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Impact of Early Enteral Nutrition on Hospital Length of Stay After Penetrating Bowel Injury: A Retrospective Cohort Study from Taiz, Yemen

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Impact of Early Enteral Nutrition on Hospital Length of Stay After Penetrating Bowel Injury: A Retrospective Cohort Study from Taiz, Yemen

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Abstract

Background: Penetrating bowel injury (PBI) following armed conflict carries substantial postoperative morbidity in low-resource settings. Early enteral nutrition (EEN) is recommended by international guidelines to attenuate surgical stress and accelerate recovery, yet evidence from conflict-affected populations remains scarce.

Objectives: This study aimed to evaluate the impact of early enteral nutrition on hospital length of stay among patients undergoing surgery for penetrating bowel injury at Al-Safwa Hospital, Taiz, Yemen.

Methods: A retrospective cohort study was conducted of patients who underwent emergency surgery for penetrating bowel injury between 2017 and 2023. Patients were classified into two groups according to postoperative feeding strategy: early enteral nutrition (EEN), defined as initiation of enteral feeding within 48 hours of surgery, and delayed enteral nutrition (DEN), defined as commencement after 48 hours. The primary outcome was hospital length of stay. Secondary outcomes included time to first bowel movement, postoperative complication rate, surgical site infection, anastomotic leak, and in-hospital mortality. Univariate and multivariate analyses were performed to identify independent predictors of prolonged hospital stay.

Results: A total of 109 patients were included; 83.5% sustained gunshot wounds and 51.4% had isolated small bowel injuries. Patients in the EEN

group demonstrated significantly shorter hospital length of stay compared with the DEN group. EEN was also associated with earlier return of bowel function, lower overall complication rates, and fewer infectious complications. The overall complication rate was 26.6%, and in-hospital mortality was 2.8%. On multivariate analysis, delayed enteral nutrition and operative duration exceeding three hours were independent predictors of prolonged hospital stays.

Conclusion: Early enteral nutrition was associated with significantly shorter hospital length of stay and improved postoperative outcomes following surgery for penetrating bowel injury in a conflict-affected, resource-limited Yemeni setting. These findings support the integration of structured early feeding protocols into postoperative care pathways for trauma laparotomy in austere environments.

Keywords: penetrating bowel injury; early enteral nutrition; hospital length of stay; conflict surgery; Yemen; trauma laparotomy; postoperative nutrition; resource-limited settings

Introduction

Penetrating bowel injury (PBI) is a common surgical emergency and remains a significant cause of morbidity and mortality, particularly in conflict-affected and low- and middle-income countries (LMICs), where delayed presentation, limited healthcare resources, and inadequate access to specialist care worsen patient outcomes [1–4]. Gunshot, blast, and stab wounds are the leading mechanisms of injury, and small bowel trauma frequently requires emergency laparotomy with bowel repair or resection [1–3]. In Yemen, the prolonged armed conflict has placed enormous pressure on the healthcare system and substantially increased the burden of penetrating abdominal injuries [4]. After surgery, patients develop a hypermetabolic, catabolic response characterized by increased energy expenditure, protein breakdown, and impaired immune function, all of which can delay recovery and increase the risk of postoperative complications [5,6].

Early enteral nutrition (EEN), usually defined as initiating oral or enteral feeding within the first 24–48 hours after surgery, has become an important component of modern perioperative care. Providing nutrients through the gastrointestinal tract helps preserve intestinal mucosal integrity, maintain gut barrier function, reduce bacterial translocation, support immune function, and stimulate the recovery of gastrointestinal motility [5,7]. Based on these physiological benefits, both the European Society for Clinical Nutrition and Metabolism (ESPEN) and the Enhanced Recovery After Surgery (ERAS) Society recommend early postoperative oral or enteral feeding whenever feasible and discourage prolonged fasting after abdominal surgery [6,8,9].

Evidence supporting EEN has grown substantially over recent years. A 2018 Cochrane review demonstrated that initiating feeding within 24 hours after lower gastrointestinal surgery significantly reduced hospital length of stay, although evidence for other postoperative complications remained uncertain because of study heterogeneity [10]. More recent systematic reviews and meta-analyses have consistently reported that EEN shortens hospital stay, promotes earlier return of bowel function, improves nutritional recovery, and reduces postoperative infectious complications without increasing the risk of anastomotic leakage or mortality [11–13]. However, most available evidence has been generated from elective gastrointestinal surgery in high-income countries, whereas studies involving trauma patients,

particularly those with penetrating bowel injuries managed under resource-limited or conflict conditions, remain scarce.

