Clinical Applications of Diffusion Imaging in Neuroradiology

Basics of Diffusion Imaging

**Free environment**
- Water molecules move freely in all directions with no restrictions.

**Complex environment**
- Water molecules encounter different structures in the microstructure of biological tissues.

Diffusion Imaging uses the motion of water to explore the tissue microstructure.

Clinical applications of diffusion imaging in neuroradiology

**Outline**

- Basics of Diffusion Imaging
- No disclosures

Clinical Applications of Diffusion Imaging in Neuroradiology

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No disclosures
Basics of Diffusion Imaging

By acquiring images with 2 b-values (b=0 and b=1000 s/mm²), the apparent diffusion coefficient (ADC) can be calculated and the ADC image no longer has a T2 component. ADC = reduced water motion

ADC = increased water motion

Most clinically important pathology

Outline

Clinical applications of diffusion imaging

Basic concept of diffusion imaging
Stroke

*Normal Brain:* 22 billion neurons, 150 trillion synapses, 84,500 miles of length of myelin fibers

*Each minute of stroke losses:* 1.9 million neurons, 14 billion synapses, and 7.5 miles of length of myelin fibers

*22 billion neurons, 150 trillion synapses, 84,500 miles of length of myelin fibers*

*Stroke: DWI* 

Most centers will perform MRI with diffusion before any other MRI sequence to demonstrate the size and location of an acute infarct. Most sensitive imaging test for detection of acute stroke.

*DWI: Stroke* 

70 year old with acute left sided weakness

Large right MCA infarct. DWI characterizes extent of infarct

DWI: Stroke

Most sensitive imaging test for acute stroke than noncontrast CT

70 year old with acute gait abnormality

61 year old with acute gait abnormality

61 year old with acute gait abnormality

Large right MCA infarct. DWI characterizes extent of infarct
70 year old with acute left sided weakness:
Infarct visible on FLAIR and CT.

3 days of left hand weakness:
ADC isointense in subacute phase of infarct.

New on set of weakness. Prior history of stroke:
Old infarct visible on T2 and FLAIR. Is there acute infarct present?
No diffusion restriction present. Old infarct has increased diffusion due to loss of brain tissue.

30 yo with Lupus and acute neurological deficits. Is there acute stroke present?
DWI demonstrates multiple infarcts and multiple vascular territories.

3 days of left hand weakness: Prior history of stroke.
ADC isointense in subacute phase of infarct.

70 year old with acute left sided weakness:
70 year old with acute left sided weakness.
Catheter Angiography demonstrated vasculitis as the etiology.

6 day old baby with seizures. Evaluate for acute ischemia.

Symmetric reduced diffusion in the basal ganglia and thalami indicates hypoxia/hypoperfusion etiology.

52 yo found down. Unresponsive on ventilator. Evaluate for anoxic injury.

What is the cause of the T2 signal hyperintensity?

Symmetric edema in the basal ganglia and thalamus.

Evaluate for anoxic injury.

52 yo found down. Unresponsive on ventilator: Evaluate for anoxic injury.

Symmetric edema in the basal ganglia and thalamus.

Evaluate for anoxic injury. Evaluate for acute ischemia.

6 day old baby with seizures: Evaluate for acute ischemia.

6 day old baby with seizures: Evaluate for acute ischemia.
DWI: Stroke Summary

17 year old with orbital infection.

DWI: Infection

Bacterial Abscesses

Some types of infections, most commonly bacterial, may become organized within a confined space. The motion of water can become restricted within this confined space.

Multiple ring enhancing brain masses. What is the etiology?

DWI: Infection

Trauma

Infection

Tumor

Stroke

Diffusion Imaging: Brain

Pattern of infarcts can indicate mechanism. Acute infarct: DWI will demonstrate restricted diffusion in acute stroke. DWI is uniquely valuable for evaluation of
DWI: Infection

17 year old with orbital infection.

Empyema!

An abscess or empyema may require emergent surgical drainage.

Acute abscesses will demonstrate central restricted diffusion. Following treatment with antibiotics and/or drainage, abscesses will generally no longer restrict on DWI.

More malignant tumors tend to have less restricted appearances.

Brain tumors may demonstrate a wide range of appearances.

Brain: Tumor

15 year old with scalp swelling.

17 year old with orbital infection.

DWI: Infection

DWI: Tumor

DWI: Brain Tumor

DWI: Brain Imaging: Brain

 DWI: Brain Tumor

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Brain tumors may demonstrate a wide range of appearances on histology. The more tightly packed the tumor cells, the greater the restriction of extracellular water motion.

Low grade tumor - JPA
High grade tumor - Medulloblastoma

Two different patients. Which one has the benign tumor?

A 12-month-old child with desmoplastic infantile ganglioglioma WHO GRADE 1.

Patient A

An 11-month-old boy with atypical teratoid/rhabdoid tumor WHO GRADE 4.

Patient B

Diffusion Imaging for Tumor Grading of Supratentorial Brain Tumors in the First Year of Life

Conclusion: ADC maps can differentiate high-versus low-grade neoplasms for supratentorial tumors presenting in the first year of life.

A few potential exceptions to the rule...
Epidermoid Cyst - Benign

Neuroradiology: DWI Clinical Applications:

**DWI: Trauma**

24 yo with acute trauma/MVA

In the setting of acute trauma, small areas of diffusion restriction in the white matter can indicate diffuse axonal injury (DAI).

**Trauma**

- Tumor
- Infection
- Stroke

**Diffusion Imaging: Brain**

**DWI: Tumor**

Complexity of the cyst restricted diffusion due to the internal Epidermoid cysts may demonstrate reduced diffusion.
**DWI: Neck**

Increasing investigation into the utility of DWI for neck pathology.

**Main focus is with tumor differentiation, or complications of infections.**

**DWI Orbit: Tumor**

Which patient’s tumor is benign?

- **Patient 1:** 7-week-old girl with history of bump on the left eye lid.
- **Patient 2:** 22-month-old girl with history of right eye swelling.

**Final Diagnosis:** Infantile hemangioma.

**Final Diagnosis:** Rhabdomyosarcoma.

**DWI Temporal Bone:**

Cholesteatoma versus effusion or granulation tissue?

**Main focus is with tumor differentiation, or infection pathology.**

**Increasing investigation into the utility of DWI**
Cholesteatomas are similar to epidermoid cysts, and should demonstrate restricted diffusion.

Problem: temporal bone creates artifact limiting visualization on DWI.

Solution: non-EPI DWI or spinal pathology.

Increasing interest in DWI for spinal pathology.

Main areas of utility include detection of acute spinal cord infarct, spinal infection, and spinal cord tumors.

DWI: Spine Acute Infarct
DWI Spine: Infection

Is this fluid an abscess?

Epidural Abscess

Summary

Diffusion can be utilized to provide identification of abscesses in the spine, neck, and lumbar. DWI has most frequent application for acute stroke.

Not everything that shows restricted diffusion is an acute stroke.

Diffusion can be utilized in neuroradiology to provide unique information in the brain, neck, and spine.