Diffusion Weighted Imaging in IBD: An Update

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Overview

• Background
• Does DWI help in IBD imaging?
• Why does it work?
  – How might we use it in the future?
• Beyond the bowel
• Use in clinical practice
Diffusion Weighted Imaging

• Imaging the motion of water molecules
  – Random motion versus impeded motion

• First applications in neuro-imaging
  – Stroke imaging, CNS infections, tumors

• Now widely used in body MRI
  – Especially oncology
Diffusion Weighted Imaging

• DWI in oncologic imaging
  – Most tumors are highly cellular
Background

• What else can DWI be used for?
  – Started to be used in body protocols, including MRE
  – Noticed that bowel segments with other evidence of inflammation also impede diffusion
Research

• Oto, et al 2009
  – 11 adult patients
  – MRE and surgery within 4 weeks
  – Found ↓ ADC in inflamed segments
  – DWI detected 94.7% of inflamed segment
    • ROC = 0.938

Oto A, et al. Acad Radiol 2009
Research

- Ream, et al 2013
  - 46 MRE exams
    - Mean age 14.3
  - Terminal ileal pathology vs. DWI
    - 41 biopsy proven TI disease
  - ↓ ACD correlated with:
    - Bowel wall thickening
    - Arterial enhancement
    - Mesenteric inflammation
    - Stricture

• Tielback, et al 2014
  – 27 adult patients
  – MRE vs. resected specimens
  – ADC correlation was not significant
    • …but very strong trend toward correlation
    • Underpowered?

Why?

• How does bowel inflammation lead to impeded diffusion?
  – No one really knows
    • Cellular theory
    • Fibrosis theory
    • Perfusion theory

Oto A, et al. *Acad Radiol* 2009
Why?

• Cellular theory
  – Inflammation = increased cellularity
    • Impeded diffusion reported in other inflammation
      – e.g., encephalitis, pyelonephritis, etc...
      – ↑ inflammatory cells → ↑ cellularity → impedes diffusion of water

Oto A, et al. Acad Radiol 2009
Morani A, et al. AJR 2015
Why?

• Fibrosis theory
  – Fibrosis has been shown to impede diffusion in cirrhotic livers
  – Inflammation and fibrosis co-exist
    • Adler, et al
Why?

• Perfusion theory
  – DWI information comes from 2 sources
    • Intravascular (perfusion)
    • Extravascular
  – Intravoxel Incoherent Motion (IVIM)

Intravoxel incoherent motion (IVIM)

- DWI with multiple b-values
- Takes into account micro-capillary perfusion and diffusion within a voxel
- May allow a more accurate and reproducible assessment of ADC values
DWI - Perfusion

Perfusion

ADC

b-value
Why?

• Perfusion theory
  – Inflammation $\rightarrow$ increased blood flow
    • $\uparrow$ blood flow = $\uparrow$ micro-capillary perfusion
    • $\uparrow$ perfusion may contribute significant DWI signal
Why?

• High signal on DWI images (↓ ADC) probably comes from all 3 sources
  – ↑ cellularity
  – Perfusion
  – Fibrosis

• Could this be useful?
Future Possibilities...

• Figure out sources for DWI signal
  – Separate signal from fibrosis vs. inflammation?
    • Could allow better treatment planning

• Can we evaluate healing
  – Mucosal healing = biomarker for treatment response and prognosis
    • Could DWI signal changes be a quantitative imaging marker?
Future Possibilities...

• Non-contrast MRE?
  – Do we need gadolinium based contrast?
    • Deposition
    • Rare allergic like reactions
    • Renal dysfunction/NSF
  – Is DWI specific enough to be relied on?
    • Sensitivity doesn’t seem to be an issue
  – Is spatial resolution adequate?
    • Can artifacts be overcome?
Non-contrast MRE?

• Can DWI replace contrast enhanced imaging?
  – Neubauer et al, 2013
    • 33 Crohn disease patients vs. 27 controls
    • DWI correctly identified 32 patients
      – All small bowel lesions detected by both methods
      – Slightly more false positives with DWI
    • CE MR → better spatial resolution

Non-contrast MRE?

- Seo et al, 2016
  - 50 adult Crohn disease patients
    - All had MRE and endoscopy within 7 days
  - Compared CE MR to DWI
  - Agreement in 91.8% of segments
    - Correlation coefficient 0.937 ($p<0.001$)
  - Conclusion: DWI was non-inferior to CE MR in well distended small bowel segments

Additional Uses for DWI

• Penetrating complications
  – Fistula, abscess
    • Addition of DWI increased detection of intra-loop fistulas and sinus tracts in adults with IBD

• Lymph nodes
  – Reactive
  – Infection
  – Malignancy
    • ↑ risk of lymphoma due to therapy

So, where do we stand?
Practical Uses

- How do I use DWI in practice?
  - Qualitative assessment
    - “Screening”
      - Think CAD...
    - Increase reader confidence
  - Extra-intestinal manifestations
    - Abscesses and penetrating disease
    - Perianal disease
    - Lymph nodes
Take Home Points

• Diffusion weighted imaging is useful in pediatric IBD
  – Should be included in MRE protocols

• Current clinical uses are qualitative
  – Detect involved segments, ↑ reader confidence
  – Extra-intestinal manifestations
Take Home Points

• Potential future directions
  – Defining sources of signal
    • Fibrosis vs. inflammation
  – Qualitative imaging biomarker for mucosal healing?

• Avoiding gadolinium contrast?
Thank You

University of Michigan
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Selected References:


