

Assessing the Efficacy of A Scoring System in Surgical NEC Diagnosis

Cerrahi NEK Tanısında Bir Skorlama Sisteminin Etkinliğinin Değerlendirilmesi

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Abstract

Objective: To evaluate the efficacy of the necrotizing enterocolitis-treatment-aid (NEC-T-Aid) tool for diagnosing perforated NEC in preterm infants, particularly in cases in which pneumoperitoneum is absent.

Methods: This retrospective study included patients with surgically confirmed perforated NEC at a single-center from 2012 to 2022. Patients were assessed using the NEC-T-Aid assessment tool, which includes the clinical, abdominal signs, serological markers, and X-ray findings. Patients without pneumoperitoneum were specifically analyzed to determine the tool's diagnostic accuracy.

Results: Among the 39 patients included in the study, 25% of those with perforated NEC without pneumoperitoneum could not be definitively diagnosed using the NEC-T-Aid tool. Patients in the pneumoperitoneum group also experienced longer delays from initial evaluation to surgery, more extensive bowel resections, and a higher incidence of pediatric intestinal failure compared with patients in the pneumoperitoneum group.

Conclusion: The NEC-T-Aid tool has limitations in diagnosing perforated NEC in patients lacking pneumoperitoneum, highlighting the need for enhanced diagnostic methods. Improving early detection and intervention strategies are crucial for better managing NEC and reducing complications, such as extensive bowel resection and pediatric intestinal failure.

Keywords: Necrotizing enterocolitis, NEC-T-Aid tool, pneumoperitoneum, pediatric intestinal failure, diagnostic accuracy

Öz

Amaç: Nekrotizan enterokolit-tedavi-yardım (NEC-T-Aid) aracının preterm bebeklerde, özellikle pnömoperitoneumun olmadığı durumlarda, perfore NEC tanısı koymadaki etkinliğini değerlendirmektir.

Yöntem: 2012'den 2022'ye kadar tek bir merkezde cerrahi olarak doğrulanmış perfore NEC'li hastalar üzerinde retrospektif bir analiz yapılmıştır. Hastalar klinik bulgular, abdominal bulgular, serolojik belirteçler ve röntgen bulgularını içeren NEC-T-Aid değerlendirme aracı kullanılarak değerlendirilmiştir. Pnömooperitoneumu olmayan olgular, aracın tanısallığını belirlemek için özel olarak analiz edilmiştir.

Bulgular: Çalışmaya dahil edilen 39 hasta arasında, pnömoperitoneumu olmayan perfore NEC'li hastaların %25'ine NEC-T-Aid aracı kullanılarak kesin tanı konulamamıştır. Bu grupta ayrıca ilk değerlendirmeden ameliyata kadar daha uzun gecikmeler, daha kapsamlı bağırsak rezeksiyonları ve pnömoperitoneumlu hastalara kıyasla daha yüksek pediatrik bağırsak yetmezliği insidansı görüldü.

Sonuç: NEC-T-Aid aracı, pnömoperitoneumu olmayan olgularda perfore NEC tanısı koymada sınırlamalara sahiptir ve gelişmiş tanı yöntemlerine olan ihtiyaç vurgulamaktadır. Erken teşhis ve müdahale stratejilerinin iyileştirilmesi, NEC'nin daha iyi yönetilmesi ve geniş bağırsak rezeksiyonu ve pediatrik bağırsak yetmezliği gibi komplikasyonların azaltılması için çok önemlidir.

Anahtar Kelimeler: Nekrotizan enterokolit, NEC-T-Aid aracı, pnömoperitoneum, pediatrik intestinal yetmezlik, tanı doğruluğu



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Introduction

Necrotizing enterocolitis (NEC) is an inflammatory disease of the bowel and is the leading cause of death due to gastrointestinal disease in preterm neonates. The symptoms of NEC can be slow and mild at the beginning of the disease, progress rapidly, and have devastating consequences. NEC is one of the most frequently encountered surgical emergencies in neonates, with operative intervention being necessary for 25-50% of diagnosed patients^(1,2). The mortality rate of NEC ranges between 20% and 30%, with the highest rate among NECs requiring surgery⁽³⁾.

