HIPEC and Peritoneal Carcinomatosis: Evolving Role of Imaging in Defining Treatment

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Target Audience
Practicing radiologists, fellows, residents

Learning Objectives

▸ To review pathophysiology of peritoneal tumors, and patient selection for cytoreductive surgery (CRS) and hyperthermic intraperitoneal chemotherapy (HIPEC).

▸ To review how CRS and HIPEC are performed, highlighting pathophysiologic and anatomic factors that complicate successful treatment.

▸ To provide an image-based glossary of terms used for reporting and staging of peritoneal disease.

▸ To review emerging reporting guidelines for peritoneal disease and examine their reproducibility.

▸ To provide a time-efficient method for anatomic surveillance and staging of peritoneal disease.

Disclosures
No relevant financial disclosures
Distribution pattern reflects interaction of cell adhesion molecules with peritoneal structures and peritoneal fluid dynamics.
CRC/HIPEC CANDIDATES

SEPARATE CONDITIONS

PSEUDOMYXOMA PERITONEI (PMP) AKA “JELLY BELLY”

MUCIN PRODUCING TUMORS

PRIMARY PERITONEAL SEROUS CARCINOMA (PPSC)

MESOTHELIOMA

PERITONEAL CARCINOMATOSIS

PRIMARY

SECONDARY

COLORECTAL APPENDIX OVARIAN GASTRIC

TUMOR TYPE

SPREAD PATTERN PATHOPHYSIOLOGY TERMS¹

COMPLETE REDISTRIBUTION

NO ADHESION TO PERITONEAL SURFACE NEAR PRIMARY DUE TO LOW AGGRESSIVENESS (LOW GRADE CANCERS)

MUCIN PRODUCING TUMOR CELLS ADHERENCE MOLECULES HAVE DECREASED BINDING BY MUCIN INTERFERENCE

MUC-2/MUC 5-AC (MUCIN)

INTEGRINS (ADHESION)

NORMAL FLOW ↑ TOWARDS SUBDIAPHRAGM

CELLS MOVE BY FLOW OF PERITONEAL FLUID

WITH ASCITES FLOW CAN REVERSE↓ FROM GRAVITY / POSITION

TERM DEFINITIONS¹

MOLECULES INVOLVED²

PERITONEAL FLUID AFFECTS LOCATION
## REVIEW OF CRS/HIPEC

### CYTOREDUCTIVE SURGERY (CRS)
Consists of various peritonectomy procedures and visceral resections with goal of complete tumor removal.

### HYPERTHERMIC INTRAPERITONEAL CHEMOTHERAPY (HIPEC)
Circulating chemo at 41-43 C intraperitoneal after CRS, with selected chemo based on cell type. Hyperthermia/increased concentration increases the cytostatic activity.

### COMMON STEPS IN CRS³

<table>
<thead>
<tr>
<th>Disease Location Dependent</th>
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<tbody>
<tr>
<td>1. Greater omentectomy-splenectomy</td>
</tr>
<tr>
<td>2. Left upper quadrant peritoneectomy</td>
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<tr>
<td>3. Right upper quadrant peritoneectomy</td>
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<tr>
<td>4. Lesser omentectomy-cholecystectomy with stripping of the omental bursa</td>
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<tr>
<td>5. Pelvic peritoneectomy with segmental sigmoidectomy</td>
</tr>
<tr>
<td>6. Antrectomy</td>
</tr>
<tr>
<td>7. Right hemicolectomy, TAHBSO, small bowel, or abdominal wall resections</td>
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### CLINICAL FACTORS FOR SELECTION⁴,⁵

<table>
<thead>
<tr>
<th>Associated with less morbidity and mortality</th>
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<tr>
<td>ECOG 0-2</td>
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<tr>
<td>Normal albumin</td>
</tr>
<tr>
<td>Age &lt; 65</td>
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<tr>
<td>BMI &lt; 35 favorable</td>
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<tr>
<td>Neoadjuvant response</td>
</tr>
<tr>
<td>Tumor grade/type</td>
</tr>
<tr>
<td>Low PCI score - cutoff tumor dependent</td>
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<tr>
<td>No distant mets</td>
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### CC* SCORE ⁵,⁶

