CONTRAST-ENHANCED ULTRASOUND OF THE BOWEL

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  • Siemens Ultrasound
  • Toshiba Ultrasound
  • Bracco Diagnostics
Objectives

• Describe use of contrast-enhanced ultrasound (CEUS) for Crohn’s disease (CD) evaluation:
  – Indications
  – Technique
  – Imaging examples
  – Quantification
  – Literature
CEUS CD Indications

• Assessment of bowel inflammatory activity
  – Follow-up known disease after CTE/MRE?
    • Quantitative biomarker – serial imaging?
  – Early predictor of response to therapy?

• Assessment of CD complications
  – Follow-up penetrating disease (e.g., abscess)
  – Abscess vs. inflammatory mass (phlegmon)
ACR Appropriateness Criteria: Follow-up CD

<table>
<thead>
<tr>
<th>Clinical Condition</th>
<th>Crohn Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variant 6:</td>
<td>Child or young adult with known Crohn disease; stable, mild symptoms and/or surveillance.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR enterography</td>
<td>9</td>
<td>MR enterography may have sensitivity and specificity similar to CT enterography and avoids radiation risks. However, the choice of examination depends on institutional preferences and resources. MRI is the preferred modality for investigating perianal disease. See statement regarding contrast in text under “Anticipated Exceptions.”</td>
</tr>
<tr>
<td>US abdomen and pelvis</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>CT enterography</td>
<td>6</td>
<td>Consider dose reduction techniques. The higher spatial resolution obtained with CT is usually not required for surveillance of areas of known Crohn disease. The RRL for the adult procedure is 😎.</td>
</tr>
<tr>
<td>X-ray small-bowel follow-through</td>
<td>5</td>
<td>😎</td>
</tr>
<tr>
<td>CT abdomen and pelvis (routine)</td>
<td>5</td>
<td>😎</td>
</tr>
<tr>
<td>X-ray abdomen</td>
<td>5</td>
<td>😎</td>
</tr>
<tr>
<td>X-ray contrast enema</td>
<td>4</td>
<td>😎</td>
</tr>
<tr>
<td>Tc-99m HMPAO leucocistography</td>
<td>2</td>
<td>😎</td>
</tr>
<tr>
<td>US pelvis endorectal</td>
<td>2</td>
<td>😎</td>
</tr>
</tbody>
</table>

*Relative Radiation Level

https://acsearch.acr.org/docs/69470/Narrative/
CEUS vs. CTE & MRE

1. Nonionizing
2. Superior contrast resolution
3. Allows real-time assessment of bowel wall enhancement & QUANTITATIVE assessment
4. Lower cost
5. Parent at bedside
6. Portability
7. Lower contrast agent adverse reaction rate?
CEUS vs. color/power Doppler

- Subjective/objective Doppler signal correlates with activity
  - Numerous studies, mostly adults
- Difficult to quantify
  - Color/vessel density?
- No “number” to follow vs. time

CEUS Technique – Preparation

• NPO solids x 4 hours
• No carbonated drinks before exam
• Full bladder can push bowel loops out of pelvis
CEUS Technique – Preparation

• Antecubital peripheral IV catheter
  – 22-gauge or large
  – 3-way stopcock
  – Short extension or no IV tubing set
CEUS Technique – Contrast Injection

• Dose per package insert
  – 1-2 ml, on average (Lumason)
  – May be able to use lower dose depending on US system
• Bolus inject contrast followed by IV flush
  – 5-10 ml; 1-2 ml per sec
CEUS Technique – Imaging

- High-frequency linear transducer
- Perform conventional gray-scale & Doppler assessment on diseased bowel segment
- Perform CEUS on diseased segment
  - Low mechanical index (MI)
  - Long-axis
  - Image for 60-90 sec
CEUS Technique – Contrast Timing

- Arrival: 10-20 sec
- Peak Enhancement: 30-40 sec
- Washout: 60-90 sec
CEUS – Example #1
CEUS – Example #2

Image Courtesy of Kassa Darge, MD, PhD
CEUS Quantification

- US machine vs. 3rd party software
- Most useful parameters?
  - Time to peak/rise time
  - Peak enhancement
  - Area-under-the-curve
CEUS Quantification

Time to Peak

Peak enhancement
Literature

- Paucity of pediatric studies
- Numerous adult studies now show CEUS correlates with small bowel CD inflammatory activity

Conclusion:

Quantitative CEUS parameters integrated into inflammatory assessments with ultrasound reduce indeterminate results and improve disease activity level determinations.
Literature – Predicting Response at 6 Weeks

Table 3

<table>
<thead>
<tr>
<th>Parameter</th>
<th>AUC</th>
<th>Cut-off Value</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak enhancement</td>
<td>0.893</td>
<td>&lt;= -52.24</td>
<td>77.8 (60.8, 89.9)</td>
<td>100 (76.8, 100)</td>
</tr>
<tr>
<td>Wash-in rate</td>
<td>0.829</td>
<td>&lt;= -28.23</td>
<td>86.1 (70.5, 95.3)</td>
<td>85.7 (57.2, 98.2)</td>
</tr>
<tr>
<td>Washout rate</td>
<td>0.889</td>
<td>&lt;= -34.12</td>
<td>77.78 (60.8, 89.9)</td>
<td>100 (76.8, 100)</td>
</tr>
<tr>
<td>Wash-in perfusion index</td>
<td>0.893</td>
<td>&lt;= -53.91</td>
<td>77.8 (60.8, 89.9)</td>
<td>100 (76.8, 100)</td>
</tr>
<tr>
<td>AUC</td>
<td>0.881</td>
<td>&lt;= -26.49</td>
<td>86.1 (70.5, 95.3)</td>
<td>100 (76.8, 100)</td>
</tr>
<tr>
<td>AUC during wash-in</td>
<td>0.868</td>
<td>&lt;= -17.69</td>
<td>77.8 (60.8, 89.9)</td>
<td>100 (76.8, 100)</td>
</tr>
<tr>
<td>AUC during washout</td>
<td>0.889</td>
<td>&lt;= -31.72</td>
<td>86.1 (70.5, 95.3)</td>
<td>100 (76.8, 100)</td>
</tr>
</tbody>
</table>

Note.—Data in parentheses are 95% confidence intervals. The areas under the receiver operating characteristic curve are produced by the different cut-off values of the percent increase of AUC, AUC during wash-in, and AUC during washout.
Literature – Abscess vs. Phlegmon

• 71 collections/inflammatory masses in 50 patients
• CEUS specificity for abscess 100%
• Significant size difference before vs. after contrast
Imminent Study at CCHMC

- IRB-approved
- 25 pediatric patients with known moderate/severe CD undergoing CTE/MRE will undergo contemporaneous CEUS
- CTE/MRE results to be compared with CEUS
- Assess agreement between two separate boluses
Conclusions

• CEUS of the bowel is feasible in children
• Likely quantitative biomarker of disease activity
  – Correlation with CTE/MRE?
  – Early predictor of therapy response?
  – Reproducibility/repeatability?
• Allows discrimination of phlegmon vs. abscess