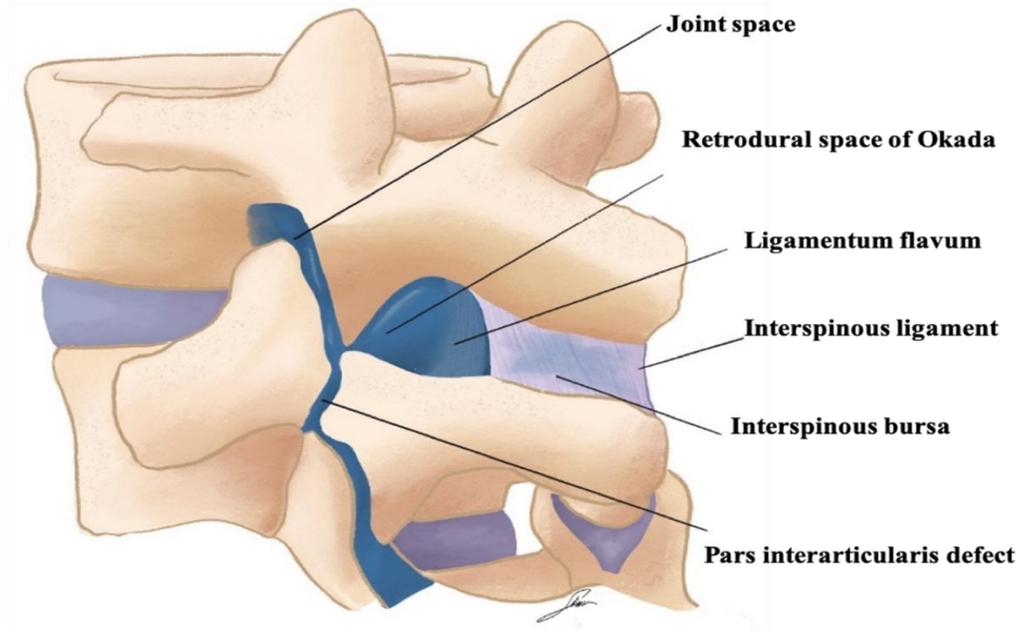
Figure 2. Illustration of the cervical spine in lateral oblique plane showing pars defect with extension of the retrodural space of okada from one level to another level.

1.2 Contents

1.2.1 Fat

The dominant component of posterior spinal epidural space, it protects the cord within the dural sac and spinal nerves from the pulastile motions of the dural sac. The amount of fat in the epidural space is propotional to the amount of fat in the body [4].

1.2.2 Nerves

Spinal nerves emerge laterally through the intervertebral foramina bilaterally. In the cervical region, there are 8 cervical nerves and 7 cervical vertebrae, with nerve numbering corresponding to the vertebra below except for the C8 nerve, which exits between the C7 and D1 levels. Conversely, in the thoracic, lumbar, and sacral regions, nerve numbering aligns with the vertebra above. The dorsal root ganglion is situated laterally and demonstrates increased enhancement following gadolinium injection.

1.2.3 Venous drainage

Through Batson's plexus and intraosseous veins [5]. The route of spread of infection and malignancy to the epidural space is likely hematogenous as the venous system is valveless and the lymphatic channels are limited and scanty.

1.2.4 Arteries

Anterior and posterior spinal arterial arcades arise from vertebral arteries, thoracic and lumbar aorta.

1.3 Normal Structures and Artifacts Mimicking Spinal epidural pathologies on MRI

1.3.1 Epidural veins

Occasionaly, epidural veins cannot be distinguished from herniated disc especially if its located in the anterior epidural space.

Motion artifact: Patient movement, CSF pulsation and swallowing, produce turbulence in blood and CSF flow resulting in mixture of increased and decreased signal intensity (Fig.3). The remedy for this is to look at other sequences or repeat the scan with saturation bands.
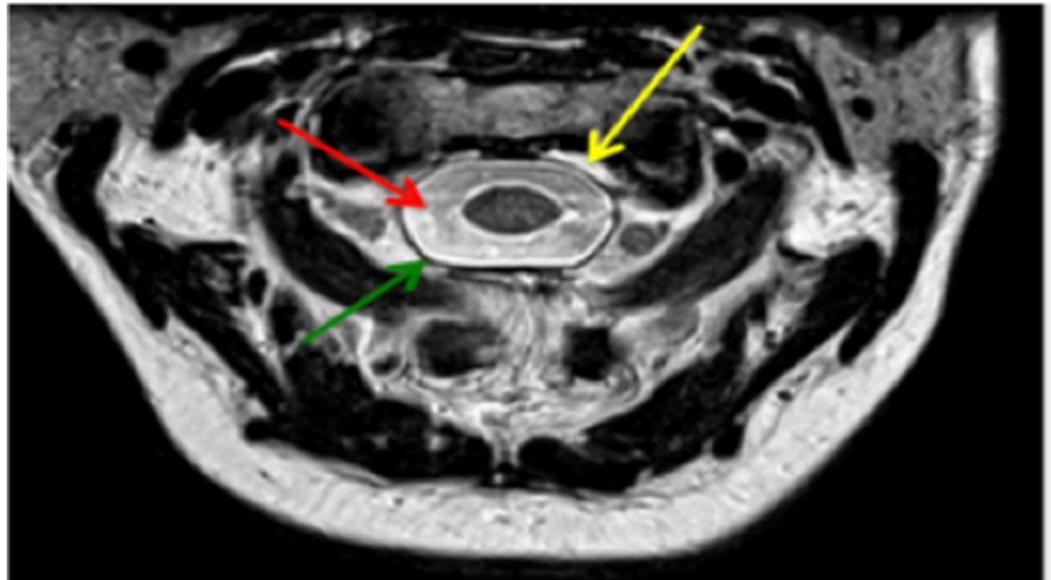

