Diffusion-weighted imaging of spinal and paraspinal infection: differential diagnoses and imaging pitfalls

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Learning objectives

To demonstrate diffusion-weighted imaging (DWI) of spinal and paraspinal infection, which included abscesses, pus collections, cellulitis and granuloma formations, in the subarachnoid, subdural and epidural spaces, and paraspinal soft tissues and iliopsoas muscle.

Background

We reviewed DWI findings in 240 patients with spinal and paraspinal infections. Underlying diseases and predisposing factors comprised of sepsis (endocarditis, IV drug user, urinary tract infection), spine surgery, infected aortic aneurysm graft, spinal or paraspinal tumor, trauma, diabetes, liver cirrhosis, renal/liver transplant, and epidural steroid injection. The causes were various types of infections including common bacterial infections, tuberculosis, brucellosis, and fungal infections. Spin-echo type echo-planar DWI with parallel imaging and the ADC maps \( (b=0, 1000 \text{ sec/mm}^2) \) were used.

Imaging findings OR Procedure details

1. Underlying Diseases / Predisposing Factors (Fig. 1 on page 5)

The most common underlying disease was diabetes mellitus. Post spine surgery and post other surgeries/procedures were also common. IV drug use was common cause especially in male young adults. Others comprised of transplantation, endocarditis, urinary tract infection, skin infection, epidural steroid injection/nerve block, and Crohn disease. Significant number of cases had unknown causes of infections.

2. Causative Organisms (Fig. 2 on page 6)

More than half of causative organisms were Staphylococcus (MSSA, MRSA). Streptococcus, E coli and other various bacteria were also found. There were a few tuberculosis and fungal infections. Causative organisms were not proven in many cases.

3. Distribution of Spinal and Paraspinal Infections (Fig. 3 on page 6)
Spinal and paraspinal infections include:

1) Osteomyelitis/discitis with or without epidural/paraspinal abscess
2) Postsurgical wound infection with or without epidural/paraspinal abscess
3) Facet joint infection with or without epidural/paraspinal abscess
4) Isolated epidural/paraspinal abscess
5) Purulent meningitis/arachnoiditis
6) Spinal cord abscess

4. Roots of Extension of Epidural Abscess (Fig. 4 on page 7)

1) Epidural abscess extending from osteomyelitis/discitis
2) Epidural abscess extending from facet joint infection
3) Epidural abscess without osteomyelitis/discitis or facet joint infection

5. Usefulness of DWI and Various Pattern of Epidural Abscesses

DWI with ADC maps are useful in early detection and accurate diagnosis of epidural / paraspinal / psoas abscesses. DWI can easily detect a small abscess or pus collection and demonstrate the extension and multiplicity of the abscess. Thus, DWI is useful for treatment planning, decision making of surgical drainage and site selection for the biopsy.

DWI can show coexistent sources of infection such as aortic graft infection, renal abscess, subpleural empyema, skin infection, and other soft tissue abscess / pus collection.

1) Epidural abscess extending from osteomyelitis/discitis
(Fig. 5 on page 8, Fig. 6 on page 9, Fig. 7 on page 9)

- This is the most common type of extension. Organisms usually involve the endplate of the vertebral body at first and extend into the disc causing discitis/osteomyelitis, and then the infection spreads to the epidural space. DWI can detect a small abscess or pus collection. DWI can demonstrate the
extension of multiple epidural/paraspinal abscesses and other sources of the infection (graft infection, renal abscess, subcutaneous infection, subpleural empyema etc.).

2) Epidural abscess extending from facet joint infection (Fig. 8 on page 10)
   - Facet joint infection is another important route of infection resulting in epidural/paraspinal/psoas abscesses. The finding of facet joint infection is sometimes very subtle. DWI is useful in the detection of small abscess or pus collection adjacent to the facet joint. Important differential diagnosis will be epidural/subdural hematoma, CSF leak, disc herniation, synovial cyst and intra/extradural tumor.

