“Bottoms Up”
Review of Rectal MRI Technique, Protocol, and Interpretation
An Educational Session for Technologists and Radiologists

ZAHRA KASSAM
Southwest Regional Lead
Cancer Imaging Program, Cancer Care Ontario
Objectives

- Review the **utility of MRI** as the primary presurgical staging modality for rectal cancer.
- Discuss **MRI protocol**, relevant anatomy, and sequence planning.
- Discuss **pearls and pitfalls** in interpretation, utility of MCCs.
- **Synoptic Reporting** – why do we have it, and what’s new in 2016?
Why is MRI staging important?

• Stratifies patients for neoadjuvant CRT vs. surgical management
• Evaluates local extent of disease
• Assesses sphincter involvement
  – Is the patient a candidate for sphincter-sparing surgery?

Graphic courtesy of www.radiologyassistant.nl
The Radiologist’s Goal

**Accuracy of Staging**
- Achieve consistency and high interobserver agreement

**Streamlined treatment planning**
- Avoid repeating MRI prior to surgery

**Establish standardization**
- Referrals, technique, and reporting
- Ontario Cancer Plan
OCPIV Goals and CIP Priority Areas

Quality of life & patient experience

- **GOAL**
  - Ensure the delivery of responsive and respectful care, optimizing individuals' quality of life across the cancer care continuum

  - Patient-centred wait times (IR targets)
  - Support providers/patients with tools for decision making, communication

Safety

- **GOAL**
  - Ensure the safety of patients and caregivers in all care settings

  - Tools to help adherence to evidence-based guidance
  - PET QA best-practices
  - Standardized protocols

Equity

- **GOAL**
  - Ensure health equity for all Ontarians across the cancer system

  - Programs to improve access to specialized services
  - Assess, expand, enhance and utilize data

Integrative care

- **GOAL**
  - Ensure the delivery of integrated care across the cancer care continuum

  - Enhanced communication for smoother transitions

Sustainability

- **GOAL**
  - Ensure a sustainable cancer system for future generations

  - Strengthen system ability to ensure resources are most optimally utilized

Effectiveness

- **GOAL**
  - Ensure the provision of effective cancer care based on best evidence

  - Leverage and expand evidence-based guidance
  - Foundation (data) for quality improvement, patient-specific indicators

CIP Priority Areas

- Appropriateness
- Timely Access
- Synoptic Reporting
- Evidence-Based PET
- Focal Ablation

Cancer Care Ontario
Background & Anatomy
## Anatomy of the Rectum

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extends from</td>
<td>Appx. 16 cm in length</td>
</tr>
<tr>
<td>upper end of anal canal</td>
<td></td>
</tr>
<tr>
<td>to rectosigmoid junction</td>
<td></td>
</tr>
<tr>
<td>Divided into thirds</td>
<td>Lower 1/3 = 0-5 cm</td>
</tr>
<tr>
<td></td>
<td>Middle 1/3 = 6-10 cm</td>
</tr>
<tr>
<td></td>
<td>Upper 1/3 = 11-16 cm</td>
</tr>
<tr>
<td>Low sigmoid vs. high</td>
<td>Draw a line from sacral promontory to symphysis pubis</td>
</tr>
<tr>
<td>rectal?</td>
<td></td>
</tr>
</tbody>
</table>

Graphic courtesy of [www.radiologyassistant.nl](http://www.radiologyassistant.nl)
Mesorectum

- Fatty tissue “envelope” surrounding rectum
  - Contains lymph nodes, blood vessels, fat & fibrous septa
  - Surrounded by mesorectal fascia
    - For simplicity, corresponds to circumferential radial margin
    - Low signal on T2
Definitions

**TME = Total Mesorectal Excision**
- Resection of tumor and surrounding fat
- Cure rate for low T-stage approaches 90% with surgery alone