Figure 3. CSF flow artifact. Axial T2WI MRI image of the upper cervical spine showing normal cervical canal. Dural layer is seen (green arrow). Minimal epidural fat (yellow arrow). Normal heterogenous CSF appearance (red arrow) around the spinal cord.

1.3.2 Incomplete Fat Saturation

Frequency-selection is the most popular method of eliminating unwanted fat signal in fat saturated sequences. This technique is prone to focal failure, which results in high signal intensity at fat-air interfaces. This artifact arises from the magnetic susceptibility differences between fat and air, or from magnetic field in homogenisity in large field of view (Fig.4).
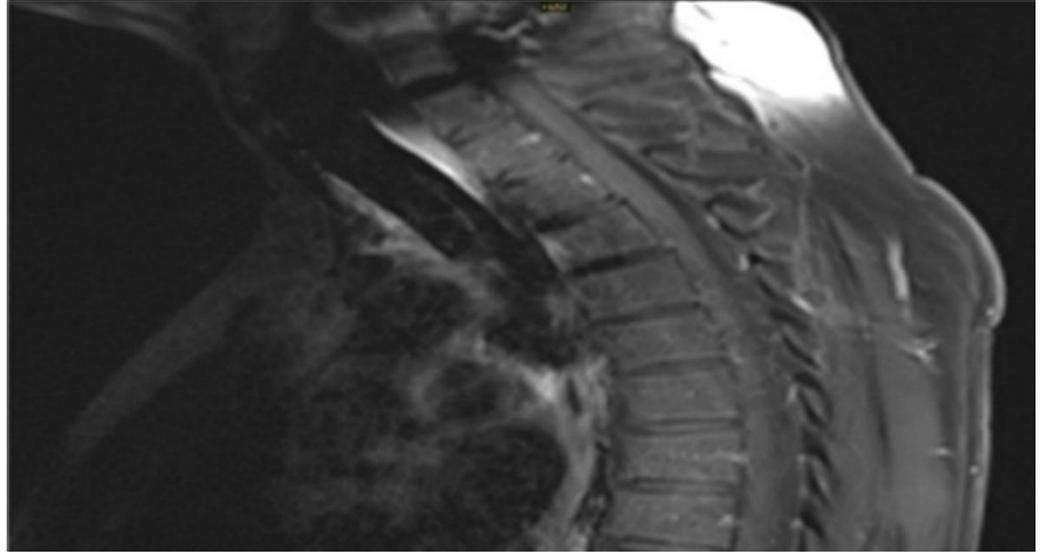
Figure 4. Incomplete fat saturation. Saggital fat-saturated T1WI showing a band of unsaturated fat at the upper part of the image.

1.3.3 Metal artifacts

Susceptibility artifact due to metalic prosthesis (e.g. pedicular screws and intervertebral spacers) occurs because these metalic hardware become highly magnetized when placed in the magnet. Use of fat saturated sequences may exaggerate this artifact.

2. EPIDURAL PATHOLOGIES

Most cervical epidural lesions present with radiculopathy and or myelopathy due to the tight space between the epidural space and the cervical cord and exiting nerves. The clinical presentation varies and largely depends on the size of the lesion, level of involvement and the presence of any preexisting conditions (e.g. degenerative changes). In a 2021 large sample study done by Youping Tao.et al examining 1581 patients using Kettlers method [6] for grading spine degenerative changes, they found that 53.9% of all patients exhibited radiographic disc degeneration in the cervical spine, with Grade 1 degeneration being the most prevalent (36.8%). C5/C6 was identified as the level most frequently and severely affected. Height loss, osteophyte formation, and endplate sclerosis were most commonly observed at C5/C6, followed by C6/C7, while spondylolisthesis was predominantly found at C4/C5(7). Epidural pathologies can be secondary to disc disease, trauma, spinal infection or neoplastic processes.

