The Radiologic Manifestations of Necrotizing Enterocolitis

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Baby R

• Former 28.5 weeker with episodes of respiratory distress in the first days of life

• On day of life 8 Baby R started full feeds

• On day of life 8 Baby R developed marked abdominal distension & guaiac positive stools
Objectives

• Overview of necrotizing enterocolitis

• Overview of common radiologic findings in necrotizing enterocolitis

• Review the future role of imaging modalities in diagnosing necrotizing enterocolitis
Necrotizing Enterocolitis (NEC)

• Is the necrosis of the mucosa or submucosa of any portion of the GI tract

• Affects predominantly preterm & low birth weight infants

• Other risk factors include:
  – Compromise of mucosal integrity & bowel integrity
  –Compromised mesenteric blood supply
  – Changes in bowel lumen
Pathophysiology

- Multifactorial process that usually affects terminal ileum and right colon

- Exact pathophysiologic mechanism is not known, but it is thought that:
  - Bacterial colonization
  - Intestinal hypoxia
  - Formula feeding
  - Activation of proinflammatory mediators & subsequently bowel necrosis
Arterial Supply of the Colon

Superior Mesenteric Artery
↓
Ileocolic, Right colic, Superior Mesenteric Arteries
↓
Terminal Ileum, Cecum, Right Colon
↓
Venous Tributaries
↓
Superior Mesenteric Vein
↓
Hepatic Portal Vein

Clinical Presentation

• Usually occurs in days 3-10 of life

• Systemic symptoms include:
  – Apnea, bradycardia, temperature instability, lethargy, poor feeding

• Gastrointestinal symptoms include:
  – Diarrhea, abdominal distention, gastric retention, gastrointestinal bleeding
# BELL Criteria

<table>
<thead>
<tr>
<th>Stage</th>
<th>Clinical Signs</th>
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Summarized from Rencken et al, 1997
Imaging Modalities

- Radiologic imaging is *key* to diagnosis and monitoring

- If NEC is suspected, abdominal films are obtained every 12-24 hours

- Supine abdominal, cross table lateral view, or left-side-down decubitus are standard
## Plain films and Bell Criteria

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<td>Ileus, intestinal pneumatosis, portal venous air, pneumoperitoneum</td>
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Summarized from Rencken et al, 1997
Normal Neonatal Abdominal Radiograph

- Liver is prominent in pediatric abdominal films
- Difficult to discern the small from large intestine
- Bowel gas pattern bordering the liver is likely to be the transverse colon
- Bowel gas pattern in the lower pelvic region likely to be the rectum

Courtesy Dr. W. Durgin, BIDMC
Radiography & Stage I NEC

• Nonspecific radiographic findings:
  – Diffuse gaseous distension of intestine
  – Loss of normal bowel gas pattern symmetry
Bowel Distension

- Occurs in the small intestine, colon, or both
- Distension of the small intestine often occurs 4-48 hours before the onset of clinical signs
- Distension of large colon occurs in 30% of NEC patients
- This is a relatively non-specific sign

Bowel Distension Radiographic Differential

- Meconium Ileus
- Total Colonic Anganlionosis
- Mid-gut volvulus
- Gastroenteritis, peritonitis, sepsis
Abnormal Gas Distribution

Radiology & Stage II NEC

- Pneumatosis intestinalis is essentially pathognomonic for NEC
- Portal venous gas is correlated with worse prognosis
Pneumatosis Intestinalis

- Intramural Air
- Focal versus diffuse
- Air can be located in the
  - Submucosa  Bubbly/cystic
  - Subserosa  Linear/curvilinear

Courtesy of Dr. Makris, Children’s Hospital Boston
Pneumatosis Intestinalis (continued)

Radiographic Differential

- In combination with dilated bowel indicative of NEC
- Feces
- Milk impaction secondary to onset of feeding
- Benign pneumatosis from extension from air in the mediastinum
- Congenital obstruction (atresias, imperforate anus, meconium plug, etc.
- Hirschsprung’s

Courtesy of Dr. Makris, Children’s Hospital Boston
Portal Venous Gas (PVG)

• Associated with severe NEC and babies with PVG have worst outcomes

• Visualized better on cross table lateral view

• On ultrasound PVG is seen as moving echogenicity in portal vein

Courtesy Dr. W. Durgin, BIDMC
PVG (continued)

Radiographic Differential

- Iatrogenic via umbilical vein catheters
- Air in biliary tree secondary to duodenal atresia with incompetent Sphincter of Oddi

http://www.hawaii.edu/medicine/pediatrics/neoxray/neoxray.html
Radiology & Stage III NEC