**MRF = Mesorectal Fascia**
- Thin envelope containing perirectal fat, blood vessels, nerves and lymph nodes

**CRM = Circumferential Radial Margin**
- Plane of resection used during surgery - often depends on tumor location
Current Operative Management

**T1 lesions:**
- Transanal endoscopic microsurgery
- Transanal local excision

**T2 and early T3 lesions:**
- Total mesorectal excision (TME)

**Advanced T3/T4 lesions:**
- Neoadjuvant therapy ± TME
Total Mesorectal Excision

Graphic courtesy of www.radiologyassistant.nl

Mesorectal fascia (MRF)
Threatened Surgical Planes - MRF

- Presacral fascia
- Tumor extension anterior to Denonvillier’s fascia
- Lateral MRF separates mesorectum from neurovascular bundles
- Serosa above the peritoneal reflection covers bowel

Adapted from Dr. Blair MacDonald
Anatomical Landmarks

- ink the bare areas (non-peritonealized margins) below the peritoneal reflections

Distance to the MRF only applies to non-peritonealized areas

Upper rectum also has a serosal margin
**Primary Tumor (T)**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TX</td>
<td>Primary tumor cannot be assessed</td>
</tr>
<tr>
<td>T0</td>
<td>No evidence of primary tumor</td>
</tr>
<tr>
<td>Tis</td>
<td>Carcinoma in situ: intraepithelial or invasion of lamina propria¹</td>
</tr>
<tr>
<td>T1</td>
<td>Tumor invades submucosa</td>
</tr>
<tr>
<td>T2</td>
<td>Tumor invades muscularis propria</td>
</tr>
<tr>
<td>T3</td>
<td>Tumor invades through the muscularis propria into pericolorectal tissues</td>
</tr>
<tr>
<td>T4a</td>
<td>Tumor penetrates to the surface of the visceral peritoneum²</td>
</tr>
<tr>
<td>T4b</td>
<td>Tumor directly invades or is adherent to other organs or structures²³</td>
</tr>
</tbody>
</table>

---

**T4a tumor penetrates through anterior rectal wall and visceral peritoneum**

*Slide courtesy of Dr. Blair MacDonald*
MRI Protocol

Graphic courtesy of www.radiologyassistant.nl
Ordering and Sequence Planning

RECTAL MRI FOR CANCER STAGING
Clinical Information Form

Dear Physician,

Thank you for completing the information below when ordering an MRI of the Rectum for staging of rectal carcinoma. This greatly facilitates the radiologist's interpretation.

Please fax this form to bookings, along with the general MR requisition for the appropriate site.

1. Does the patient have biopsy-confirmed rectal carcinoma?
   - Yes
   - No

2. Is the tumor palpable on DRE?
   - Yes
   - No
   - Distance from anal verge: _______ cm

3. If the patient has had previous therapy, please complete the following:
   (a) Surgery:
      - Date of surgery: ______________
      - Type of surgery: ______________

   (b) Chemotherapy:
      - Date of last cycle: ______________

   (c) Radiotherapy:
      - Date of last treatment: ______________

   (d) Histology:
      - Mucinous
      - Non-mucinous

4. Additional pertinent clinical information (optional):
   - _______
   - _______

When possible, please indicate tumor location on diagram above (for MRI planning purposes)
   - Unable to assess
What clinical information is needed?

- General tumor location, i.e. distance from anal verge
  - Important for planning of the MR study
- Biopsy proven primary rectal cancer?
- Mucinous vs. non-mucinous
  - May change MR protocol

RECTAL MRI FOR CANCER STAGING
Clinical Information Form

Dear Physician,

Thank you for completing the information below when ordering an MRI of the Rectum for staging of rectal carcinoma. This greatly facilitates the radiologist’s interpretation.

Please fax this form to bookings, along with the general MRI requisition for the appropriate site.