2.1 Herniated Disc

Herniated cervical discs may extend into the anterior epidural space by perforating the intervertebral disc posterior annulus fibrous and posterior longitudinal ligament [8,9]. It appears as disc extrusion, protrusion or sequestration. The sequestered fragment may migrate laterally, cranially or caudally in the epidural space (Fig.5) and (Fig.6).
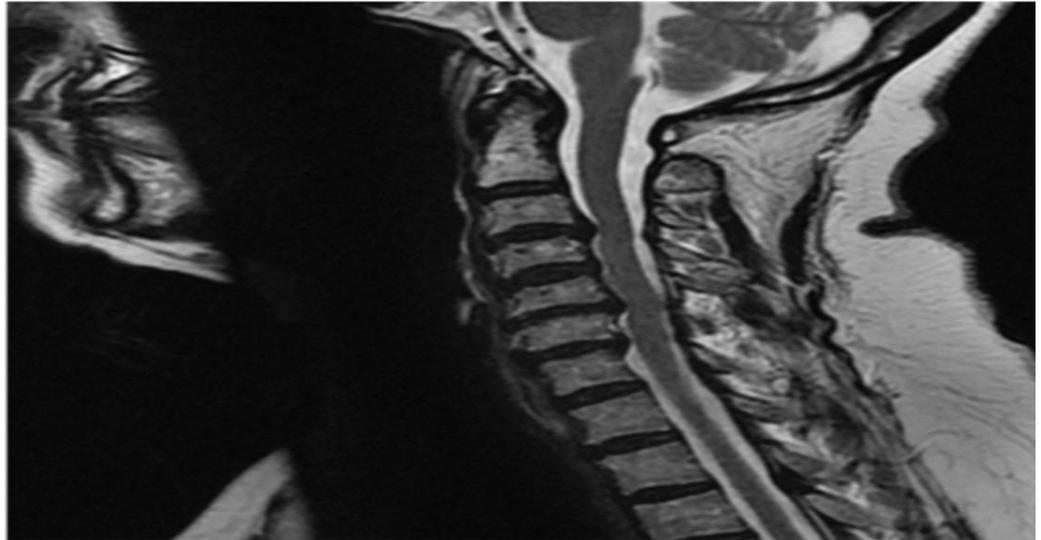

Figure 5. Degenerative disc disease. Saggital T2WI of the cervical spine showing multilevel disc protrusion particularly at C3-4, C5-6 and C6-7 levels.
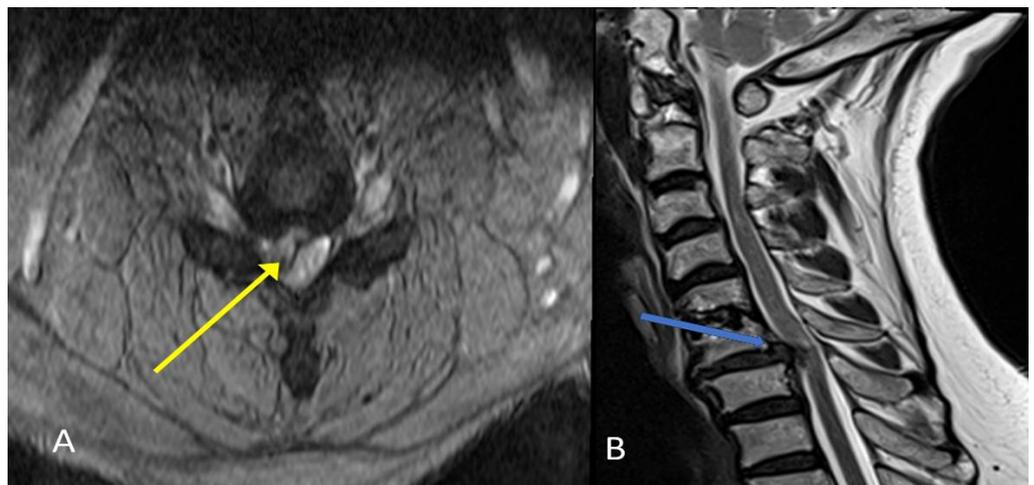

Figure 6. (A) Right-sided C6-7 disc protrusion causing severe compression on the right nerve root and stenosis of the spinal canal at the same level (yellow arrow). Also, focal myelomalacia at the affected cord (B) (blue arrow).

2.2 Epidural infections

2.2.1 Pyogenic

Pyogenic infections can be primary or secondary to trauma, prior surgical intervention, or as a complication of vertebral osteomyelitis. Secondary hematogenous type is more encountered in diabetics, alcoholics, cancer patients and those with immunosuppressive conditions or medications [10]. Staph aureus as the most common isolated pathogen in both forms [10,11] (Fig.7).

Figure 7. Epidural abscess secondary to vertebral discitis/osteomyelitis. A, Sagittal post contrast T1WI showing peripherally enhancing collection at the anterior epidural space extending from C2 to C6. B, axial T1WI showing the anterior location of the collection. Case courtesy of Lahy hospital and medical center, Burlington, MA.

2.2.2 Tuberculosis (TB)

TB is common in third world countries, mainly caused by hematogenous spread of mycobacterium TB from a primary lung, lymph node or the GI tract(12).