3) Epidural abscess without osteomyelitis/discitis or facet joint infection (Fig. 9, Fig. 10, Fig. 11, Fig. 12, Fig. 13)
   - Epidural/paraspinal/psoas abscesses can occur without facet joint infection or osteomyelitis/discitis.
   - The routes of the infection are: 1) Direct hematogenous spread to the epidural space. 2) Infection related to epidural steroid injection or nerve block injection, often also associated with purulent leptomeningitis. 3) Direct extension from skin or wound infection. DWI is often the key image in the diagnosis of isolated abscess.

6. Unusual Spinal and Paraspinal Infections (Fig. 14 on page 14, Fig. 15 on page 14, Fig. 16 on page 15, Fig. 17 on page 16)

1) Tuberculosis (Fig. 14 on page 14)

2) Fungal infection
   - Candidiasis (Fig. 15 on page 14)
   - Sporothrix (Fig. 16 on page 15)

3) Spinal cord abscess (Fig. 17 on page 16)

7. Mimics of Epidural Abscess, Purulent Leptomeningitis, and Cord Abscess (Fig. 18 on page 17, Fig. 19 on page 18, Fig. 20 on page 19, Fig. 21 on page 19, Fig. 22 on page 20, Fig. 23 on page 21)

1) Disc herniation (Fig. 18 on page 17)
2) Epidural/subdural hematoma (Fig. 19 on page 18)

3) Subarachnoid hemorrhage (Fig. 20 on page 19)

4) CSF leak (Fig. 21 on page 19)

5) Epidermoid (Fig. 22 on page 20)

6) Spinal cord infarction (Fig. 23 on page 21)

8. Limitations and Pitfalls of Evaluation of DW Signals and Calculation of ADC (Fig. 24 on page 21)

DWI and the ADC values are affected by chemical shift artifacts and paramagnetic diamagnetic susceptibility artifacts because DWI is innately comprised of echoplanar imaging with chemical fat saturation.

DW signals of the vertebral body are variable depending on the proportion between red and yellow bone marrows. The bone marrow fat causes signal void on DWI because DWI innately uses chemical fat saturation techniques. Moreover, bony trabecula also cause signal loss due to diamagnetic susceptibility artifacts. Thus, the calculated ADC values are affected by chemical shift and susceptibility artifacts.

DW signals and ADC values of the disc are also variable due to the presence of degenerative changes.

ADC values of abscess/pus are significantly lower than those in CSF, muscle or postoperative fluid collection.

ADC values in epidural and paraspinal/psoas abscesses, which are presumably diluted by the exudate, were slightly higher than those reported in brain abscesses.

Images for this section:
Fig. 3
**Fig. 5:** Epidural abscess/prevertebral abscess with discitis/osteomyelitis at C4-6. 62 yo M with neck pain and altered mental status, DM, right elbow infection, sepsis. MRSA proven by biopsy (surgical drainage).

**Fig. 6:** Multiple paraspinal/psoas abscesses and epidural abscess associated with osteomyelitis/discitis at L4/5. MSSA proven by percutaneous drainage. 41 yo M with low back pain, left leg weakness, post-discectomy for lower back pain. DWI clearly demonstrates the extension of multiple epidural and paraspinal abscesses.
Fig. 7: Epidural and psoas abscesses with ostomyelitis/discitis at T11/12 and L4/L5. 42 yo F with UTI. A right renal abscess is incidentally noted on DWI.
Fig. 8: Septic facet joint infection and epidural abscess. 43 yo M with IV drug abuse. MSSA was proven.

Fig. 9: Epidural abscess from C5 through T8 (direct spread from the site of intercostal nerve block for his chest pain at an outside hospital). 56 yo M. Left clavicle and subcutaneous infections are also visualized. The patient was under immunosuppressive therapy for RA.
**Fig. 10:** Isolated small ventral epidural abscess similar to a disc hernia. 45 M with low back pain and lower extremity weakness. Streptococcus mirelli was proven in the blood.

