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Ultrasound versus Radiography for Evaluating Surgical Necrotizing Enterocolitis

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INTRODUCTION

- Necrotizing enterocolitis, can be difficult to diagnose and is the leading cause of death in neonates with very low birth weight with a mortality up to 35%[4]
- It develops following the feeding of preterm babies, progressing to intestinal necrosis, sepsis and death[4]
- Current gold standard of NEC diagnostic workup is abdominal X-ray (AR)[6]
- Abdominal X-ray, despite its specificity up to 92-100%, sensitivity is rated as low as 13% leading to missed NEC cases
- Pathognomonic findings such as pneumatosis, perforation and portal venous gas are difficult to identify on x-ray[9]
- Abdominal ultrasound (AUS), portable and non-invasive, has been shown to be superior to AR in diagnosis, management, and prediction of outcomes for NEC[1]
- Sensitivity of AUS in intestinal necrosis and perforation is greater than that of AR[3]
- However, AUS lacks integration in clinical practice[5]

SIGNIFICANCE

- Abdominal radiograph (AR), the imaging standard for NEC, may miss up to 50% of early signs of NEC and has been described to have a sensitivity as low as 15.4% for detecting pneumoperitoneum[9]
- Abdominal ultrasound (US) is portable, non-invasive, and allows real-time bowel integrity, movement, and perfusion assessment.
- Integration of AUS has been limited due to unfamiliarity of clinicians, a poor diagnostic consensus among clinicians, and a lack of a standardized algorithm[3]
- We aim to evaluate the concordance between US and AR in detecting NEC features and the diagnostic performance of both modalities in detecting pneumoperitoneum.

REFERENCES

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SCAN ME

METHODS

- IRB-approved retrospective, cross-sectional, single-center study
- Identification of infants with a diagnosis of NEC confirmed by pathology reports that had a bowel US and AR studies obtained before surgery from January 2012 to August 2022
- Clinical and demographic data extracted from CHOP electronic chart system
- Two pediatric radiologists, blinded to reports, evaluated the images to determine the presence of pneumatosis (PI), portal vein gas (PVG), bowel distension (BD), and pneumoperitoneum on both modalities
- A third pediatric radiologist resolved discrepant responses
- The diagnostic performance of both modalities to detect perforation based on the presence of pneumoperitoneum, and the concordance between them were calculated using the kappa statistic (**κ**)
- Studies with insufficient diagnostic quality were excluded

RESULTS

US findings	Kappa coefficient	Interobserver effect
Portal vein gas	0.89	96%
Pneumatosis	0.37	70%
Ascites	0.21	84%
Type of ascites	0.61	84%
Free gas	0.66	87%
Peristalsis*	0.26	57%
Perfusion*	0.42	58%
Distension	0.48	74%

Figure 1. The agreement of specific pathognomonic findings between the three pediatric radiologists in terms of the kappa coefficient. 1.0: perfect agreement. 0.81⩽ Kappa (**κ**) ⩽ 0.99: almost perfect agreement. 0.61 ⩽ Kappa (**κ**) ⩽ 0.80: substantial agreement. 0.41 ⩽ Kappa (**κ**) ⩽ 0.60: moderate agreement. 0.21 ⩽ Kappa (**κ**) ⩽ 0.40: fair agreement. 0.01 ⩽ Kappa (**κ**) ⩽ 0.20: slight agreement. 0: No agreement. Kappa (**κ**)‹ 0: agreement worse than chance.

Statistic	Value	95% CI
Sensitivity	35.00%	15.39% to 59.22%
Specificity	90.00%	55.50% to 99.75%
Positive Likelihood Ratio	3.50	0.50 to 24.67
Negative Likelihood Ratio	0.72	0.49 to 1.06
Disease prevalence (*)	66.67%	47.19% to 82.71%
Positive Predictive Value (*)	87.50%	49.82% to 98.01%
Negative Predictive Value (*)	40.91%	32.08% to 50.36%
Accuracy (*)	53.33%	34.33% to 71.66%

(*) These values are dependent on disease prevalence.

Figure 2A. Statistical properties of abdominal ultrasound. Of note, the sensitivity of 35%.

Statistic	Value	95% CI
Sensitivity	15.00%	3.21% to 37.89%
Specificity	100.00%	69.15% to 100.00%
Positive Likelihood Ratio		
Negative Likelihood Ratio	0.85	0.71 to 1.02
Disease prevalence (*)	66.67%	47.19% to 82.71%
Positive Predictive Value (*)	100.00%	29.24% to 100.00%
Negative Predictive Value (*)	37.04%	32.86% to 41.42%
Accuracy (*)	43.33%	25.46% to 62.57%

(*) These values are dependent on disease prevalence.

Figure 2B. Statistical properties of abdominal x-ray. Of note, the sensitivity of 15%, compared to the 35% sensitivity of abdominal ultrasound in Figure 2A.

Discussion and Insights

- Cohort included 9 girls and 22 boys, median age 23 days
- 23 (76%) were born prematurely, 20 had confirmed intestinal perforation
- US demonstrated 35% sensitivity and 90% specificity, while AR demonstrated 15% sensitivity and 100% specificity
- Agreement between US and AR was 10/30 (33%) for PI (**κ**=0.01), 22/28 (79%) for PVG (**κ**=0.2), 19/31 (61%) for BD (**κ**=0.21), and 24/31 (77%) for pneumoperitoneum (**κ**=0.34).
- Each feature was present more frequently on US than AR
- This study demonstrated AUS is a valuable complimentary tool for detecting NEC features and intestinal perforation
- Despite a low to moderate agreement between both modalities, US consistently outperformed AR in identifying NEC features
- These findings highlight the significance of integrating US into NEC diagnostic process and the need for revising current NEC algorithm
- Future efforts should include larger cohorts and a collaborative approach to improve the NEC diagnostic algorithm