The precise prevalance of spinal tuberculosis is unknown in many regions globally. However, in countries with a higher prevalence of pulmonary tuberculosis, it is anticipated that the incidence of spinal tuberculosis would also be relatively high. Roughly 10% of individuals diagnosed with extrapulmonary tuberculosis experience skeletal manifestations. Among these patients, spinal

tuberculosis affects half of these skeletal tuberculosis cases (Gautam et al., 2005).(14)

The disease primarily involves the vertebrae with relative sparing of the disc until late in the process. Vertebral laminar erosion, soft tissue epidural abscesses and posterior spinal myositis are the major MRI findings. Limb weakness, neuropathy and neural pathology can result from epidural abscesses (Fig.8).
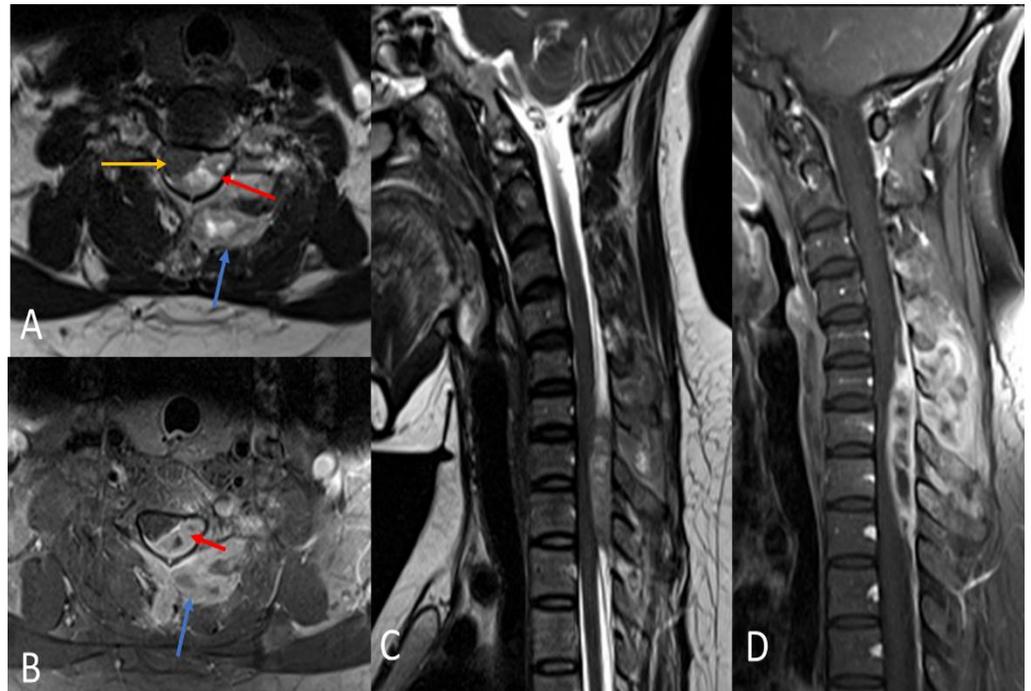

Figure 8. 29 Female patient with Disseminated TB with Worsening pain in the neck and left-sided upper extremity weakness. Axial T2WI (A) and axial post contrast T1WI (B) showing posterior epidural enhancement (red arrow) and posterior epidural abscess extending from C4-C5 to T2-T3, with heterogeneous enhancement and some necrotic/cystic component centrally on T2WI. Mass effect on the cervical cord (yellow arrow) causing its displacement to the anterior right side with severe canal stenosis and cord compression. Multiple left paraspinal abscesses (blue arrow) and inflammatory changes of the posterior elements . Sagittal T2WI (C) and sagittal post contrast T1WI (D) showing the craniocaudal extent of the disease and the mass effect on the spinal cord.

2.2.3 Neoplastic process

Benign

Spinal epidural lipomatosis: This pathology is defined by unencapsulated aggregates of lipomatous tissue in the epidural space (15). The condition can be

attributed to steroid use, Cushing's syndrome or idiopathic causes. The dorsal epidural space is where this is most prominent. It is known for its circumferential mass effect on the dural sac and is diagnosed when epidural fat thickness exceeds 7 mm(16) .

Spinal angiolipoma: Spinal angiolipomas are rare benign lesions that internally shows mature adipose component intermixed with abnormal blood vessels. They can be either infiltrative or noninfiltrative. The usual location for these lesions is the posterior epidural space (17). On MRI, it will show flow void and intrinsic fat signal within the lesion which will differentiate it from high flow AVMs and capillary hemangiomas. The infiltrative subtype may destruct the adjacent vertebral bodies or may extend through the neural foramina (18).

Paravertebral Arteriovenous malformation: This entity is divided into spinal arteriovenous malformations, spinal cord arteriovenous fistulas, dural arteriovenous fistulas, and arteriovenous malformations that are extradural in location but drain into the epidural veins (these are called paravertebral AVMs/AVFs). The paraspinal AVF is an uncommon variant of spinal AVFs. They include the intracanalicular and vertebral AVFs and can be due to congenital or traumatic etiology. They are mostly encountered in the cervical spine. Muscular or vertebral tributaries act as feeding vessels. Drainage is usually via paravertebral, epidural or intradural veins (19). MRI will detect the location of the nidus, pattern of vascularity including the origin of feeding arteries and the venous drainage of the lesion. Additionally, any abnormal spinal cord signal should be reported as these lesions can have either compressive or congestive myelopathy(Fig.9) (Goyal et al., 1999) .

