Imaging of necrotizing enterocolitis: the role of ultrasound

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Objectives

- Discuss the role of abdominal radiographs in NEC
- Review ultrasound findings in NEC
- Discuss the role of ultrasound in NEC
NEC

- Remains cause of significant morbidity and mortality in neonates, particularly related to development of bowel necrosis
- Prompt diagnosis and early detection of bowel necrosis leading to earlier treatment and surgical intervention may result in improved outcomes
- US has a role in improving NEC diagnosis & monitoring
NEC

- Diagnosis and monitoring of NEC has traditionally relied on combination of clinical, biochemical and radiographic findings
- Basis for Bell staging criteria
NEC: abdominal radiographs

- Current standard imaging modality
- Use at diagnosis, routinely during NEC watch, and at time of acute clinical deterioration
NEC: abdominal radiographs

- Bowel gas pattern
  - Loss of normal mosaic pattern
  - Dilatation (in >90% of NEC) but nonspecific
  - Bowel separation – but not reliable for wall thickening
  - Fixed loop(s) on serial radiographs

- Intramural gas
  - Virtually pathognomonic of NEC

- Portal venous gas

- Pneumoperitoneum
Normal mosaic bowel gas pattern
Abnormal bowel gas pattern
Abnormal bowel gas pattern

Of 30/75 neonates with bowel separation on AXR, only 4 had bowel wall thickening on US.
Of 19/34 neonates with NEC with bowel separation on AXR, only 3 had bowel wall thickening on US.

NEC: abdominal radiographs

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- Pneumoperitoneum
31wkGA 15d
Rectal bleeding
Term 5d♀ AVSD/TAPVR
Abdominal distension
NEC: abdominal radiographs

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- Pneumoperitoneum
37wkGA, 4d♀, twin, IUGR
30wkGA 8d♂
Abdominal distension, shock
Limitations of abdominal radiographs

- Ileus from multiple etiologies can cause bowel dilatation
- Diagnosis of pneumatosis may be difficult
  - Mottled lucencies 2ry to meconium/stool
  - Linear lucencies due to overlapping loops
- Portal venous gas may be due to UVC
- Extraintestinal gas may not be free due to intraperitoneal inflammation
Limitations of abdominal radiographs

- Extrapulmonary gas considered indicator of severity in NEC
- However, severe NEC can develop in absence of pneumatosis or portal venous gas
- Ominous progression of NEC may be missed → failure to intervene early
NEC: utility of ultrasound

- Direct visualization of bowel:
  - Peristalsis
  - Bowel wall thickness
  - Pneumatosis
  - Perfusion

- Direct visualization of peritoneal fluid

- Visualization of portal venous gas and pneumoperitoneum
NEC: utility of ultrasound

- Aids in diagnosis when radiographic findings are nonspecific
- May detect complications before visible or not visible on radiographs (necrotic bowel and abscess formation)
NEC: ultrasound technique

- Use of high frequency linear array transducers
- Systematic evaluation of bowel in all 4 quadrants
- Combination of gray-scale & color Doppler
NEC: ultrasound technique

- Limitations:
  - Marked bowel gas dilatation
    
    *(Faingold et al, Radiology 2005;235:587-594, in only 2/32 neonates, bowel could not be evaluated in all 4 quadrants)*
  - Patient instability
  - HFOV (limits Doppler interrogation)
NEC: ultrasound

- Bowel wall
  - Pneumatosis
  - Echogenicity
  - Thickening (>2.6mm)
  - Thinning (<1.0mm)
  - Hyperemia
  - Absent perfusion
  - Peristalsis
NEC: pneumatosis
NEC: pneumatomasis
NEC: pneumatosisis

- *Silva CT et al. Pediatr Radiol 2013;43:1453-1463*
  In 34 patients with NEC, 12 had pneumatosisis:
  - Pneumatosisis on both US & AXR: 7
  - Pneumatosisis only on US: 4
  - Pneumatosisis only on AXR: 1