This lack of evidence is particularly relevant in Yemen, where patients with penetrating bowel injury often present late, have severe intra-abdominal contamination, and receive care in hospitals with limited nutritional and critical care resources [1,4]. Hospital length of stay is an especially important outcome in such settings because prolonged hospitalization places additional strain on already overstretched healthcare services and increases healthcare costs for both hospitals and patients. To our knowledge, no published study has specifically evaluated the association between early enteral nutrition and hospital length of stay following penetrating bowel injury in a conflict-affected setting. Therefore, this study aimed to evaluate the impact of early enteral nutrition on hospital length of stay among patients undergoing surgery for penetrating bowel injury at Al-Safwa Hospital, Taiz, Yemen.

Methods

Study Design and Setting

This was a retrospective cohort study conducted at Al-Safwa Hospital in Taiz, Yemen, a tertiary referral trauma center serving a conflict-affected civilian population. The study included patients managed between January 2017 and December 2023.

Study Population

All adult patients (aged ≥ 18 years) who underwent emergency exploratory laparotomy for intraoperatively confirmed penetrating bowel injury were eligible for inclusion. Exclusion criteria were death within 24 hours of surgery; non-operative management; isolated extra-abdominal injuries without bowel involvement; and incomplete nutritional or clinical outcome data precluding group classification or outcome ascertainment. After applying these criteria, 109 patients were included in the final analysis.

Exposure Variable

The exposure of interest was the timing of postoperative enteral nutrition. Early enteral nutrition (EEN) was defined as initiation of oral or enteral feeding within 48 hours of the index surgical procedure. Delayed enteral nutrition (DEN) was defined as commencement after 48 hours. Feeding modality included an oral liquid diet, nasogastric tube feeding, or nasojejunal tube feeding, as determined by the operating surgeon according to operative

findings, patient tolerance, and institutional resources. Group allocation was determined retrospectively from documented nursing and medical records.

Data Collection

Data were extracted retrospectively from medical records using a standardized data abstraction form. Variables collected included: patient demographic characteristics; mechanism of injury; time from injury to surgery; operative findings including injury site, extent, degree of fecal contamination, and associated intra-abdominal organ injuries; type of bowel repair; timing and route of postoperative enteral nutrition; use of parenteral nutrition; time to return of bowel function; postoperative complications; ICU admission and length of stay; mechanical ventilation; total hospital length of stay; and in-hospital mortality. Data were abstracted independently by two trained investigators, with discrepancies resolved by consensus.

Outcome Measures

The primary outcome was hospital length of stay, measured in days from the index surgical procedure to discharge or death. Secondary outcomes were time to return of bowel function (first passage of flatus or stool); ICU admission rate; ICU length of stay; unplanned reoperation; overall postoperative complication rate; and in-hospital mortality.

Statistical Analysis

All analyses were performed using IBM SPSS Statistics version 24. Continuous variables were summarized as median with interquartile range (IQR) following confirmation of non-normal distribution by the Shapiro-Wilk test. Categorical variables were expressed as frequencies and percentages. Between-group comparisons used the Mann-Whitney U test for continuous variables and the chi-square test or Fisher's exact test for categorical variables. To determine the independent association between enteral nutrition timing and hospital length of stay, a multivariable Gamma regression model with log link function was fitted, this model being selected on the basis that hospital length of stay exhibited a right-skewed, continuous, strictly positive distribution consistent with the Gamma family. Covariates included age, AAST injury severity grade, presence of associated injuries, shock on admission, and sex. Results are expressed as exponentiated coefficients ($\text{Exp}[B]$) representing ratios of mean hospital length of stay, with 95% Wald confidence intervals. All P values were two-sided; statistical significance was defined as $P < 0.05$.

Ethical Considerations

The study was approved by the Institutional Review Board of the Faculty of Medicine, Taiz University [ECTU2024/20-2], on 4-1-2024, with administrative approval from Al-Safwa Hospital, Taiz, Yemen. Because of the retrospective design and use of anonymized clinical data, the requirement for informed consent was waived. Patient confidentiality was maintained throughout the study, which was conducted in accordance with the Declaration of Helsinki.