2.3 Neoplastic lesions

2.3.1 Lymphoma

In contrast to the vertebral spinal lymphomatous infiltration, primary spinal epidural lymphoma is very rare and usually of the non-Hodgkin type. It may occur due to hematogenous spread from unidentified lymphoid tissue or direct spread through the neural foramina from vertebral or paravertebral region. The imaging characteristics of primary spinal epidural lymphoma is of isointense soft tissue signal on T1 weighted images with iso-hyperintense signal on T2 weighted images and intense gadolinium contrast enhancement (21,22).
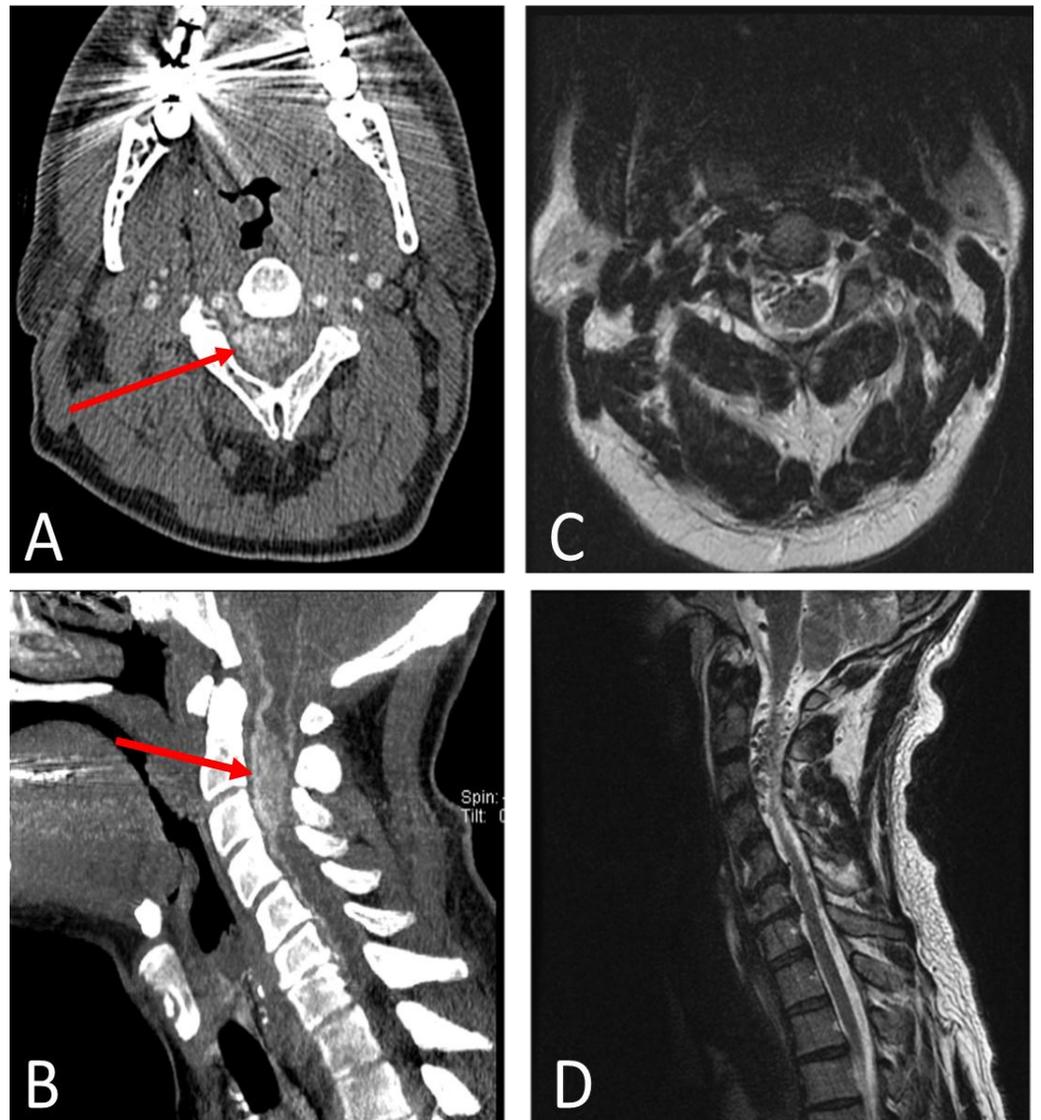
Figure 9. (A) and (B), axial and sagittal CT angiogram of the cervical region showing a large AVM at the epidural space al C2-C3 level. (C) and (D) showing axial and sagittal MRI T2WI of the same region showing the extensive abnormal vessels as flow voids. Case courtesy of Lahy Hospital and medical center, Burlington MA