Managing NEC in premature infants poses a challenge, particularly in determining the appropriate surgical timing. Although radiological findings like pneumatosis and portal venous gas, confirm the diagnosis of NEC, reliance solely on these findings is not sufficient to suggest surgery, as some cases resolve medically. The only definitive indication for surgical intervention in NEC patients continues to be the presence of intestinal perforation⁽⁴⁻⁷⁾. NEC can lead to short-bowel syndrome, particularly when diagnosed late and involving multiple segments of the intestine⁽⁸⁾. In our study conducted in 2022, we focused on perforated NEC cases without pneumoperitoneum on abdominal X-ray and observed that diagnosis is often delayed in such patients, who typically present with multi-segmental involvement necessitating more extensive bowel resection procedures⁽⁹⁾.

In 2022, Coles et al.⁽⁶⁾ introduced a scoring system for accurate diagnosis and appropriate management. The objective of this study was to assess the effectiveness of this scoring system in the surgical diagnosis of NEC in patients who did not exhibit pneumoperitoneum on abdominal X-rays.

Materials and Methods

Data Collection and Study Group

The study was approved by the institutional review board (2023/07-19), retrospective data review analysis of patients who underwent surgery for NEC at a single-center from 2012 to 2022 was performed. Local ethics committee approval was obtained from the University of Health Sciences Turkey, İzmir Tepecik Education and Research Hospital Ethical Committee in compliance with the Declaration of Helsinki ethical standards for this retrospective single-center study (approval no: 2023 7-13, date: 02.08.2023). The study included neonates with surgically confirmed perforated NEC, whereas patients with incomplete medical records, those who

received percutaneous drain placement during the initial operation, and surgically and histopathologically confirmed non-perforated NEC were excluded from the study.

A total of 39 patients were included in the study, and all private health information was collected in adherence to strict privacy protocols. Informed consent was obtained from all parents of the enrolled patients. Examination and imaging findings of the patients were compared with the operative findings. All patients were evaluated using the NEC-treatment-aid (NEC-T-Aid) assessment tool.

NEC-T-Aid Assessment Tool

The NEC-T-Aid assessment tool⁽⁶⁾ has four sections; clinical signs, abdominal signs, serological markers and X-ray findings. Patients were evaluated using NEC-T-Aid parameters. These parameters were;

- General signs; increased frequency of desaturation/bradycardia, tachycardia, apnea, temperature instability, and sudden increase in ventilation setting
- Abdominal signs; worsening abdominal distension/dicoloration, abdominal tenderness, increased number of aspirates, vomiting, visible blood in the stool, and bilious aspirates
- Investigations; new/worsening metabolic acidosis, new/worsening metabolic changes, white cell count suggestive of sepsis, high/worsening C-reactive protein, low/falling platelets
- Abdominal X-ray; evidence of perforation, pneumatosis, peritoneal fluid, bowel dilatation, normal X-ray

In our previous study, the NEC-T-Aid score was categorized as follows:

- 0-3: Normal/dysmotility,
- 4-7: Sepsis,
- 8-10: Suspected NEC,
- >10: Confirmed NEC.

Statistical Analysis

For discrete and continuous variables, descriptive statistics (mean, standard error, median, and quartiles value) were calculated. In addition, the homogeneity of variances, which is a prerequisite for parametric tests, was checked using Levene's test. The assumption of normality

was tested using the Shapiro-Wilk test. To compare the differences between the two groups, an independent sample t-test was used when the parametric test prerequisites were fulfilled, and the Mann-Whitney U test was used when such prerequisites were not fulfilled. The chi-square test was used to determine the relationships between the two discrete variables. When the expected sources were less than 20%, the values were determined using the Monte Carlo simulation method to include them in the analysis. Data were evaluated using SPSS version 25 (IBM Statistics, New York, USA). Statistical significance was set at $p < 0.05$.