1. Does the patient have biopsy-confirmed rectal carcinoma?  □ Yes □ No
2. Is the tumor palpable on DRE?  □ Yes □ No
   Distance from anal verge: ______ cm
3. If the patient has had previous therapy, please complete the following:
   (a) Surgery:
      Date of surgery:___________
      Type of surgery:___________
   (b) Chemotherapy:
      Date of last cycle:___________
   (c) Radiotherapy:
      Date of last treatment:___________
   (d) Histology:
      Mucinous □
      Non-mucinous □

When possible, please indicate tumor location on diagram above (for MRI planning purposes)
□ Unable to assess

4. Additional pertinent clinical information (optional):
## MR Protocol

### CCO recommendations 2015

<table>
<thead>
<tr>
<th></th>
<th>Patient preparation</th>
<th>Sequences</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Required</strong></td>
<td>-</td>
<td>High resolution, non-fat saturated T2-weighted sequences perpendicular to the long axis of the rectum, using phased array coil</td>
</tr>
<tr>
<td><strong>Recommended</strong>*</td>
<td>Antiperistaltics (buscopan)</td>
<td>-</td>
</tr>
</tbody>
</table>
| **Optional**     | • Pre-procedure enema  
                  • Luminal distention  
                  • IV contrast       | DWI +Gd T1                                                           |
| **Not routinely recommended** |                       | Fat saturated T2 sequences                                                 |
## Optimal Protocol Specifications

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Imaging Plane</th>
<th>TR/TE</th>
<th>FOV (cm)</th>
<th>Section Thickness (mm)</th>
<th>Matrix Size</th>
<th>ETL</th>
<th>NSA</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sagittal</td>
<td>2500-5000/85</td>
<td>24</td>
<td>22</td>
<td>512x256</td>
<td>8</td>
<td>2</td>
<td>Allow visualization of the tumour</td>
</tr>
<tr>
<td>2</td>
<td>Axial</td>
<td>4000/85</td>
<td>24</td>
<td>22</td>
<td>512x256</td>
<td>8</td>
<td>2</td>
<td>Pelvic sidewall to sidewall, from iliac crest to symphysis pubis</td>
</tr>
<tr>
<td>3</td>
<td>Oblique axial</td>
<td>4000/85</td>
<td>16 (20 for 1.0T machines)</td>
<td>3-0</td>
<td>256x256</td>
<td>8</td>
<td>4</td>
<td>Through tumour and perirectal tissues, perpendicular to long axis of rectum</td>
</tr>
<tr>
<td>4</td>
<td>Coronal oblique</td>
<td>4000/85</td>
<td>16 (20 for 1.0T machines)</td>
<td>3-0</td>
<td>256x256</td>
<td>8</td>
<td>4</td>
<td>For low rectal tumours (at or below origin of levators)</td>
</tr>
</tbody>
</table>
Sample MR Protocol

St. Joseph’s Hospital, London

- Buscopan 20 mg IV/IM, No Gd for routine cases
- Ax T1/T2 TSE whole pelvis
- Sag T2 TSE 240 mm FOV
- Axial oblique T2 TSE 220 mm FOV (3/0)
- Coronal oblique T2 TSE 220 mm (3/0)
- Axial whole pelvis DWI
  - B values 0, 250, 500, 1000 + ADC map
Sequence planning
Pitfalls in Angulation

Improper angulation leads to overstaging, with presumed extension beyond MRF (T3)

Proper angulation reveals a T2 lesion
A “C-shaped” Tumor

Required 2 angles
Troubleshooting: Endoluminal Contrast

Retroverted uterus, with fundus contacting and compressing rectal mass. Difficult to stage

Ultrasound gel distends rectum and displaces retroverted uterus anteriorly, thereby eliminating extrinsic compression of tumor
Troubleshooting: Endoluminal Contrast

Without endoluminal contrast

With endoluminal contrast
Diffusion Weighted Imaging

Indications

- Useful to screen for small, difficult to visualize tumors
- Can provide information similar to IV contrast
Example of DWI in Rectal Cancer
Multiparametric Analysis