2.3.2 Metastasis

Around 5-10% of cancer patients develop epidural metastatic lesions leading to cord compression (23,24). Roughly, 85% of epidural metastatic lesions are likely to originate from local infiltration of adjacent osseous vertebral body lesions predominantly affecting the epidural space close to the vertebral column rather than from the neural arch(Fig.10) (Desforges & Byrne, 1992). Epidural soft tissue

metastatic lesions may cause destruction of the adjacent vertebrae, extension along the posterior longitudinal ligament, intervertebral neural foramen involvement or compression of the dural sac and its contents.
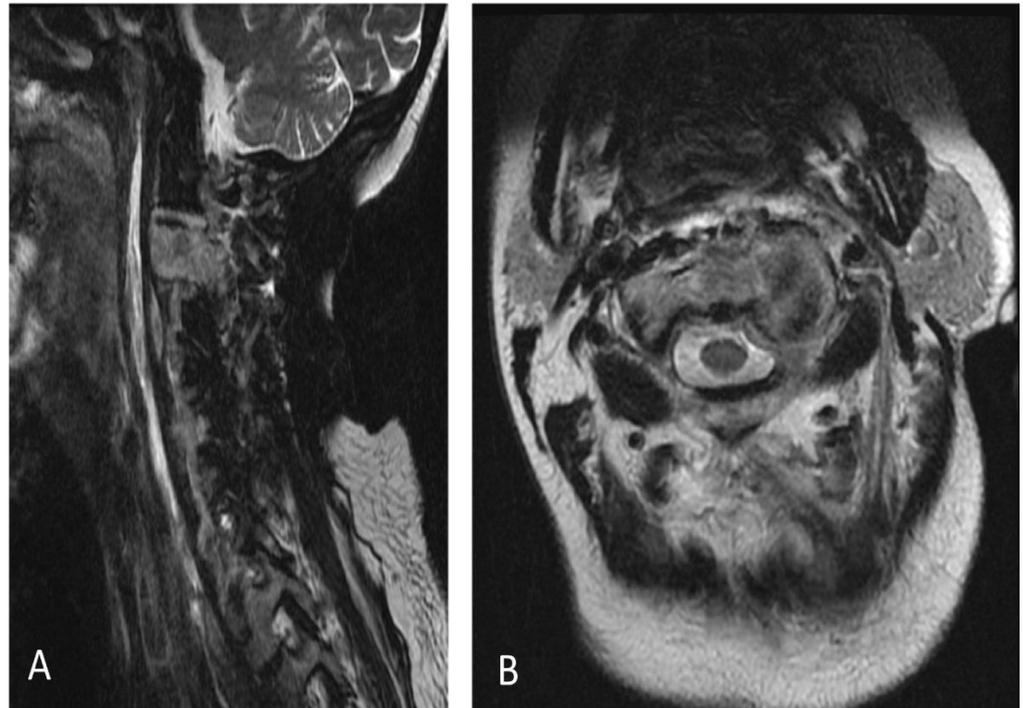

Figure 10. Prostate cancer metastasis. (A) and (B), sagittal and axial T2WI of the cervical spine showing C2 osseous lesion envading the left epidural space. Case courtesy of Lahy Hospital and medical center, Burlington, MA.