Score measures tumor burden in OR after CRS to predict HIPEC benefit.

| CC-0 |
| No visible tumor |
| CC-1 |
| < 2.5 mm |
| CC-2 |
| 2.5 mm-2.5 cm |
| CC-3 |
| > 2.5 cm |

Goal is CC-0 or CC-1 higher survival!

### CONTRAINDICATIONS TO HIPEC⁴

| N3 nodes |
| >3 liver mets |
| Metastatic Relative |
| Unknown primary |
| SBO |
| CC score > 1 |
| Grade 3 signet ring |
| Grade 3 adenoCA |
| Frozen pelvis |
| Biliary obstruction |

### ↑ RISK FOR INCOMPLETE CRS⁷

| “Danger zones” – upper abdomen & SB (next slide) |
| Pelvic side wall & sacrum |
| Miliary spread (<2 mm nodules) |
| Bladder trigone |
| Hydro |
| Biliary obstruction |
| Frozen pelvis |
| Root of mesentery |
| Epiphenric, retroperi, celiac, periportal lymph nodes |
| Ligament of Treitz |

* CC score = Completeness of Cytoreduction Score

Conforms to various peritonectomy procedures and visceral resections with goal of complete tumor removal.

Circulating chemo at 41-43 C intraperitoneal after CRS, with selected chemo based on cell type. Hyperthermia/increased concentration increases the cytostatic activity.

Score measures tumor burden in OR after CRS to predict HIPEC benefit.

Goal is CC-0 or CC-1 higher survival!

Conforms to various peritonectomy procedures and visceral resections with goal of complete tumor removal.
The Danger Zones

**Small Bowel Mesentery**
- Discrete nodular implants (left)
- Lobulated confluent implants (middle)
- Confluent infiltrative implants distorting adjacent small bowel (right)
- Don’t confuse with ascites!

**Small Bowel (SB) Serosa**
- SB infiltration & distortion by nodular, infiltrative implants (left)
- Confluent serosal implants of intermediate density (middle & right)

**SMA Root**
- Permeative, ill-defined soft tissue (left)
- Confluent and nodular implants (middle)
- Discrete nodules and/or lymphadenopathy (right)

**Porta Hepatis**
- Discrete nodules / lymph nodes (red arrows)
- Abnormal infiltrative soft tissue (yellow arrow)
- Reported separately since it↓CRS success
Cocoon Abdomen

**Abdominal Cocoon Syndrome** occurs when there is total or partial encapsulation of the small bowel by a fibro-collagenous membrane from an inflammatory process commonly leading to acute or chronic bowel obstruction.

There are several small bowel loops clustered in the mesentery, surrounded by this loculated ascites, producing a "cocoon abdomen“ (white circles). However, the bowel loops are not dilated.
In order to provide valuable information to the surgeon, radiologists should report disease information needed to estimate the likelihood of successful of CRS. Some institutions who perform CRS/HIPEC use the PCI to determine the success of CRS. A surgical PCI of >20 is associated with poor outcomes for CRS. Above are some representative examples of disease location.  