T2

ADC

PET

mMR
MRI Interpretation: Pearls and Pitfalls
### What am I supposed to be looking at?

| **Tumor location**                | • Relationship to anal sphincter, verge  
|                                 | • Pelvic sidewall involved?            |
| **Tumor morphology**             | • Signal intensity, surface ulceration  
|                                 | • Mucinous composition? (high T2 signal) |
| **Local extent**                 | • T-stage, EMDI                        |
|                                 | • Disease outside circumferential radial margin |
| **Metastatic spread & biomarkers**| • N-stage, adjacent tumor deposits, extramural vascular invasion |
Distance from anal verge

- Measure along a straight line (like rigid scope) to the lower, rolled border of the tumor.
- The top of puborectalis sling is 35 – 42 mm above the anal verge.

Image courtesy of Dr. Blair MacDonald
Anterior peritoneal reflection:
Look for disappearing anterior fat
T2 vs. T3 disease
Why is this so important?

T2/early T3 – surgical

T3 – prognosis worsens as extramural depth of invasion increases

- Some centres treat early T3 disease like T2
- Advanced T3 disease requires neoadjuvant chemoradiation
T3 disease

- Extension of tumor into the perirectal fat
- Extension of the tumor should have a \textit{rounded} or \textit{nodular} border
- Should be continuous with the main tumor itself
Pitfall: Desmoplastic T2 vs. T3

Linear spicules represent desmoplastic reaction in a T2 tumor. T3 lesion shows nodular, convex extension beyond the muscularis propria.
T2 vs. T3

Fibrous, desmoplastic reaction

Nodular tumor extension

Adapted from Dr. Blair MacDonald
T2 vs. T3

Definite T3
- Tumor bulge into perirectal fat
- PPV T3 = 99%
- Nodular growth into perirectal fat
- PPV T3 = 94%

“Advanced T2/early T3”
- Spiculation in perirectal fat
- PPV T3 = 51%

T2 vs. Early T3

MR stage T2; pT3a
Deciding between T2 & T3 – Pearl

**Ulcerated masses**
- When T-staging, look at the deepest part of the ulcer
- Invasion should occur there first (less protection)
- If fat is clean deep to the ulcer, more likely T2

**If still unsure**
- “T2 vs. early T3”
- Management may not change

T3b Ulcerated Tumor
Extramural Depth of Invasion (EMDI) and T3 disease

- **T3a**: <1 mm EMDI (prognosis similar to T2)
- **T3b**: 1-5 mm EMDI – good prognosis
- **T3c**: 5-15 mm EMDI – poor prognosis
- **T3d**: >15 mm EMDI – worse prognosis
Measuring EMDI and distance to MRF

Images courtesy of Dr. Blair MacDonald
Measuring distance to MRF

*Always measure the shortest distance at the tumor/fat interface*

Images courtesy of Dr. Blair MacDonald
Distinction: CRM+ or CRM-

- ≤ 1 mm between tumor and MRF highly predictive for **positive** CRM
- ≥5 mm between tumor and MRF highly predictive for **negative** CRM
Low rectal tumors

- Lower extent of tumor is *at or below* the top border of the puborectalis
- **Worse prognosis**
  - Higher rate of recurrence because mesorectal fat tapers inferiorly
  - Less inherent protection
  - Involvement of anal sphincter complex not currently included in TNM classification
- **Need to see**
  - Levators
  - Sphincter complex
  - Intersphincteric plane
  - Relationship to rectal wall