2.4 Miscellaneous

2.4.1 Epidural hematoma

Epidural hematoma can be spontaneous from coagulopathy, therapeutic thrombolysis, vascular anomalies or post traumatic in nature. Patients present acutely due to cord compression and tend to rapidly progress to quickly irreversible neurologic deficits (26). On MRI and CT, epidural hematoma can be seen as a biconvex lesion which follows the blood signal intensity/density depending on its age which tapers superiorly and inferiorly (Fig11,12) (27). Gradient and susceptibility weighted imaging (SWI) sequences will confirm the presence of blood products. Enhancement is usually peripheral but may be variable.
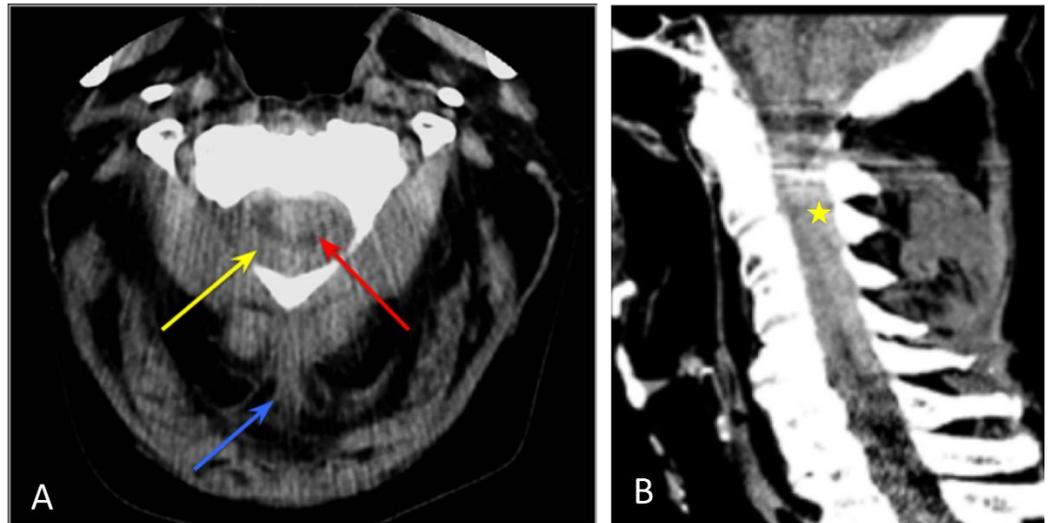
Figure 11. Trauma. Axial (A) and sagittal (B) CT cervical spine: Soft tissue stranding posterior to spinous processes (Blue arrow). A hyperdense collection (yellow arrow) noted mainly in the posterior epidural space posterior to the cervical canal effacing the CSF space (red arrow). The sagittal view showing the craniocaudal extension of the epidural hematoma (yellow star). Case courtesy of Lahy Hospital and medical center, Burlington, MA.
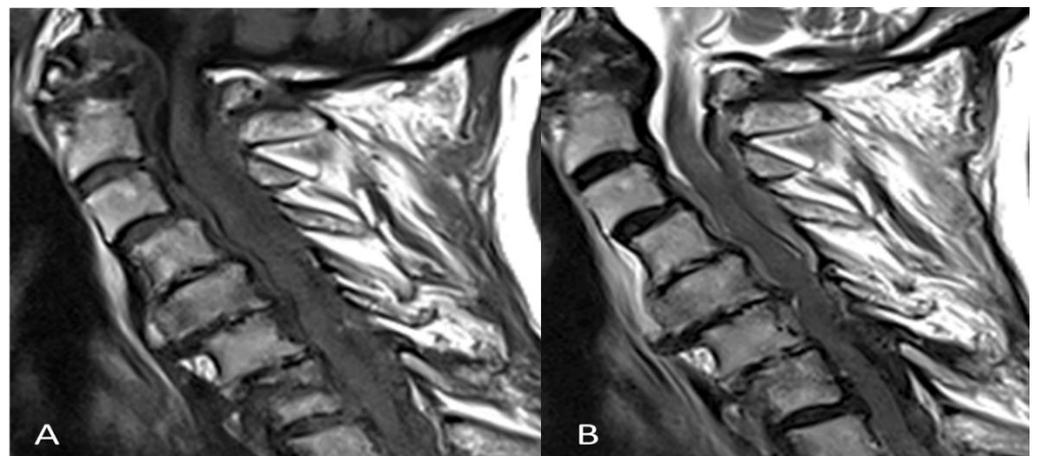

Figure 12. Sagittal T1WI (A) and T2WI (B) showing circumferential epidural hematoma with canal stenosis and compression and deformity of the spinal cord

3. CONCLUSION

Evaluating cervical epidural space is important and is often overlooked. Familiarity with different imaging modality, normal anatomy, common

pathologies and imaging pitfalls is essential for accurate interpretations. Missed pathology can lead to dire complications.

4. CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest related to this manuscript.

5. FUNDING

No funding was received to support this study

6. ACKNOWLEDGMENT

The authors would like to thank all individuals who contributed to the completion of this work. During the preparation of this manuscript, the authors used GPT-4 (OpenAI, San Francisco, USA) to enhance the readability of some sections, ensure consistency, and reduce redundancies. All content generated using this tool was carefully reviewed, edited, and approved by the authors, who take full responsibility for the final version of the manuscript.

7. REFERENCES

[1] Gala FB, Aswani Y. Imaging in spinal posterior epidural space lesions: A pictorial essay. Indian Journal of Radiology and Imaging [Internet]. 2016 Aug 1 [cited 2024 Mar 2];26(3):299–315. Available from: https://drive.google.com/file/u/1/d/1uGDM89x1WcuECoQAHwOtTCnxo10 5iKc7/view?usp=drive_web&usp=embed_facebook

[2] Okada K. [Studies on the cervical facet joints using arthrography of the cervical facet joint (author's transl)]. Nihon Seikeigeka Gakkai Zasshi. 1981 Jun;55(6):563–80.

[3] Lehman VT, Murthy NS, Diehn FE, Verdoorn JT, Maus TP. The posterior ligamentous complex inflammatory syndrome: Spread of fluid and inflammation in the retrodural space of Okada. Clin Radiol [Internet]. 2015 [cited 2024 Mar 2];70(5):528–35. Available from: https://drive.google.com/file/u/1/d/1Qwxw3VRaDv4XqHs0InthGbaxbjtTr9 Pg/view?usp=drive_web&usp=embed_facebook

[4] Reina MA, Franco CD, López A, Dé Andrés JA, van Zundert A. Clinical implications of epidural fat in the spinal canal. A scanning electron microscopic study. Acta Anaesthesiol Belg. 2009;60(1):7–17.