Simplified Preoperative Assessment for Appendix Tumor (SPAAT) Score

- Used for complete redistribution pattern as seen in *low-grade* mucinous adenocarcinoma of the appendix or pseudomyxoma peritonei
- **Most important feature** is **Scalloping !!**
- Five anatomic regions assessed for *scalloping*:
  - **Liver** (white arrows) = 1 point
  - **Spleen** (blue arrows) = 1 point
  - **Pancreas** = 1 point
  - **Portal vein** = 1 point
  - **Mesenteric foreshortening** (circle) = 3 points
    - (Cauliflowering/tethered cocoon-like appearance of SB)
- Total of 7 points, 0 points given if absent

**Practical take home**

- Call scalloping and 4 danger areas
- Scoring systems will evolve overtime, but emphasize important features for reporting
- Correlation of radiographic and surgical observation will positively impact clinical management
48 y/o male with peritoneal carcinomatosis from poorly differentiated adenocarcinoma with signet ring cells unknown primary who presented with large bowel obstruction and disease progression despite neoadjuvant chemo. Coronal and Sagittal CT images demonstrate diffuse large bowel obstruction with small soft tissue attenuation nodules throughout the mesentery, bowel, and surface of liver.

The patient was taken to the OR for a laparoscopic descending loop colostomy but deemed inoperable given diffuse disease and having a surgical PCI score of 39.
Coronal Look for...
- Diaphragmatic/sub-diaphragmatic implants
- Pleural implants
- Lung
- Cardiophrenic lymph nodes
- Portal system
- Vessel involvement

Axial Look for...
- Hepatic & perihepatic disease
- Gallbladder fossa
- Liver intersegmental fissures
- Porta hepatis
- Gastrohepatic ligament
- Lesser sac
- Stomach
- Spleen/perisplenic
- Omentum
- Small bowel mesentery
- Small bowel
- Large Bowel
- Abdominal wall
- Pelvic side wall

Sagittal Look for...
- Abdominal wall involvement
- Omental disease
- Small bowel/mesenteric angulation/tethering
- Retroperitoneum
- Lymph nodes
- Pelvic recesses

PAUSE Method\textsuperscript{7}: Suggested Standardized Reporting Method

- PCI, Primary Tumor
- Ascites
- Unfavorable Locations
- Small Bowel/Mesentery
- Extraperitoneal disease
Our Institution’s Reporting Template

- Utilizes a synoptic report with a pick list
- Ensures all critical anatomic areas are evaluated
- Provide a more complete report in a time efficient manner
- Used by surgeons as a roadmap
No CT measurable deposits

OR

Plaque-like thickening in the diaphragmatic/subdiaphragmatic region

OR

Indeterminate nodularity or stranding in the diaphragmatic/subdiaphragmatic region

Include size if measurable, location, invasion into thoracic cavity
Hepatic/Perihepatic Disease: (Pick List)

No CT measurable perihepatic, subcapsular or hepatic metastases

OR

Indeterminate perihepatic nodularity or stranding

OR

Perihepatic and/or subcapsular hepatic metastatic disease is present

OR

Perihepatic metastatic disease infiltrates the liver parenchyma

OR

Intraparenchymal hepatic metastases are present
Gallbladder Fossa/Left Inter-Segmental Fissure: (Pick List)

Present

OR

No CT measurable metastatic disease

OR

Indeterminate nodularity or stranding

**GB fossa = between GB and liver**

Left IS fissure = fissure for the ligamentum venosum
Present

OR

No CT measurable metastatic disease

OR

Indeterminate nodularity or stranding

In **GH ligament**, document implants or nodes > **1 cm** in SA

OR

< **1cm** with rounded, heterogenous or irregular borders

In **PH**, document implants or nodes > **1.5 cm** in SA

OR

< **1.5 cm** with rounded, heterogenous or irregular borders
Our Institution’s Reporting Template

**Lesser Sac Disease : (Pick List)**

- Present
- OR
- No CT measurable metastatic disease
- OR
- Indeterminate nodularity or stranding

**Pancreas: (Pick List)**

- Normal
- OR
- If abnormal, describe:

**Tumor Abutment/Invasion of Stomach: (Pick List)**

- Present
- OR
- No CT measurable metastatic disease
- OR
- Indeterminate nodularity or stranding

