Advances in Imaging Technology
In The Management of Colorectal Cancer

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Massachusetts General Hospital
Harvard Medical School
>150,000 patients diagnosed each year with CRC

> 55,000 deaths in 2006-2007 from CRC
Colorectal Cancer Screening
Multiple studies demonstrated that 80% CRC originate from a precursor lesion.
Risk of Cancer very low in polyps < 1 cm

Adenomatous polyp

Early detection and removal of these lesions can be preventative of colon cancer

Muto T et.al. Cancer 1975

Winawer SJ. Am J Med 1999
## CRC: Pattern of Spread

<table>
<thead>
<tr>
<th>Modified Duke</th>
<th>TNM</th>
<th>5 year survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>85-100%</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>30-70%</td>
</tr>
<tr>
<td>D</td>
<td>3</td>
<td>20-50%</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>0-5%</td>
</tr>
</tbody>
</table>
Higher local failure in locally advanced rectal cancer (T3/T4 and/or N disease)

1. Lack of serosal layer
2. Complex anatomy (levator, pelvic sidewall)
Prognostic Indicators in Rectal Cancer

- **Tumor**
  - Level of tumor invasion
  - Depth of extramural spread
  - Mesorectal fascia involvement (CRM)

- **Node involvement**

- **Distant Metastasis**
Role of Imaging in CRC

- **Staging (TNM)** - Influences management
  - **Tumor stage** -
    - Rectal wall invasion and local spread
    - Rectum T1/T2: Local resection
    - T3 and beyond: ChemoXRT
  - **Nodes**: Regional vs Distant
  - **Metastases**: Hepatic vs. Extrahepatic
MDCT: CRC *Survey* Exam
MDCT: CRC Survey Exam
MDCT for Liver Resection Planning

Sahani et al. AJR 2002
MDCT: Mapping Hepatic Vascular Anatomy

Sahani et al. AJR 2002; Kapoor et al AJR 2005; Sahani et al. JCAT 2005
MDCT: CRC Staging

- CT Accuracy
  - Overall: 48-74%
  - Liver: 78%
  - Extrahepatic: 71%
  - Lymph nodes: 23-73%
CT: Limitations

- T2 or T3-T4
- Nodal disease
- Metastases
Rectal Cancer: Local staging
**T-stage: Endorectal Coil MR**

- Superior SNR and resolution
- Permits visualization of layers of rectum
- Enables differentiation of T1-T2 from T3-T4 disease
- Visualization of mesorectal fascia and anal sphincter
# T-stage Accuracy of MRI (64-90%)

<table>
<thead>
<tr>
<th>Study</th>
<th>EUS</th>
<th>MRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zagoria et al 1997</td>
<td>70%</td>
<td>80%</td>
</tr>
<tr>
<td>Kim 1999</td>
<td>81%</td>
<td>81%</td>
</tr>
<tr>
<td>Hunerbein 2000</td>
<td>84%</td>
<td>91%</td>
</tr>
<tr>
<td>Fuchsjager 2003</td>
<td>64%</td>
<td>64%</td>
</tr>
</tbody>
</table>
Optimal Endorectal Coil Positioning
High Rectal Lesions
T-stage: MR vs. EUS

- T-staging accuracy
  - MR 84.6 %
  - EUS 76.9 %

- MR less operator dependent

- Preferred by surgeons

- Tumor penetration of the rectal wall

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MR</strong></td>
<td>86 %</td>
<td>65 %</td>
</tr>
<tr>
<td><strong>EUS</strong></td>
<td>89 %</td>
<td>33 %</td>
</tr>
</tbody>
</table>

T-stage: Phased Array Surface Coil MR

- High-resolution technique comparable to Endo-MR for T-stage (T3-T4)
- Superior display of tumor & mesorectal fascia (MRF)*
- Nodal disease is better predicted **
- Patient compliance


MR Technique

• Combined pelvic phased array and endorectal coils
  – No bowel prep
  – First endo-rect coil inserted
    • Lidocaine gel
  – Pelvic phased array coil is then placed
MRI Technique

• Multiplanar T2-FSE with no FS
  – TR/TE: 4500-5500/102ms
  – ETL: 16
  – FOV: 14-16
  – MATRIX: 256X 256

