POSITIVE VERSUS NEUTRAL ORAL CONTRAST:

Which Should You Use for Abdominal CT?

Lisa L. Chu, M.D.
Z. Jane Wang, M.D.
Eleanor L. Ormsby, M.D.
Antonio C. Westphalen, M.D.
Benjamin M. Yeh, M.D.

Department of Radiology & Biomedical Imaging
University of California, San Francisco
Disclosures

- Zhen Jane Wang, M.D.
  - Nextrast, Inc. shareholder
- Benjamin M. Yeh, M.D.
  - General Electric Healthcare research agreement
  - Nextrast, Inc. shareholder
  - Oxford University Press book royalties
- Other authors have no disclosures
Learning Objectives

- Understand merits and pitfalls of positive and neutral oral contrast agents
- Assess evidence-based use of different oral contrast agents in specific settings
- Discuss future directions of oral contrast agents
- Target audience: general and abdominal radiologists
Introduction

- Use of some type of oral contrast (positive or neutral) is better than no oral contrast for optimal evaluation of abdomen

- Historically, positive oral contrast considered standard of care

- Recent publications focus on neutral or no oral contrast
  - Few head-to-head papers support positive oral contrast use, likely biased by historical context
Introduction

- Conspicuity of CT findings depends on type of oral contrast and "color" of underlying disease.

Cartoon illustration of CT with neutral oral contrast. It may be difficult to discern extraluminal masses given similar attenuation to that of neutral contrast.

Cartoon illustration of CT with positive oral contrast shows extraluminal masses more vividly.
Conspicuity of CT findings depends on type of oral contrast and “color” of underlying disease.
Any oral contrast better than none

- More intestinal CT findings made with any kind of oral agent than no oral agent
  - Neutral contrast → more intestinal findings detected
  - \( N = 716 \) barium & 576 water (neutral) oral contrast CT scans, and 716 CT scans without oral contrast

Source: Kammerer et al., Eur Rad 2015.
### Oral Contrast & Disease Conspicuity

- Positive and neutral oral contrast agents each have benefits and drawbacks to consider.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Positive</th>
<th>Neutral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abscess</td>
<td>++++</td>
<td>++</td>
</tr>
<tr>
<td>Bowel fistula</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Bowel leak</td>
<td>++</td>
<td><strong>X</strong></td>
</tr>
<tr>
<td>Extraluminal hematoma</td>
<td>++++</td>
<td>++</td>
</tr>
<tr>
<td>Extraluminal tumor</td>
<td>++++</td>
<td>++</td>
</tr>
<tr>
<td>Bowel wall inflammation</td>
<td>++</td>
<td>++++</td>
</tr>
<tr>
<td>Bowel wall ischemia</td>
<td>+</td>
<td>++++</td>
</tr>
<tr>
<td>Intraluminal tumor</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>GI bleeding</td>
<td><strong>X</strong></td>
<td>++</td>
</tr>
</tbody>
</table>
Neutral oral contrast helps in the evaluation of...

- Bowel wall disease
  - Inflammatory bowel disease
  - Bowel wall ischemia
  - Shock bowel
- Intraluminal hypervascular tumors
- Extraluminal calcifications
Merits of neutral oral contrast: Crohn’s disease

Clinical history: 51 year old woman with Crohn’s disease presents with abdominal pain, nausea and vomiting.

Imaging findings: On CT with IV and positive oral contrast, the positive contrast obscures bowel wall hyperenhancement (arrow). CT enterography with IV and neutral oral contrast performed six months prior clearly shows bowel wall hyperenhancement (arrow) consistent with active disease.

Teaching point: CT enterography which uses neutral oral contrast is superior to positive oral contrast in evaluating for bowel wall hyperemia in active Crohn’s disease.
**Merits of neutral oral contrast:** Bowel wall ischemia

**Clinical history:** 51 year old woman status post CABG presents with abdominal pain.

**Imaging findings:** CT with IV and positive oral contrast shows pneumatosis of ileum (arrow) but wall enhancement is poorly evaluated. Subsequent CT with IV and neutral contrast shows pneumatosis AND lack of wall enhancement of the same ileal loop due to infarction (arrow). RLQ renal transplant (arrows).

**Teaching point:** Acute mesenteric ischemia is a life-threatening condition (mortality rate of 50-90%) that requires prompt diagnosis and treatment. Be wary that positive oral contrast can obscure wall hypoenhancement.
Merits of neutral oral contrast: Hypervascular mass (#1)

Clinical history: 71 year old man with history of colon cancer.