**Fig. 11:** Epidural abscess and purulent leptomenigitis as complications after steroid epidural injection at an outside hospital. Subpleural empyema and psoas abscesses are also visualized. 50 yo F. MRSA was proven in the CSF.
Fig. 12: Isolated epidural abscess from skin infection. 51 M with neck pain for 1 week. He went to see a chiropractor with no relief. On conventional MRI at outside hospital, hematoma or fluid collection was suspected. (-> continued on next slide Fig 13)
**Fig. 13:** On the next day MRI in our hospital, DWI shows not only the epidural abscess but also a soft tissue abscess in the posterior neck. However, the patient died from septic shock (MRSA), hyperkalemia, renal failure, lactic acidosis, and multiple organ failure in 24 hrs.

**Fig. 14:** Tuberculosis. Psoas abscess and osteomyelitis/discitis at T12-L1. 25 yo M with low back pain. TB was proven by drainage.
**Fig. 15:** Candidiasis with epidural/psoas abscess with discitis/osteomuelitis at L2/3 and L4/5. 54 yo M. Candida was proven by biopsy.
Fig. 16: Sporothrix with low T2, iso T1 nodules with enhancement and arachnoiditis at L4-S1. 22 yo M. Status post laminectomy.
**Fig. 17:** 13 yo F with a spinal cord abscess associated with a syrinx in Chiari I malformation. Sagittal T2-weighted and gadolinium-enhanced T1-weighted images show a syrinx in the upper portion (red arrows) and enhancing abscess in the lower portion of the syrinx (yellow arrows). DWI shows restriction in the abscess (yellow arrow) but hypointensity in the unaffected syrinx (red arrow).
Fig. 18: Extruded disc herniation. 36 yo M
**Fig. 19:** Epidural hematoma. 82 yo F with trauma (T3-T4 fracture-distraction)

**Fig. 20:** Subarachnoid hemorrhage. 76 yo F presented with progressive lower extremity weakness. Patient has been on aspirin and plavix.
**Fig. 21:** CSF leak after lumbar puncture (22G, L4/5). 3 yo boy with back pain, refused to walk after lumbar puncture. DWI shows CSF signals in the epidural space.
Fig. 22: Ruptured epidermoid with chemical meningitis. 53 yo F presented with fever, obtundation, seizures, neck stiffness, lower extremity paraplegia, and neutrophilic leukocytosis. Pathology shows multilayers of the squamous cell and inflammatory cell infiltration.

Fig. 23: Spinal cord infarction due to dissection of the descending aorta. 60 y M with acute onset paralysis.
Fig. 24: Artifacts from a fusion device - a limitation of DWI. A small paraspinal abscess is well visualized on DWI and the ADC map although the images are distorted due to artifacts. However, the epidural abscess seen on T2WI and GdT1 was not identified on DWI and ADC.
Conclusion

1. DWI with ADC maps are useful in early detection and accurate diagnosis of epidural/paraspinal/psoas abscesses. DWI can easily detect a small abscess or pus collection and demonstrate the extension and multiplicity of the abscess. Thus, DWI is also useful for treatment planning, decision making of surgical drainage and site selection for the biopsy.

2. DWI can show coexistent sources of infection such as aortic graft infection, renal abscess, subpleural empyema, skin infection, purulent leptomenigitis, and other soft tissue abscess/pus collection.

3. Epidural/paraspinal/psoas abscesses can occur with or without osteomyelitis/discitis or facet joint infection. Isolated epidural abscess can occur as direct hematogenous spread or as a complication of epidural steroid injection/nerve block.

4. Important differential diagnoses include epidural/subdural/subarachnoid hemorrhage, CSF leak, disc herniation, synovial cyst, granulation tissue, intra/extradural tumor, and postsurgical fluid collections.

5. DWI and the ADC values are affected by chemical shift artifacts and paramagnetic diamagnetic susceptibility artifacts because DWI is innately comprised of echoplanar imaging with chemical fat saturation. Caution is needed for evaluation.

6. ADC values in epidural and paraspinal/psoas abscesses in our study were slightly higher than those that had been reported in brain abscesses.

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