- *Muchantef K et al. Pediatr Radiol 2013;43:1444-1452*
  In 5 patients with NEC that had pneumatosisis
  - Pneumatosisis only on US: 5
  - Pneumatosisis on AXR: 0

- US more sensitive than AXR
NEC: echogenic & thickened bowel wall
NEC: bowel wall thinning
NEC: bowel perfusion
NEC: bowel perfusion
NEC: bowel perfusion
NEC: ultrasound

- Free peritoneal fluid: low-level echoes
- Localized fluid collection: suggests perforation
- Portal venous gas
- Pneumoperitoneum
NEC: echogenic free fluid
NEC: fluid collections
NEC: fluid collections

- 11/12 neonates with NEC without free gas on AXR had complex ascites on US & required surgery
- Good correlation of complex ascites with debris on US with intestinal gangrene or perforation
NEC: portal venous gas
NEC: portal venous gas


- In 93 patients with NEC:
  - PVG on AXR: 1
  - PVG on US: 7

- US superior to AXR in diagnosis of PVG
NEC: pneumoperitoneum
NEC: pneumoperitoneum
NEC: indications for ultrasound

- **Diagnosis**
  - Mild symptoms + nonspecific AXR

- **Follow-up**
  - Discrepancy between AXR/clinical evolution
  - Clinical deterioration but no free gas on AXR
NEC: indications for ultrasound

- Detection of bowel necrosis
- Prospective study: 26 infants with NEC stage II/III w/o free gas on AXR and w/o clinical deterioration to indicate surgery
  - US suggestive of bowel necrosis in 5, confirmed at surgery in 4
  - Sensitivity 100%, specificity 95%, PPV 80%, NPV 100%
- US can identify or exclude infants with NEC who may need surgery by detecting bowel necrosis prior to the development of perforation or clinical deterioration
- Early surgery in NEC may lead to improved outcomes
NEC: US of bowel necrosis

26wkGA, 42d ♀, abdominal distension
NEC: US of bowel necrosis

34wkGA, 7d♂
Complex CHD, post-op
NEC: role of ultrasound

- *Balassy et al. Presented at APSA 2011*

- Retrospective analysis in 39 neonates with suspected or definite NEC
  - 7 (18%) had AXR only (Pneumatosis 4, Pneumoperitoneum 3)
  - 32 (82%) had US to assist in
    - (i) diagnosis in 17 (53%) or
    - (ii) management in 15 (46%) - antibiotics/surgery

- US helped to establish diagnosis in 13/17 & changed management in 10/15

- US provided additional information for diagnosis or management in 23/32 (72%) who had US and 23/39 (59%) of whole series
NEC: sequence of events
US for NEC: implementation

- Team of interested sonographers/radiologists
  - Start with normal infants to establish technical settings and define normal standards
  - Learning curve
- Collaboration between radiology, NICU and pediatric surgery
Conclusion

- Ultrasound is at least complementary to radiographs in the evaluation of NEC
- Ultrasound can be extremely useful by clarifying radiographic findings and adding information not visible or not obtainable from radiographs
- Addition of ultrasound to imaging evaluation of NEC may affect patient’s management and possibly outcome
What’s still needed?

More prospective studies to:

- Compare ultrasound with radiographs
- Better define indications of ultrasound
- Evaluate impact of ultrasound on patient’s management and outcome
Sonography in NEC: suggested readings

- **Necrotizing Enterocolitis: Assessment of Bowel Viability with Color Doppler US**

- **Necrotizing Enterocolitis: Review of State-of-the-Art Imaging Findings with Pathologic Correlation**

- **Correlation of Sonographic Findings and Outcome in Necrotizing Enterocolitis**

- **A Prospective Comparison of Intestinal Sonography and Abdominal Radiographs in a Neonatal Intensive Care Unit**
  Silva CT, Daneman A, Navarro OM et al. Pediatric Radiology 2013; 43: 1453-1463

- **Prospective Evaluation of the Impact of Sonography on the Management and Surgical Intervention of Neonates with Necrotizing Enterocolitis**