

# Sensitivity and Specificity of Abdominal Ultrasound in Diagnosing Necrotizing Enterocolitis in Preterm Infants: A Meta-Analysis

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## INTRODUCTION

- Necrotizing enterocolitis (NEC) is the most common bowel disease in premature infants and is defined by the loss of mucosal integrity of the bowel wall causing ischemia and necrosis which can lead to bowel perforation and sepsis<sup>1</sup>.
- The current standard of care for diagnosis of NEC is based upon clinical suspicion, laboratory values and grading according to the Modified Bell's criteria (Table 1), which incorporates abdominal radiograph.
- This meta-analysis was conducted to estimate the overall sensitivity and specificity bowel ultrasound (BUS) for differentiation between preterm infants who are grade I versus grade II-III by the Modified Bell's criteria.

## METHODS

- Our institutional health sciences library conducted a literature search using PubMed, Embase, and CINAHL up to December 2016. Additionally, an ancestry query was performed from the article "Usefulness of abdominal ultrasound in diagnosing necrotizing enterocolitis." (Figure 2)
- Studies analyzing the diagnostic sensitivity and specificity of bowel US for NEC in neonates were considered eligible for inclusion if the following criteria were also met in entirety:
- Premature birth, as defined as occurring prior to 37 weeks.
  - Bowel US (Figure 1) was performed on those with clinical correlates suspicious for NEC.
  - Disease staging and categorization according to Modified Bell's criteria.
  - US imaging criteria included at least one of the following: bowel wall thickening (BWT), pneumatosis intestinalis, portal venous gas and pneumoperitoneum.
  - Sufficient data existed to evaluate sensitivity, specificity, and positive predictive value.
  - Full-text articles.

Figure 1: Bowel Ultrasound

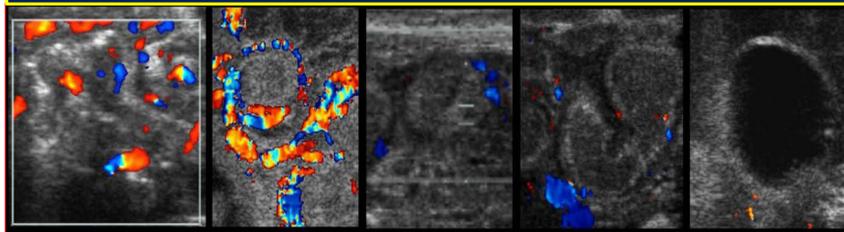
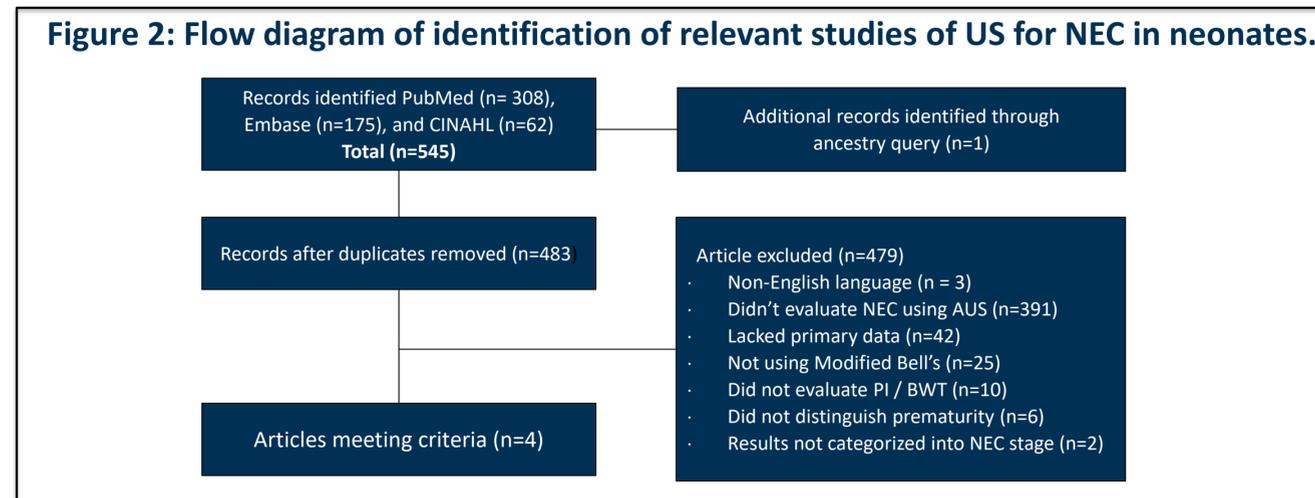