• Persistent (sentinel) loop sign

• Asymmetric bowel dilatation

• Ascites

• Pneumoperitoneum
Persistent Loop Sign (Sentinel Loop)

- Is the persistence of a dilated loop of bowel on subsequent radiographs for 24 to 36 hours

Radiographic Differential

- Appendicitis
- Paralytic Ileus
- Pancreatitis
- Drug-induced

Pneumoperitoneum

Radiographic Differential

• Idiopathic perforation
• Focal intestinal perforation
• Intestinal obstruction
• Iatrogenic (puncture with nasogastric tube)

Baby R

- Baby gram radiographic findings:
  - Distended bowel loops
  - Pneumatosis intestinalis
  - Free Air under the left diaphragm

Courtesy of Dr. Makris, Children’s Hospital Boston
Treatment of NEC

• Clinical Management
  – Discontinue feeds
  – IV fluids
  – Gastric decompression via NG tube
  – Total parenteral nutrition
  – Broad-spectrum antibiotics

• Surgical Management
  – Indications include pneumoperitoneum, sentinel loops, ascites, or worsening clinical picture
  – Resection of the necrotic bowel, proximal enterostomy, with subsequent reanastomosis at a later time
Outcome of Baby R

- Underwent exploratory laparotomy
- Subsequently had right hemicolecction with ileocecal valve resection
- Follow-up radiograph is shown

Courtesy of Dr. Makris, Children’s Hospital Boston
Chronic Complications of NEC

• Usually occurs a few weeks after acute disease

• Radiographic follow-up conducted for 2 years

• Course can be complicated by NEC strictures, bowel obstruction, enterenterofistulae, enterocysts
Post-NEC Stricture

• Single or multiple strictures occur

• Commonly occur in the left colon

• Spontaneous resolution of NEC strictures occurs

• Routine barium enemas are performed in children who undergo surgery, but not in children who have had medical management of NEC
NEC Strictures


From Rabinowitz, JG. “Radiographic Manifestations” in Neonatal Necrotizing Enterocolitis, Brown EG, Sweet AY eds. 1980
NEC & other Imaging Modalities

- Abdominal plain radiographs are nonspecific in the early and late stages of NEC.

- The use of computed tomography in NEC diagnosis has been explored.

- Use of MRI in NEC diagnosis is under study.
NEC & CT

• The permeation of contrast administered into ischemic bowel has been reported in animal models of NEC

• The contrast is resorbed from the peritoneum & is excreted into the urinary system
NEC & CT (continued)

- Study included babies with NEC and controls (n=22) who were orally given non-ionic contrast

- After contrast administration, they collected the urine of babies with NEC and controls and CT the urine

- They found that after contrast, the urine of babies with suspected and definite NEC have higher Hounsfield Units than controls

<table>
<thead>
<tr>
<th>Control Urine</th>
<th>Urine of babies who underwent other GI study</th>
<th>Urine of babies with suspected NEC</th>
<th>Urine of babies with definite NEC</th>
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<td>5.6 HU +/- 3.9</td>
<td>6.7 HU +/- 3.2</td>
<td>26.0 HU +/- 3.4</td>
<td>71.0 HU +/- 18.8</td>
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summarized from Rencken et al, 1997
NEC & MRI

• Maalouf et al report MRI findings of NEC amongst a group of low birth weight and preterm infants and their controls.

• They conclude that the following characteristics were associated with severe forms of NEC:
  - Fluid levels within lumen
  - Intramural gas
  - Bubble-like appearance in bowel wall

• Bowel areas with a bubble-like appearance corresponded to areas of bowel that were surgically resected.
NEC & MRI

Bubble-like Appearance

Intramural Air

Air-fluid levels

NEC & Ultrasound

Pseudo-kidney sign

- Non-specific sign seen in any process where blood, pus, fluid, tumor invades bowel wall

- Necrotic bowel cannot be distinguished from inflammatory bowel disease

- Given, demographics of preterm population, this sign is most consistent with NEC

From Kodroff et al, 1984
Portal Venous Gas & Ultrasound

Right Upper Quadrant

Liver Ultrasound of Neonate with NEC

U/S

Normal Ultrasound

Echogenicities in liver parenchyma

Microbubble in portal vein

From Merrit et al, 1984
Conclusion

• The incidence of NEC is increasing secondary to increased survival of low-birth weight and pre-term infants

• Diagnostic imaging, specifically plain films are important in the diagnosis, progression, and follow-up of NEC

• But, secondary to the sensitivity of current abdominal plain films, the use of CT, MRI, and U/S could provide a more sensitive and specific imaging alternative
References

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