*Include degree of involvement/invasion*
Our Institution’s Reporting Template

**Splenic/Perisplenic Disease: ( Pick List)**

- No CT measurable perisplenic or splenic metastases
  - OR
- Indeterminate perisplenic nodularity or stranding
  - OR
- Perisplenic and/or subcapsular splenic metastatic disease is present
  - OR
- Perisplenic metastatic disease infiltrates the splenic parenchyma
  - OR
- Intraparenchymal splenic metastases are present

*Include involvement of splenic hilum and/or splenic ligaments*
Omental Disease: (Pick List)

- No CT measurable omental metastases
  - OR
  - Present, with discrete nodularity and/or mass(es)
    - OR
    - Present, with omental caking
      - OR
  - Indeterminate nodularity or stranding in the omentum
Our Institution’s Reporting Template

Root of SMA: (Pick List)
*Defined as next to SMA or SMV but not para-aortic in location*

Present
  
  OR

No CT measurable metastatic disease
  
  OR

Indeterminate nodularity or stranding

SB Mesentery Disease: (Pick List)
*Defined as anywhere in SB mesentery except for root of SMA*

Present
  
  OR

No CT measurable metastatic disease
  
  OR

Indeterminate nodularity or stranding
No involvement of small bowel

OR

Indeterminate nodularity or stranding abuts the small bowel

OR

Tumor definitely abuts small bowel, but no tethering or angulation and no wall thickening or invasion

OR

Tethering or angulation of small bowel appears to be related to SB mesenteric tumor infiltration

OR

Diffuse or segmental small bowel wall thickening is present

*Include location, length of involvement, multifocality, +/- obstruction*
No involvement of colon

OR

Indeterminate nodularity or stranding abuts the colon

OR

Tumor definitely abuts colon, but no wall thickening or invasion

OR

Diffuse or segmental colonic wall thickening is present

Include location, e.g., rectosigmoid or above peritoneal reflection/outside of pelvis and what segment, length of involvement, multifocality, ± obstruction
Appendix: (Pick List)

Visualized and normal

OR

Not visualized, but no abnormalities identified adjacent to the tip of the cecum in the expected location of the appendix

OR

Post appendectomy

OR

Implants or primary tumor present
Peritoneal Thickening and/or Nodularity: (Pick List)

- Present
- **OR**
- Absent

Describe peritoneal involvement:
*Carefully assess and include* 
cul-de-sac recesses

Disease Involving Abdominal Wall or Umbilicus: (Pick List)

- Present
- **OR**
- Absent
Our Institution’s Reporting Template

Uterus/Ovaries/Pelvic Ligaments: (Pick List)

- Not applicable
- Normal
- If abnormal, describe:

Bladder: (Pick List)

- Normal
- If abnormal, describe:
**Retroperitoneal Lymph Nodes: (Pick List)**

(1 cm or larger in SA OR < 1cm SA and rounded, heterogeneous, irregular borders)

- Normal
- Above the level of renal hilum: *describe, including largest SA LNs*
- Below the level of renal hilum: *describe, including largest SA LNs*

**Ascites: (Pick List)**

- Absent
- Small Volume
- Moderate volume
- Large volume
Our Institution’s Reporting Template

**Pleura: (Pick List)**

- No pleural effusion
  
  OR
  
  Pleural effusion(s) present

- No pleural metastases
  
  OR
  
  Pleural metastases present
  
  OR
  
  Indeterminate nodularity and/or thickening of the visualized pleura

**Lung: (Pick List)**

- No pulmonary metastases
  
  OR
  
  Pulmonary metastases are present
  
  OR
  
  Indeterminate pulmonary nodules
Cardiophrenic Lymph Nodes:
Describe: *give size of largest SA LNs*

Retrocrural Lymph Nodes :
Describe: *give size of largest SA LNs*

Other:
Describe:
Summary/ Clinical Implications

• Identifying candidates for CRS/HIPEC is a multifaceted decision and relies heavily on imaging findings.

• Implementing a standardized process for image review and reporting will assist in reliably identifying candidates that may benefit from these new treatment options.
References


Thank You!

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