Results

Study Population and Baseline Characteristics

One hundred and nine patients met the inclusion criteria. Of these, 94 (86.2%) received EEN within 48 hours of surgery, and 15 (13.8%) received delayed enteral nutrition. One patient was excluded from the multivariable analysis owing to missing covariate data; 108 patients were included in the regression model. The median age of the cohort was 28 years (IQR 22–35), and 102 patients (93.6%) were male. Gunshot wounds accounted for 83.5% of injuries, blast or shrapnel injuries for (16.5%). Isolated small bowel injury was the most frequent pattern (51.4%), followed by isolated colonic injury (28.4%) and combined small bowel and colon injury (16.5%). Peritoneal contamination was present in 75.2% of patients overall. No statistically significant differences were identified between the EEN and DEN groups across any baseline variable (Table 1).

Table 1.

Baseline demographic and clinical characteristics of the study population

Characteristic	EEN (n = 94) n (%)	DEN (n = 15) n (%)	Total (n = 109) n (%)	P value
Age, years, median (IQR)	28 (23–35)	24 (20–38)	28 (22–35)	0.555
Age <30 years	53 (56.4%)	10 (66.7%)	63 (57.8%)	0.454
Age ≥30 years	41 (43.6%)	5 (33.3%)	46 (42.2%)	
Sex: male	89 (94.7%)	13 (86.7%)	102 (93.6%)	0.247
Mechanism of injury				0.071
Gunshot wound	76 (80.9%)	15 (100.0%)	91 (83.5%)	—
Blast/shrapnel	18 (19.1%)	0 (0.0%)	18 (16.5%)	—
Injury pattern				0.151
Isolated small bowel	47 (50.0%)	6 (40.0%)	56 (51.4%)	—

Characteristic	EEN (n = 94) n (%)	DEN (n = 15) n (%)	Total (n = 109) n (%)	P value
Isolated colon	31 (33.0%)	3 (20.0%)	31 (28.4%)	—
Combined small bowel & colon	16 (17.0%)	6 (40.0%)	18 (16.5%)	—
AAST grade high (III–V)	41 (43.4%)	8 (53.3%)	49 (44.9%)	0.482
Peritoneal contamination	68 (72.3%)	14 (93.3%)	82 (75.2%)	0.110
Shock on admission	27 (28.7%)	7 (46.7%)	34 (31.2%)	0.229
Associated injuries	61 (64.9%)	10 (66.7%)	71 (65.1%)	0.892

EEN = early enteral nutrition; DEN = delayed enteral nutrition; IQR = interquartile range; AAST = American Association for the Surgery of Trauma. P values by Mann–Whitney U test, chi-square test, or Fisher’s exact test as appropriate.

Gastrointestinal Recovery

Return of bowel sounds occurred significantly earlier in the EEN group (median 1 day [IQR 1–2] vs. 2 days [IQR 1–3]; $p = 0.021$). Time to first passage of flatus showed a similar trend that did not reach statistical significance (median 3 days [IQR 2–4] vs. 4 days [IQR 3–5]; $p = 0.091$). Abdominal distension and vomiting occurred more frequently in the DEN group, but neither difference reached conventional significance (Table 2).

Table 2.

Postoperative gastrointestinal recovery outcomes

Outcome	EEN (n = 94)	DEN (n = 15)	P value
Return of bowel sounds, days, median (IQR)	1 (1–2)	2 (1–3)	0.021*
First passage of flatus, days, median (IQR)	3 (2–4)	4 (3–5)	0.091
Abdominal distension, n (%)	27 (28.7%)	7 (46.7%)	0.229
Vomiting, n (%)	9 (9.6%)	4 (26.7%)	0.079

P values by Mann–Whitney U test (continuous) or Fisher’s exact test (categorical). *: indicates statistical significance ($p < 0.05$).