[5] Batson O V. THE FUNCTION OF THE VERTEBRAL VEINS AND THEIR RÔLE IN THE SPREAD OF METASTASES. Ann Surg [Internet]. 1940 Mar

[cited 2024 Mar 4];112(1):138. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1387927/

[6] Wilke HJ, Rohlmann F, Neidlinger-Wilke C, Werner K, Claes L, Kettler A. Validity and interobserver agreement of a new radiographic grading system for intervertebral disc degeneration: Part I. Lumbar spine. Eur Spine J [Internet]. 2006 [cited 2024 Mar 5];15(6):720–30. Available from: https://pubmed.ncbi.nlm.nih.gov/16328226/

[7] Tao Y, Galbusera F, Niemeyer · Frank, Samartzis · Dino, Vogele D, Wilke · Hans-Joachim. Radiographic cervical spine degenerative findings: a study on a large population from age 18 to 97 years. European Spine Journal [Internet]. 2021 [cited 2024 Mar 5];30:431–43. Available from: https://doi.org/10.1007/s00586-020-06615-0

[8] Chen CY, Chuang YL, Yao MS, Chiu WT, Chen CL, Chan WP. Posterior Epidural Migration of a Sequestrated Lumbar Disk Fragment: MR Imaging Findings. [cited 2024 Mar 5]; Available from: www.ajnr.org

[9] Dösoğlu M, Is M, Gezen F, Ziyal M. Posterior epidural migration of a lumbar disc fragment causing cauda equina syndrome: case report and review of the relevant literature. Eur Spine J [Internet]. 2001 [cited 2024 Mar 5];10(4):348–51. Available from: https://pubmed.ncbi.nlm.nih.gov/11563623/

[10] Joshi SM, Hatfield RH, Martin J, Taylor W. Spinal epidural abscess: A diagnostic challenge. Br J Neurosurg. 2003 Apr;17(2):160–3.

[11] Mackenzie AR, Laing RBS, Smith CC, Kaar GF, Smith FW. Spinal epidural abscess: the importance of early diagnosis and treatment. J Neurol Neurosurg Psychiatry. 1998;65:209–12.

[12] Ansari S, Amanullah M, Ahmad K, Rauniyar RK. Pott's spine: Diagnostic imaging modalities and technology advancements. N Am J Med Sci [Internet]. 2013 Jul [cited 2024 Mar 2];5(7):404–11. Available from: https://drive.google.com/file/u/1/d/1uQWpmKc_hNAkX_evqnSZ2pgUZ3e GwHDl/view?usp=drive_web&usp=embed_facebook

[13] Gautam MP, Karki P, Rijal S, Singh R. Pott's spine and paraplegia. JNMA J Nepal Med Assoc. 2005;44(159):106–15.

[14] Talbot JC, Bismil Q, Saralaya D, Newton DAG, Frizzel RM, Shaw DL. Musculoskeletal Tuberculosis in Bradford – A 6-Year Review. Ann R Coll Surg Engl [Internet]. 2007 May [cited 2024 Mar 5];89(4):405. Available from: /pmc/articles/PMC1963589/

[15] Quint DJ, Boulos RS, Sanders WP, Mehta BA, Patel SC, Tiel RL. Epidural lipomatosis. https://doi.org/101148/radiology16923174998 [Internet]. 1988 Nov 1 [cited 2024 Mar 2];169(2):485–90. Available from: https://pubs.rsna.org/doi/10.1148/radiology.169.2.3174998

[16]   Fogel GR, Cunningham PY, Esses SI. Spinal epidural lipomatosis: Case reports, literature review and meta-analysis. Spine Journal [Internet]. 2005 Mar [cited 2024 Mar 2];5(2):202–11. Available from: https://drive.google.com/file/u/1/d/1cCEjBNHmh1fTGnfl4eRN3VzYO2W-vFy5/view?usp=drive_web&usp=embed_facebook

[17]   Leu NH, Chen CY, Shy CG, Lu CY, Wu CS, Chen DC, et al. MR Imaging of an Infiltrating Spinal Epidural Angiolipoma. AJNR Am J Neuroradiol [Internet]. 2003 May [cited 2024 Mar 2];24(5):1008. Available from: /pmc/articles/PMC7975787/

[18]   S K, H A, M A, Y I, K N. Infiltrating spinal angiolipoma causing myelopathy: case report. Neurosurgery [Internet]. 1990 Aug [cited 2024 Mar 2];27(2):315. Available from: https://pubmed.ncbi.nlm.nih.gov/2385353/

[19]   M.D. PhDPL. Vascular Diseases in Neonates, Infants and Children. Springer Berlin Heidelberg. 1997;

[20]   Goyal M, Willinsky RA, Montanera W, TerBrugge K. Paravertebral Arteriovenous Malformations with Epidural Drainage: Clinical Spectrum, Imaging Features, and Results of Treatment. AJNR Am J Neuroradiol [Internet]. 1999 [cited 2024 Mar 2];20(5):749. Available from: /pmc/articles/PMC7056146/

[21]   Boukobza M, Mazel C, Touboul E. Primary vertebral and spinal epidural non-Hodgkin's lymphoma with spinal cord compression. Neuroradiology. 1996 May;38(4):333–7.