Imaging findings: CT with IV and positive oral contrast obscures an enhancing mass at the fourth portion of the duodenum (arrow), not seen for 5 consecutive CT scans with positive oral contrast. Subsequent CT with IV and neutral oral contrast clearly shows the stable duodenal mass (arrow), in retrospect present on all prior scans, and which was proven to be a GIST on surgical pathology.

Teaching point: Positive oral contrast can obscure enhancing intraluminal tumors due to similar hyperattenuation. Consider neutral oral contrast instead when evaluating for intraluminal hypervascular masses.
Merits of neutral oral contrast: Intraluminal mass (#2)

Clinical history: 45 year old woman with unintentional weight loss for evaluation for malignancy.

Imaging findings: CT with IV and positive oral contrast obscures an enhancing intraluminal mass in the stomach (arrow) which was missed. Years later, upper endoscopy reveals a gastric submucosal mass. Subsequent CT with IV and neutral oral contrast reveals the mass (arrow). Mass later shown to be ectopic pancreatic rest.

Teaching point: Positive oral contrast can obscure enhancing intraluminal tumors due to similar hyperattenuation. Neutral oral contrast better visualizes intraluminal hypervascular masses.
Merits of neutral oral contrast: Extraluminal calcification

Clinical history: 86 year old woman with serous ovarian carcinoma.

Imaging findings: At first glance on CT with positive oral contrast, right posterior hyperdense lesion (arrow) appears to be positive oral contrast. Comparison with CT with IV and neutral oral contrast shows that it is actually calcified serous ovarian carcinoma (arrow) and not within a bowel segment.

Teaching point: Positive oral contrast makes it more difficult to confidently diagnose certain extraluminal calcifications.
Pitfalls of neutral oral contrast: Peritoneal metastasis

Clinical history: 78 year old man with colon cancer.

Imaging findings: At initial CT with IV and neutral oral contrast, left pelvic metastasis (arrow) was not detected, even though a PET scan showed FDG uptake in that region. Subsequent CT 1 week later with IV and positive oral contrast clearly shows the mesenteric mass (arrow).

Teaching point: CT sensitivity for peritoneal metastases is reported to be 28 to 70% in multiple publications. Peritoneal metastases may be less conspicuous with neutral than with positive oral contrast.
Positive oral contrast helps in the evaluation of...

- Extraluminal tumors
- Abscesses
- Fistulas / leaks
Merits of positive oral contrast: Extraluminal tumors (#1)

Clinical history: 55 year old man with history of liver transplant presents with abdominal pain.

Imaging findings: CT with IV and neutral oral contrast obscures two hypoattenuating mesenteric masses (arrows). With CT with positive oral contrast, the mesenteric masses (arrows) are much more discrete. They were proven to be desmoid tumors on pathology.

Teaching point: Hypoattenuating mesenteric masses may have similar density to neutral oral contrast. Positive oral contrast is superior in the evaluation for extraluminal tumors.
Merits of positive oral contrast: Extraluminal tumors (#2)

Clinical history: 35 year old woman with metastatic ovarian cancer.

Imaging findings: CT with IV and neutral oral contrast obscures multiple mesenteric masses (arrows). On CT with IV and positive oral contrast, the mesenteric masses (arrows) can be easily differentiated from adjacent bowel.

Teaching point: Even when mesenteric masses have density slightly different to that of neutral oral contrast, they can be easily missed. Positive oral contrast is superior in the evaluation of such masses.
**Merits of positive oral contrast:** Extraluminal tumor (#3)

**Clinical history:** 57 year old woman with metastatic ovarian cancer.

**Imaging findings:** On CT with IV and neutral oral contrast, the paracolic metastasis was missed (arrows). On subsequent CT with IV and positive oral contrast, the paracolic metastasis (arrows) was more easily differentiated from the adjacent descending colon.

**Teaching point:** Be sure to include “running” the colon in your CT search pattern. At first glance, the paracolic mass can be mistaken for colon. However, positive oral contrast clearly shows that it is extraluminal.
Merits of positive oral contrast: Intra-abdominal abscesses

Clinical history: 27 year old man with fever and abdominal pain.

Imaging findings: On CT with neutral oral contrast and without IV contrast, it is difficult to distinguish multiple interloop abscesses (arrows) from adjacent bowel loops. On CT with IV and positive oral contrast, the interloop abscesses (arrows) can be more easily distinguished from bowel loops.

Teaching point: The intra-abdominal abscesses may have similar density to neutral oral contrast. Positive oral contrast provides higher conspicuity and confidence for the detection of intra-abdominal abscesses.
Merits of positive oral contrast: Gastrogastric fistula

Clinical history: 54 year old woman with history of Roux-en-Y gastric bypass with abdominal pain.