Results

A total of 72 patients were diagnosed with NEC during the study period, and 39 patients (19 girls and 20 boys) were included in the study. The mean maternal age was 27 years, gestational age was 31 weeks, and birth weight was 1877 g. The most common hospitalization diagnosis was respiratory distress syndrome (61.5%). The most common examination findings were abdominal distention (97.4%) and abdominal color discoloration (64.1%). A palpable mass was detected in 23.1% of patients. Gas deposition (82%) was the most common finding on direct standing abdominal X-ray, while pneumoperitoneum was observed in 49% of the patients. The median time from the initial evaluation of the cases by the surgical team to surgery was 24 hours (1-144). This time was found to be statistically higher in patients with perforated NEC without pneumoperitoneum (30-hours) than in patients with pneumoperitoneum (6-hours) ($p < 0.001$; Mann-Whitney U test). In addition, in these cases, NEC involvement was more frequently multi-segmental

($p = 0.048$; Fisher's Exact test) and the resected bowel length was longer ($p = 0.003$; Mann-Whitney U test). However, no significant difference was found in mortality between groups ($p = 0.695$; Fisher's Exact test). A comparative analysis of demographic characteristics and prognosis between groups is shown in Table 1.

The evaluation of all patients was conducted using the NEC-T-Aid. A comparison was performed between patients with NEC and those without pneumoperitoneum across 20 parameters. With the exception of one parameter (bowel dilatation on X-ray, $p = 0.003$; Fisher's Exact test), no significant differences were observed between the two groups. Notably, the total NEC-T-Aid score exhibited a noteworthy increase in the group of patients with pneumoperitoneum ($p < 0.001$; Independent Samples t-test). It is important to note that even though all patients in our study had perforated NEC, the NEC-Aid assessment tool failed to definitively diagnose NEC in 25% of cases in which pneumoperitoneum was absent. A comparison of NEC-T-Aid parameters and the overall scores between the two groups is provided in Table 1. Although all of our patients had perforated NEC, the NEC-Aid assessment tool could not diagnose 25% of patients did not have pneumoperitoneum as confirmed NEC. The comparison of NEC-T-Aid parameters and total scores between the groups is shown in Table 2.

Discussion

NEC stands as a prominent contributor to morbidity and mortality among newborns, with the highest risk observed in premature and very low birth weight infants, those weighing less than 1500 g. The mortality rate of patients with this condition varies from 15% to 30%^(10,11). Conventionally, the

Table 1. Comparative analysis of demographic characteristics and prognosis between groups

	Patients with pneumoperitoneum (n=19)	Patients without Pneumoperitoneum (n=20)	p
Mean maternal age: year ± SE	28±1	27±1	0.529 ^a
Mean gestational age: month ± SE	31±1	33±1	0.164 ^a
Mean birth weight: gram ± SE	1662±171	2081±164	0.087 ^a
Median time from the initial evaluation to the operation: hours (Q1-Q3)	6 (4.5-24)	30 (24-36)	0.001^b
Resected bowel length: cm (Q1-Q3)	5 (2-9)	11 (7.5-30)	0.003^b
Multi-segmental: percentage	21%	55%	0.048^c
Mortality: percentage	16%	25%	0.695 ^c
Short bowel syndrome: percentage	0	20%	0.101 ^c

Bold values indicate significant p-values ($p < 0.05$), ^a: Independent Samples t-test, ^b: Mann-Whitney U test, ^c: Fisher's Exact test, SE: Standard errors, Q1-Q3: Quartiles

Table 2. Comparison of NEC-T-Aid parameters and total score between groups

	Patients with pneumoperitoneum (n=19)	Patients without pneumoperitoneum (n=20)	p
Increased frequency of desats/bradys	57.9%	80.0%	0.251 ^a
Tachycardia	15.8%	15.0%	1.000 ^b
Apnea	0	0	
Temperature instability	0	0	
Sudden increase in ventilation settings	78.9%	80.0%	1.000 ^b
Worsening abdominal distention/discoloration	100%	94.7%	0.487 ^b
Abdominal tenderness	100%	95.0%	1.000 ^b
Increased aspirates	63.2%	85.0%	0.155 ^b
Vomiting	26.3%	45.0%	0.378 ^a
Visible blood in stool	31.6%	55.0%	0.250 ^a
Bilious aspirates	78.9%	65.0%	0.541 ^a
New/worsening metabolic acidosis	78.9%	85.0%	0.695 ^b
New/worsening metabolic changes	26.3%	25.0%	1.000 ^b
WCC suggestive of sepsis	73.7%	90.0%	0.235 ^b
High/worsening CRP	84.2%	90.0%	0.661 ^b
Low/falling platelets	57.9%	65.0%	0.266 ^a
Evidence of perforation on X-ray	100%	0	<0.001 ^b
Evidence of pneumatosis on X-ray	21.1%	20.0%	1.000 ^a
Evidence of peritoneal fluid on X-ray	15.8%	10.0%	0.661 ^b
Bowel dilatation on X-ray	63.2%	100%	0.003^b
Total score: mean ± SE	23.0±1.2	15.1±1.0	<0.001^c
NEC-T-Aid category			
-Normal/dysmotility	0	0	0.047^b
-Sepsis	0	0	
-Suspected NEC	0	25%	
-Confirmed NEC	100%	75%	

