Disclosure

• Nothing to disclose
Content Organization

- Introduction
- Pathophysiology, Imaging of NEC and Clinical aspects
- CDS Technique and Standard Protocol

- Spectrum of Color Doppler findings
- Case based approach
- Pearls and Pitfalls
- Conclusion
Introduction

- NEC - Serious multifactorial GI disease of unknown etiology.
- Mainly premature infant.
- Combination of immaturity, enteral feeding, ischemia, infection, etc.
- Incidence 1 to 5% NICU admissions.
- Pneumatosis intestinalis
- Pneumoperitoneum is only universally agreed sign - indication for surgical procedure.
- Perforation - 12-31% of neonates with NEC.
Pathology

- Ischemic necrosis with inflammation in the mucosa and often extending through bowel wall.
- Distal ileum and prox Colon most affected.
- Any portion of intestine may be involved.
- Transmural Necrosis: excessive response of inflammatory cascade – cytokines & complement.
Bell’s Staging Criteria

– Severity of disease and guide management
– Clinical picture, laboratory and AXR

I - Suspected NEC
   non specific AXR- Medical TX
II - Definite NEC –
   Pneumatosis intestinalis, bowel separation, PVG etc. - Medical TX
III-Advanced / Severe –
   Definite free air + findings listed in II
   - Surgical.

Abdominal Imaging

• Abdominal Radiograph (AXR): Standard modality of detection and monitoring

• US of the abdomen: Bowel assessment
  – Grey-Scale
  – Color Doppler Sonography (CDS)

Faingold et al. Radiology 2005
Applications of Color Doppler Sonography in NEC

- Differentiate normal from NEC (Grey-Scale)

- Assessment of bowel viability (CDS)
  - Changes in gas pattern
  - Gasless abdomen
  - Persistent loop sign
  - Slow to improve
  - Worsening of clinical status
CDS Technique & Standard Protocol

**Abdominal Sonography:** 20 to 25 minutes

- Linear array (8-20 mHz)
- 4 quadrants
- Bowel wall
  - echotexture, thickness, peristalsis
  - intramural air
  - perfusion Color Doppler Sonography (CDS)

**Color Doppler Sonography (CDS):**

# of CD signals - dots or lines/cm², optimize CDS gain and scale

- CD flow considered present when CDS signal reproducible

**Other features:**

- portal venous gas
- free air
- free fluid + character
- SMA/SMV + relationship
Data Sheet

PVG - Y N
ASCITES/COLLECTION - Y N SPECIFY -
FREE AIR - Y N
BOWEL THICKNESS – MURAL AIR - PERISTALSIS - BLOOD FLOW
RUQ
RLQ
LUQ
LLQ
SMA- BLOOD FLOW (DOPPLER)
SMA/SMV RELATIONSHIP -
CDS Technique & Standard Protocol

- NICU nurse available, neonates must be monitored. Beware of desaturation.
- When placing transducer be gentle.
- The exam is tailored to assess bowel with CDS, however all data is relevant. Data for each quadrant should be entered separately.
- Make sure to fill data sheet for every patient. It will help the final report.
- In case data is not available for a specific quadrant, this should be mentioned in the report. For example, “RUQ equivocal”.
Ultrasound

• FINDINGS according to literature:
  – Free air
  – Portal Venous Gas (PVG)
  – Ascites and Fluid collection (Debris)
  – Bowel wall thickening
  – Bowel wall thinning
  – Pneumatosis Intestinalis

Faingold et al. Radiology 2005
Epelman et al. Radiographics 2008
Ultrasound
Ultrasound
NEC - Bowel Wall Appearance
NEC - Bowel Wall Appearance
CDS Patterns of Mural Perfusion

- Normal
  - 1-9 dots/cm² (mean 3.78 +/- 0.20) and 0-2 lines/cm²

- Increased perfusion
  - Rim Appearance, “Y” appearance and zebra pattern

- Absent perfusion: Sensitivity 100%, specificity 90%
  - Single or multiple loops

Faingold et al. Radiology 2005
Video-Normal Flow
Bowel Perfusion Patterns:
Increased

Y Appearance

Rim Appearance

Zebra Pattern
Bowel Perfusion Patterns:
Absent

Single Necrotic loop

Multiple Necrotic Loops
Video-Abnormal Flow
Video-Abnormal Flow
Case Based Approach