• Axial T1 SE
  – TR/TE: 600/11
  – FOV: 14
  – Matrix 256 x 256

• Axial/cor/sag post Gd-T1-SPGR FS 2d/3D
  – TR/TE: 240/4.2
  – FA: 75
# T-stage Accuracy: Endo-MR Vs Phased MR (70-85% Vs. 71-89%)

<table>
<thead>
<tr>
<th>Study</th>
<th>Endo-MRI</th>
<th>Phased-MRI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2005</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oberholzer K. JMRI.</td>
<td>70%</td>
<td>71-89%</td>
</tr>
<tr>
<td>Bianchi PP. J Gastrointest Surg.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2004</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akin O. Clin Imaging.</td>
<td>85%</td>
<td>75%</td>
</tr>
<tr>
<td>Bipat S. Radiology.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Endo-MR T2 vs. T3 Disease

? T3

T3
T-stage: Phased Array Surface Coil MR

- N=99 TME with detailed histo-path evaluation
  - MRI 94% agreement for T-stage with pathology
  - Extra-mural venous invasion 15/18

Circumferential Resection Margin (CRM)

- Positive tumor/node < 1mm of MRF
  - Predicts local recurrence
- MRI predicted CRM with 92% agreement with histopathology*

## T-stage Accuracy of MRI (52-97%)

<table>
<thead>
<tr>
<th>Study</th>
<th>EUS</th>
<th>MRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td></td>
<td>52-92%</td>
</tr>
<tr>
<td>MERCURY Study. Radiology Hancock L. Colorectal Dis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>88-97%</td>
<td>78-97%</td>
</tr>
</tbody>
</table>
Rectal CA-3T MR

Improved SNR
N-stage: MR

- Node +ve: adverse prognosis
- Nodes near MRF can threatens CRM
- Node size unreliable for characterization
  - 3-6 mm indeterminate
  - > 6 mm suspicious
  - > 8 mm malignant
- Signal or contour abnormality are better predictors
  - 85 % agreement with pathology

# N-stage Accuracy of MRI and EUS (60-75%)

<table>
<thead>
<tr>
<th>Study</th>
<th>EUS</th>
<th>MRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td></td>
<td>60%</td>
</tr>
<tr>
<td>Hancock L. Colorectal Dis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>60-74%</td>
<td>65-75%</td>
</tr>
<tr>
<td>Siddiqui AA. Int Semin Surg Oncol.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tatli S. JMRI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kim JC. Am J Surg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>64-76%</td>
<td>62%</td>
</tr>
<tr>
<td>Oberholzer K. JMRI.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bianchi PP. J Gastrointest Surg.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Koh DM. Eur Radiol.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
N Stage - DWI for Lymph node characterization
N-Stage:

Pre USPIO  

Malignant

Post USPIO  

Malignant

Courtesy: A.Padhani – UK
M-Stage : Liver Metastases

- 60% pts of CRC develop liver metastasis
- Untreated: Median survival 6-12 mts, no survivors at 5 yrs
- Surgery: 66% 2 yr and 33% 5 year survival

Homsi J, Garrett CR. Cancer Control 2006;13:42-47
Cohen AD, Keneny NE. Oncologist 2003;6:553-66
Liver Surgery: Considerations

• Poor prognostic factors
  • Tumor > 7 cm
  • Multiple lesions
  • Tumors involving > 2 segments
  • Requiring major hepatectomy

Homsi J, Garrett CR. Cancer Control 2006;13:42-47
Cohen AD, Keneny NE. Oncologist 2003;6:553-66
Marrero JA. Current opinion in Gastroenterology 2006;22:248-253
CRC Metastases: Right Hepatectomy
CRC Metastasis

Hepatic Resection Possible
“Lesion Is Too Small To Characterize”

CECT Vs. MRI

Lesions > 1.5 cm can be routinely characterized on a dual MDCT
Small Lesion Detection: CT Vs. MR

CT can confidently detect > 80% of lesions > 1.5 cm.