Figure 1: In the initial stages of NEC that correspond to the radiographic phase of bowel distension, bowel hyperemia is appreciated on color Doppler US. As the disease progresses bowel wall thickening occurs, which is usually accompanied by hyperemia, loss of the gut signature and loss of the external bowel wall definition. Pneumatosis intestinalis may be present as well. Later in severe cases the mucosa and submucosa becomes markedly thinned bowel wall, which is much more prone to perforation.<sup>1</sup>

Table 1: Modified Bell's Staging Criteria for NEC

Stage	Staging Signs	Intestinal Signs	Radiologic Signs	Treatment
IA	Temperature instability, apnea, bradycardia	Elevated pregavage residuals, mild abdominal distention, occult blood in stool	Normal or mild ileus	NPO, antibiotics x 3 days
IB	Same as IA	Same as IA, plus gross blood in stool	Same as IA	Same as IA
IIA Mildly III	Same as IA	Same as I, plus absent bowel sounds, abdominal tenderness	Ileus, pneumatosis intestinalis	NPO, antibiotics x 7 to 10 days
IIB Moderately III	Same as I, plus mild metabolic acidosis, mild thrombocytopenia	Same as I, plus absent bowel sounds, definite abdominal tenderness, abdominal cellulitis, right lower quadrant mass	Same as IIA, plus portal vein gas, with or without ascites	NPO, antibiotics x 14 days
IIIA Severely III: Bowel Intact	Same as IIB, plus hypotension, bradycardia, respiratory acidosis, metabolic acidosis, disseminated intravascular coagulation, neutropenia	Same as I and II, plus signs of generalized peritonitis, marked tenderness and distention of abdomen	Same as IIB, plus definite ascites	NPO, antibiotics x 14 days, fluid resuscitation, inotropic support, ventilator therapy, paracentesis
IIIB Severely III: bowel perforated	Same as IIIA	Same as IIIA	Same as IIB, plus pneumoperitoneum	Same as IIA, plus surgery

Figure 2: Flow diagram of identification of relevant studies of US for NEC in neonates.



## RESULTS

Table 2: Sensitivity and Specificity of BWT and Pneumatosis Intestinalis

Study	Bowel Wall Thickening				Pneumatosis Intestinalis			
	TP	FP	FN	TN	TP	FP	FN	TN
Dilli 2010	11	10	28	44	5	0	34	54
Kamali 2015	0	3	0	31	0	0	0	0
Prithviraj 2015	31	12	0	17	27	4	4	25
Shebry 2012	4	3	12	11	10	9	6	5
<b>Total</b>	<b>46</b>	<b>28</b>	<b>40</b>	<b>103</b>	<b>42</b>	<b>13</b>	<b>44</b>	<b>84</b>
	<b>SEN: 53%, SPEC: 79%, PPV 62%, NPV: 72%</b>				<b>SEN: 49%, SPEC: 87%, PPV 76%, NPV: 66%</b>			

Table 2: Pooled evaluation of the four studies demonstrates specificity greater than sensitivity for both features. Abdominal radiograph has been found to have high specificity and low sensitivity<sup>6</sup> across multiple imaging features, representing a need for a high-sensitivity imaging modality especially in less-obvious disease presentations.

## DISCUSSION

- Three of four studies were performed in developing nations. This raises the question of applicability to patient populations in developed nations.
- This is a relatively small meta-analysis in the end with only four included studies with 217 patients. This means that this question could definitely benefit from more research to improve our knowledge about the true sensitivity and specificity of bowel ultrasound for NEC in a larger population.
- The gold standard we used was a clinical composite standard and not a pathological standard. In the end, the modified Bell's criteria is only our best clinical guess as to whether the patient has developed NEC and not a true pathologic or microbiologic indication that the patient has suffered from this disease.

## CONCLUSION

- The pooled results indicate that BUS evaluation of both BWT and PI have high diagnostic accuracy for necrotizing enterocolitis in preterm neonates.
- Bowel ultrasound findings of BWT and PI are 49-53% sensitive and 79-87% specific for differentiating possible NEC from definite NEC.
- Both bowel wall thickening and pneumatosis on bowel ultrasound demonstrated increased sensitivity in differentiating Bells I from II-III compared to abdominal radiographs.
- We were able to aggregate four high quality studies and derive a better estimate for the sensitivity and specificity of bowel ultrasound for the diagnosis of NEC. We feel that our study will help radiologists justify the performance of bowel ultrasound for NEC to their clinical colleagues since the reported sensitivities and specificities are equal or better than those reported for abdominal radiographs.

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