- cases of NEC with AXR and CDS are provided

- Clinical information is available with the modified Bell Staging System (Pediatr Clin North Am 1986; 33:179-201)

At the end of each case comments regarding Imaging and outcome are available.
Case 1 - Bell stage II A

- 5 day old female
- 32 w GA
Case 1 - Bell stage II A
Case 1 - Bell stage II A

- AXR showed Pneumatosis and CDS demonstrated thick walled bowel loops with present peristalsis and hyperemic flow pattern compatible with viable loops.
- The premature neonate did well clinically.
Case 2 - Bell stage III A

- 1 week old male
- 35 w GA
Case 2 - Bell stage III A
Case 2 - Bell stage III A

- This patient did not have pneumoperitoneum, but had a “persistent loop sign” and was thrombocytopenic.
- CDS showed single bowel loop without flow in RLQ and other loops were hyperemic and viable.
- Gangrenous cecum and TI were resected and baby did well clinically.
Case 3 - Bell Stage II B

- 2 week old female
- 33 w GA
Case 3 - Bell Stage II B
Although clinically well, AXR showed asymmetry of gas pattern with loop separation.

CDS showed hyperemic bowel loops with a single segment with thinning of bowel wall and no flow in RLQ. CDS upgraded to staging to III.

Baby deteriorated and laparotomy disclosed gangrenous bowel loop.
Case 4 - Bell stage III B

- 6 week old female
- 24 w GA
Case 4 - Bell stage III B
Case 4 - Bell stage III B

- AXR showed “free air” and with dilated loops and separation.
- CDS demonstrated multiple bowel loops with no CDS flow, therefore non viable.
- Neonate died less than 12 hours after CDS study.
- Remember: babies with “Free air” may have single or multiple bowel loops with no flow. CDS helps “prognosticating” even though they are Stage III.
Case 5 – Bell Stage II B

- 30 w GA female
- 38 w corrected
Case 6-Stage II B

- 27 w GA
- 33w corrected
Case 6
Case 6

- Featureless bowel
Case 7 - Stage II A

- 28 w GA male
- 2 w old
Case 7
Case 7

4 weeks later
Case 7

- “The missing link?”
Pearls and Pitfalls

• Start with large ROIs to compare bowel.
• Presence of flow in normal cases and hyperemic patterns are obvious.
• Optimize CDS settings.
• In case of increased in gas causing artefact, if there is peristalsis - bowel is viable.
• Unstable patient not compatible with CDS evaluation. However if baby is stable and desaturates, wait until oxygen saturation returns to normal and continue exam.
Pearls

• Knowing normal CDS is imperative.
• When neonates have more advanced disease - decrease in peristalsis and more fluid filled bowel loops.
• To implement CDS protocol, limit number of radiologists and technologists involved. It is important to get enough experience and exposure.
• Use the data sheet. In the report, make sure to mention “sampled bowel loops…” It gives credibility and acknowledges a certain limitation of technique.
• Spend a few more minutes in RLQ. Statistically, it is the most affected quadrant. Reposition the baby with the help of NICU nurse.
Pitfalls

- Neonates on High Frequency Ventilation are difficult to evaluate and CDS not reliable.
- Decrease in cardiac output and use of vasopressors and inotropes may cause difficulty in detecting CDS signals. Optimize settings and discuss case with neonatologist. Follow-up may be helpful.
- Increase in bowel gas, uncooperative neonates (crying for example) limits CDS evaluation of intestinal blood flow. See artefact below!
Pitfalls

• A lack of standard protocol and experience will impact in poor performance.
Conclusions

• CDS can depict changes in bowel wall perfusion in neonates with NEC
• Viable loops show present to ↑ flow.
• Absence of perfusion indicates bowel necrosis in NEC
• CDS comprehensive technique to assess bowel viability in neonates
• CDS operator dependent and requires use of standard protocol, technique and cooperation with NICU team
Summary

• The applications and challenges of bowel viability assessment in NEC were discussed.
• Comprehensive description of technique and standard protocol were presented. Hopefully, we will obtain a more reliable and reproducible test across different institutions.
Thank you!