Bold values indicate significant p-values (p<0.05), ^a: Yates Continuity Correction test, ^b: Fisher's Exact test, ^c: Independent Samples t-test, desats/bradys: Desaturations/bradycardias, SE: Standard errors, NEC: Necrotizing enterocolitis, NEC-T-Aid: Necrotizing enterocolitis-treatment-aid, CRP: C-reactive protein, WCC: White cell count

diagnosis of NEC relies on Bell's Modified Staging Criteria, which classifies NEC into three distinct stages: Mild (referred to as Bell's Stage I), moderate (Bell's Stage II), and severe (Bell's Stage III). Advanced NEC, denoted as Bell's Stage III, requires surgical intervention and is characterized by bowel perforation resulting in pneumoperitoneum, hypotension, signs indicative of peritonitis, and severe metabolic acidosis^(4,12). It is estimated that approximately 20-40% of infants afflicted with NEC will require surgical management, and the mortality rate among these infants can soar as high as 50%⁽⁷⁾.

The principal objectives of surgical intervention in NEC include the containment of enteric spillage and removal of necrotic intestinal segments while preserving the maximum length of viable intestine⁽¹³⁾. Evidence of pneumoperitoneum on plain radiography is the only absolute indication for operation^(7,14,15). However, it is worth highlighting that pneumoperitoneum is detected in less than half of all infants with intestinal perforation or necrosis during surgery, highlighting its limited sensitivity as a marker for identifying infants requiring surgical intervention for NEC⁽¹⁶⁾. In our study, similar to findings in the existing literature, it was observed that more than half of the patients with

perforated NEC did not present with radiographic evidence of pneumoperitoneum.

Although Bell's criteria hold historical significance, their clinical utility has diminished over time. Consequently, numerous diagnostic scoring systems have been developed to enhance the identification and management of NEC⁽¹⁷⁻¹⁹⁾. In our study, when evaluating patients using the NEC-T-Aid parameters, we found that 25% of patients in the perforated NEC group without pneumoperitoneum could not be definitively diagnosed.

Pediatric intestinal failure is a complex and potentially life-threatening condition that can result from various underlying causes; including congenital anomalies, surgical complications, and acquired diseases. NEC is the leading cause of pediatric intestinal failure⁽²⁾. In our series, the median time from the initial evaluation to surgery and resected bowel length were significantly longer in the NEC group without pneumoperitoneum. Pediatric intestinal failure developed in 10.3% of patients, all of whom were also in the NEC group without pneumoperitoneum.

Study Limitations

Our study had several limitations. It was retrospective in design, conducted at a single center, and involved a relatively small sample size, limiting the generalizability of its findings.

Conclusion

NEC continues to be a major cause of morbidity and mortality in preterm infants, and diagnostic challenges are particularly evident in cases without pneumoperitoneum. These cases often result in more extensive bowel resections and a higher risk of pediatric intestinal failure. Our retrospective evaluation using the NEC-T-Aid tool revealed that 25% of perforated NEC cases without pneumoperitoneum could not be definitively diagnosed. This study underscores the limitations of current diagnostic tools and emphasizes the need for improved methods to enhance early diagnosis and intervention in NEC.

Ethics

Ethics Committee Approval: Local ethics committee approval was obtained from the University of Health Sciences Turkey, İzmir Tepecik Education and Research Hospital Ethical Committee in compliance with the Declaration of Helsinki ethical standards for this retrospective single-center study (approval no: 2023 7-13, date: 02.08.2023).

Informed Consent: Informed consent was obtained from all parents of the enrolled patients.

Footnotes

Authorship Contributions

Surgical and Medical Practices: B.T.K., Concept: B.T.K., Design: B.T.K., Data Collection or Processing: B.T.K., F.M.Ü., Analysis or Interpretation: B.T.K., F.M.Ü., Literature Search: B.T.K., F.M.Ü., Writing: B.T.K.

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