In fatty liver, hypovascular lesions are less conspicuous on CT.
M-Stage: CT and MR

CECT

MR
<table>
<thead>
<tr>
<th>Studies</th>
<th>Assessment</th>
<th>Accuracy</th>
<th>&lt; 1cm lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bartolozzi et al. (2004) CRC</td>
<td>Unenhanced MR</td>
<td>92/128 (72%)</td>
<td>24/47 (51%)</td>
</tr>
<tr>
<td></td>
<td>Mn-DPDP MR</td>
<td>115/128 (90%)</td>
<td>39/47 (83%)</td>
</tr>
<tr>
<td></td>
<td>CT</td>
<td>91/128 (71%)</td>
<td>17/47 (38%)</td>
</tr>
<tr>
<td>Kim MJ et al. (2004)</td>
<td>MnDPDP MR</td>
<td>92/121 (76%)</td>
<td>76%</td>
</tr>
<tr>
<td></td>
<td>SPIO-enhanced.</td>
<td>105/121 (87%)</td>
<td>87%</td>
</tr>
<tr>
<td>Ward J et al. (2003) CRC</td>
<td>PC-T2W-FSE CE-MR</td>
<td>83/101 (81%)</td>
<td>22/27 (82%)</td>
</tr>
<tr>
<td></td>
<td>Unenhanced MR</td>
<td>92/101 (92%)</td>
<td>24/27 (92%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80/101 (79%)</td>
<td>21/27 (81%)</td>
</tr>
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### M-stage: MR vs. FDG-PET

<table>
<thead>
<tr>
<th></th>
<th>FDG-PET</th>
<th>MRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metastases:</td>
<td>65</td>
<td>88</td>
</tr>
<tr>
<td>Lesions &lt;1cm:</td>
<td>12</td>
<td>33</td>
</tr>
</tbody>
</table>

Sahani DV et al. AJR 2005
M-Stage: Role DWI imaging
Role of PET/PET-CT in CRC

- Restaging recurrent disease
  - Johnson et al *Dis Col Rectum* 2001
- Before surgery with curative intent
- Increased CEA with inconclusive conventional workup
- Evaluation of equivocal findings on other imaging
Colorectal Recurrence
Equivocal CT findings

- 55yo M s/p APR presacral soft tissue abnormality – post op vs recurrence?
Rising CEA
Inconclusive CT

60 yo M s/p APR
with chemo and XRT
with rising CEA
# Role of CT and PET in CRC

<table>
<thead>
<tr>
<th>Care path in CRC</th>
<th>CT</th>
<th>PET</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Accuracy</td>
<td>Accuracy</td>
</tr>
<tr>
<td></td>
<td>Sensitivity</td>
<td>Specificity</td>
</tr>
<tr>
<td>Pre-operative staging</td>
<td>48 to 77%</td>
<td>83 to 95%</td>
</tr>
<tr>
<td>Recurrent CRC</td>
<td>46 to 69%</td>
<td>96%</td>
</tr>
<tr>
<td>Liver Metastases</td>
<td>38 to 79%</td>
<td>97%</td>
</tr>
<tr>
<td>Lymph Node Metastases</td>
<td>22 to 73%</td>
<td>96%</td>
</tr>
</tbody>
</table>

Data obtained from meta-analysis of 11 studies
Newer Treatments: Neoadjuvant options with therapies targeting neoangiogenesis

Conventional methods of monitoring treatment response is less effective or inaccurate
CTp Technique
Average blood flow reduction of 36%

*Willett CG et al. Nat Med. 2004 Feb;10(2):145-7*
Monitoring Antiangiogenic (Avastin) Response in Rectal Cancer

Rectal Cancer: CTp changes following Treatment

Sahani. SCBT/MR 2007
### Predicting Response: Baseline CTp

- **Response:** Downstage of T-stage on pathology from pre treatment

<table>
<thead>
<tr>
<th>Perfusion Parameter</th>
<th>Responders 10/16</th>
<th>Non-responders 6/16</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BF</td>
<td>67.5 ±10.6</td>
<td>87.3 ±18.8</td>
<td>0.02</td>
</tr>
<tr>
<td>MTT</td>
<td>9.1 ± 1.9</td>
<td>6.3 ± 3.0</td>
<td>0.04</td>
</tr>
</tbody>
</table>

*Sahani. SCBT/MR 2007*
Perfusion CT: Response to Therapy CXRT

Summary

• Initial CRC staging
  – CT: Survey
  – MR: T-N staging, liver

• PET/CT is a combination of two powerful, complementary modalities
  – Tumor recurrence/Metastases

• Monitoring Angiogenesis is feasible with CT/MR
Summary

• **High-resolution MRI is highly accurate for preoperative staging**
  – Allows identification of critical prognostic risk factors

• **Impacts selection of appropriate management protocol and surgical planning**

• **Accurate assessment of nodal disease remains a challenge**
  – DWI and Lymphotropic MR contrast agent appear promising for lymph node characterization