Graphic courtesy of www.radiologyassistant.nl
Anatomy of the Low Rectum
FIGURE 1. A, Diagrammatic coronal oblique view through long-axis of the anal canal. Low rectal cancer is defined as adenocarcinoma with an inferior tumor edge less than 6 cm from the anal verge, anatomically represented by a line between the origins of the levator muscle (horizontal beige line). The horizontal black line (1 cm above puborectalis sling) represents the site between the mesorectal fascia plane and the intersphincteric plane. MRI evaluation of the mesorectal fascia (dashed green line) has been validated previously. This study aimed to validate a previously reported technique for MRI assessment of the intersphincteric plane (dashed red line). Low rectal cancer circumferential resection margin involvement may occur at the mesorectal fascia plane or at the intersphincteric plane (B). When tumor extends beyond muscularis propria/internal sphincter the intersphincteric plane is “unsafe” (C); therefore, preoperative therapy and an ELAPE (dashed blue line) is recommended. When the intersphincteric plane is “safe” (D), an intersphincteric resection (dashed green line) ± anastomosis is feasible.
Reporting of low rectal cancer in 2015

Provide a “level” rather than a “T-stage”

iii) For low rectal tumors (maximum tumor depth at or below the puborectalis sling):

- Not applicable (tumor above the puborectalis sling)
- Level 1 (submucosa only, no involvement of internal sphincter)
- Level 2 (confined to the internal sphincter; no involvement of intersphincteric fat)
- Level 3 (intersphincteric fat involved)
- Level 4 (involves external sphincter or beyond)
Involvement of the levator and intersphincteric plane – Level 4
## N-Staging

Predictors of malignancy – what we use

<table>
<thead>
<tr>
<th>N+ disease in rectal Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>25% measure &lt;5 mm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>“Suspicious” nodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irregular border</td>
</tr>
<tr>
<td>Mixed signal intensity</td>
</tr>
<tr>
<td>Size &gt; 5 mm (short axis)</td>
</tr>
<tr>
<td>Sens 85%, Spec 97%</td>
</tr>
</tbody>
</table>

### Pearls
- Look for “polka dots” of low signal inside node – even in nodes <5 mm, this is suspicious
- +ve Nodes outside MRF – non-surgical

### Pitfall – mucinous nodes

Brown, G. et al
Radiology. 2003; 227: 371-377
Mucinous Tumor & Nodes

- “Watery”, bright on T2
- Easy to miss if you’re not looking
- IR or SPAIR helpful for detection
The “Polka-Dot Node” Sign

- Large nodes – 17 mm short axis
- “Normal” size node – 5 mm short axis
Extramural Vascular Invasion

- Presence of tumor cells beyond muscularis propria, in endothelium lined vessels
- Vessel = tubular structure containing signal void on T2
- Lack of signal void or enlarged vessel suggests invasion
- Biomarker of poor prognosis
Liver Metastases in CRC

Not necessarily “end stage” anymore...

- 50% patients with CRC will develop liver metastasis
- Mean survival time for untreated liver metastases is 6-13 months
- Liver resection increases 5-year survival rate from 0-1% to ≈ 50%
Reporting liver mets - “Must-do’s”

- Number of lesions
- Affected & spared segments
- 2D/3D size of largest lesion
- Location relative to portal and hepatic veins
- Distance from liver capsule to liver lesion (depth)

Image credit: RadiologyAssistant.nl
Synoptic MRI Reporting
OCPIV Goals and CIP Priority Areas

**Quality of life & patient experience**

**GOAL**
Ensure the delivery of responsive and respectful care, optimizing individuals’ quality of life across the cancer care continuum

- Patient-centred wait times (IR targets)
- Support providers/patients with tools for decision making, communication

**Safety**

**GOAL**
Ensure the safety of patients and caregivers in all care settings

- Tools to help adherence to evidence-based guidance
- PET QA best-practices
- Standardized protocols

**Equity**

**GOAL**
Ensure health equity for all Ontarians across the cancer system

- Programs to improve access to specialized services
- Assess, expand, enhance and utilize data