Imaging findings: CT with positive oral contrast shows oral contrast flowing from the gastric pouch (arrow) into the gastric remnant (arrow), suggesting a communication between the two cavities.

Teaching point: Gastrogastric fistula occurs in up to 6% of Roux-en-Y gastric bypasses. Two theories for fistula formation exists: (1) incomplete stomach division during creation of pouch, and (2) staple-line failure. Positive oral contrast can be used to evaluate for fistulas anywhere in the GI tract. Neutral oral contrast is of limited value in these scenarios.
Mimics of positive oral contrast: Colonic varices

Clinical history: 54 year old man with abdominal pain.
Imaging findings: CT with IV and positive oral contrast shows extensive colonic varices from a colonic vascular malformation (arrow). At first glance, the colonic varices can be mistaken for positive oral contrast. However, further review shows that positive oral contrast has not yet reached the colon.

Teaching point: Be sure to determine how far the oral contrast has gone before assuming intraluminal hyperdense material is positive oral contrast.
Pitfalls of positive oral contrast: Serosal calcifications

Clinical history: 78 year old woman with serous adenocarcinoma omental metastases of unknown primary.

Imaging findings: CT with IV and positive oral contrast shows extraluminal hyperdense material (arrows). These were initially mistaken for leakage of positive oral contrast. However, comparison with prior studies showed that the extraluminal calcifications were unchanged and consistent with serosal calcifications.

Teaching point: Comparison with prior CT scans, particularly those without positive oral contrast, is key to avoiding this potential pitfall.
Pitfalls of positive oral contrast: Pseudo-wall thickening

Clinical history: 59 year old man with lymphoma presents with abdominal pain.

Imaging findings: CT with IV and positive oral contrast shows pseudo-wall thickening at the cecum (arrow) due to poor mixing of the positive oral contrast and bowel contents. There is incidental note of splenomegaly (arrow), ascites (arrow), and right pleural effusion (arrow).

Teaching point: Be wary of mixing artifacts, a pitfall which can occur anywhere in the GI tract. Pseudolesions are more common with positive than neutral contrast.
Pitfalls of positive oral contrast: Pseudolesions & poor mixing

Clinical history: 78 year old woman with lower abdominal pain.

Imaging findings: CT with IV and positive oral contrast shows a pseudolesion in the small bowel (arrow) due to poor mixing of oral contrast and bowel contents.

Repeat CT with IV and neutral oral contrast shows no mass in that region (arrow) but instead shows real cecal nodular fold thickening (arrow) which was missed on CT with positive oral contrast (arrow). Cecal biopsy revealed tubulovillous adenoma.

Teaching point: Positive oral contrast may show heterogeneous mixing that resembles intraluminal mass or hide real intraluminal masses.
Merits of no oral contrast: Emergency room setting

Numerous publications report on potential benefits of no oral contrast for abdominal CT triage in the emergency room setting.

Caveats:
- Most publications focus on rapid throughput and related overall cost savings.
- Data on CT sensitivity for actual disease is limited by small sample sizes for publications where no oral contrast was compared with oral contrast use in the emergency room setting.
- None of the publications are adequately powered to assess cost of misdiagnosis when no oral contrast is administered.

In practice:

- Majority of practices use positive oral contrast for most abdominal scans
- There is no consensus on which oral contrast to use (positive, neutral, no oral contrast) for most indications

Recommendations:

- Positive oral contrast is probably best when there is concern for peritoneal tumors or extraluminal fluid collections
- Neutral oral contrast is best when focus is on bowel wall inflammation or ischemia
- Each agent has pitfalls. Patients may have concurrent findings on the same CT scan, some that would be more conspicuous with positive and others with neutral oral contrast
  - Example: Abdominal pain patients may have both bowel wall inflammation (seen best with neutral agent) and abscesses (seen best with positive agent)
Future Directions

- “Biphasic” dual energy CT oral agent lets contrast signal be digitally subtracted as needed

Disclaimer: No biphasic CT contrast agents are FDA approved yet for clinical use.

Rathnayake et al, in submission
Conclusion

- Conspicuity of CT findings depends on type of oral contrast and “color” of underlying disease. Positive and neutral oral contrast agents each have strengths and weaknesses.

- Practical approach
  - Protocol based on leading suspected diagnosis
  - Repeat exam as needed with CT, MRI or PET when clinical findings do not match radiologic findings

- Future – “biphasic” dual energy CT agents?
References


Contact information: Lisa L. Chu, M.D. Lisa.Chu@ucsf.edu