**Integrated care**

**GOAL**
Ensure the delivery of integrated care across the cancer care continuum

- Enhanced communication for smoother transitions

**Sustainability**

**GOAL**
Ensure the delivery of integrated care across the cancer care continuum

- Strengthen system ability to ensure resources are most optimally utilized

**Effectiveness**

**GOAL**
Ensure the provision of effective cancer care based on best evidence

- Leverage and expand evidence-based guidance
- Foundation (data) for quality improvement, patient-specific indicators

CIP Priority Areas

- **APPROPRIATENESS**
- **TIMELY ACCESS**
- **SYNOPTIC REPORTING**
- **EVIDENCE-BASED PET**
- **FOCAL ABLATION**
Where do I find the synoptic report?

The Cancer Imaging Program has developed two white papers regarding synoptic reporting:

1. **Synoptic Radiology Reporting: Clinical Checklist Development Governance**
   - Provides a clear methodology for a systematized approach to clinical checklist development for synoptic radiology reports (accessible version - Clinical Checklist Development Governance)

2. **Synoptic Radiology Reporting for Cancer Imaging - The Architecture of a Cancer Imaging Synoptic Report**
   - White paper to guide template development for radiology synoptic reporting (accessible version - Architecture of a Cancer Imaging Synoptic Report)

The Cancer Imaging Program also has an MRI Rectal Staging Template.

The template is to be used by oncology specialists to assist with neoadjuvant chemo radiation decisions, and preoperative planning for patients with adenocarcinoma of the rectum (who are being considered for total mesorectal excision with or without abdominal perineal resection).

It is also a key communication tool to inform treatment and prognostic discussions at multidisciplinary cancer conferences. The accompanying support material provides the description of terms, evidence basis, and limitations.

- MRI Rectal Staging Template
- MRI Rectal Staging Template User’s Guide
- MRI Rectal Template Revision Summary
Drivers and Contributors to a New Report

MRI Rectal Staging Report - version 2

- New CCO Cancer Imaging Program, Engagement of Leads
- Increasing experience from adopters at 14 provincial cancer programs
- Feedback from Dr. Gina Brown and comparison with MERCURY proforma reports
- CPAC, Quick Silver national projects revises synoptic report
- New innovations in synoptic reporting, voice recognition, MR technology
- New literature, tacit knowledge, research opportunities
Summary of changes

• Formatting with headings: Clinical information, Procedure description, Findings, and Impression

• Re-ordered some of the fields to match radiology read out logic and group similar fields

• Remove or change fields that were confusing

• New description of depth of invasion of the anorectal tumors using levels, to avoid confusion with T-Criteria

• Add some options to control the (synoptic) language in the majority of fields allow for complete list of choices.
Synoptic report

What do the clinicians want to know?

- Please give a T-stage and N-stage
- State whether the CRM is positive or negative
- Comment on whether there is extramesorectal disease
Multidisciplinary Case Conferences (MCCs)
What happens at MCC?

• Increasing body of evidence to show that MCCs lead to improved clinical outcomes
• Little evidence reporting how MCCs lead to these improvements
• Few studies report the quality of the MCC or compliance of final with MCC recommendation
• Few studies report the quality of care received by patients
Effect Of Multidisciplinary Cancer Conference (MCC) On Treatment Plan For Patients With Primary Rectal Cancer

Snelgrove R. Diseases of the Colon and Rectum 2015

- Rectal cancer MCC led to 30% change of initial treatment strategy
  - 7/42 changed to primary surgery
  - 5/42 changed to preCRT or chemotherapy
  - ~40% of changes were due to re-interpretation of the MRI

Please attend your local MCCs! They are an excellent vehicle for learning and CME.
Summary

As the primary pre-surgical staging modality for rectal cancer, high quality, accurate MRI is crucial for staging.

Keys to success: (1) Consistent MRI protocol/reporting; (2) Dialogue between technologists and radiologists, and amongst multidisciplinary team; (3) Follow-up of challenging cases.


MCCs make all of us better radiologists, and improve patient outcomes.