Primary Outcome: Hospital Length of Stay

Patients in the EEN group had significantly shorter hospital stays compared with those in the DEN group (median 5 days [IQR 4–7] vs. 11 days [IQR 8–28]; $p < 0.001$). ICU length of stay was similarly shorter (median 0 days [IQR 0–2] vs. 4 days [IQR 1–6]; $p < 0.001$) (Table 3)

Table 3.**Primary outcome: hospital length of stay and related outcomes**

Outcome	EEN (n = 94)	DEN (n = 15)	P value
Hospital length of stay, days, median (IQR)	5 (4–7)	11 (8–28)	< 0.001*
ICU length of stay, days, median (IQR)	0 (0–2)	4 (1–6)	< 0.001*
ICU admission, n (%)	33 (35.1%)	12 (80.0%)	0.001*
Unplanned reoperation, n (%)	8 (8.5%)	7 (46.7%)	0.001*
Overall complication rate, n (%)	20 (21.3%)	9 (60.0%)	0.003*
In-hospital mortality, n (%)	0 (0.0%)	3 (20.0%)	0.002*

EEN = early enteral nutrition; DEN = delayed enteral nutrition; IQR = interquartile range; ICU = intensive care unit. P values by Mann–Whitney U test (continuous) or Fisher’s exact test (categorical). The detailed breakdown of individual postoperative complications by category is reported in a companion manuscript from the same cohort. *: indicates statistical significance ($p < 0.05$).

Multivariable Analysis

The multivariable Gamma regression model was statistically significant overall (omnibus likelihood ratio $\chi^2 = 52.704$, $df = 5$; $p < 0.001$) with excellent model fit (deviance/ $df = 0.314$). Delayed enteral nutrition was the sole statistically significant independent predictor of prolonged hospital length of stay ($\text{Exp}[B] = 2.35$, 95% CI 1.73–3.18; $p < 0.001$), indicating that patients who received delayed feeding had a mean stay 2.35 times longer than those fed early after adjustment for all covariates. Shock on admission was the only other variable to reach statistical significance ($\text{Exp}[B] = 0.70$, 95% CI 0.55–0.88; $p = 0.002$), Shock $\text{Exp}(B)$ is recalculated as the inverse of SPSS output ($0.70 = 1.43$) to present shock-present vs. shock-absent direction, and that reflecting the longer stay of patients who experienced hemodynamic instability. Age, injury severity, sex, and presence of associated injuries were not independently associated with hospital length of stay (Table 4).

Table 4.

Multivariable Gamma regression analysis: independent predictors of hospital length of stay

Variable	Exp(B)	95% CI	P value
Delayed enteral nutrition (>48 h vs. <48 h)	2.35	1.73–3.18	< 0.001*
Shock on admission (yes vs no)	1.43 ¹	1.14–1.82	0.002*
High AAST grade (III–V vs I–II)	0.89	0.72–1.09	0.245
Associated injuries (yes vs no)	0.84	0.67–1.05	0.133
Age (per year)	0.99	0.98–1.00	0.216

Exp(B) = exponentiated coefficient representing the ratio of mean hospital length of stay relative to the reference category. Model: Gamma distribution with log link function; outcome: hospital length of stay (days). Omnibus likelihood ratio $\chi^2 = 52.704$ (df = 5), $p < 0.001$; deviance/df = 0.314. ¹ Shock Exp (B) is recalculated as the inverse of SPSS output ($0.70^{-1} = 1.43$) to present shock-present vs. shock-absent direction. AAST = American Association for the Surgery of Trauma; CI = confidence interval. *: indicates statistical significance ($p < 0.05$).

Discussion

This retrospective cohort study provides the first evidence from a conflict-affected setting in Yemen on the relationship between the timing of enteral nutrition and postoperative hospital length of stay following penetrating bowel injury. After adjustment for injury severity, hemodynamic status, associated injuries, age, and sex, initiation of early enteral nutrition (EEN) within 48 hours of emergency laparotomy was independently associated with a 2.35-fold shorter mean hospital stay than delayed enteral nutrition (DEN). The observed six-day reduction in median hospital stay is clinically meaningful in a resource-constrained healthcare system, where prolonged admissions place considerable pressure on limited hospital beds and surgical resources. Beyond reducing hospital stay, patients who received EEN experienced earlier recovery of bowel function, lower rates of intensive care unit admission and reoperation, and no in-hospital deaths, whereas mortality reached 20% among patients receiving delayed feeding. Collectively, these findings suggest that the timing of postoperative nutritional support may play an important role in improving recovery after penetrating bowel trauma.

Our findings are consistent with a growing body of evidence supporting the benefits of early postoperative enteral nutrition, although the magnitude of benefit observed in this study exceeds that reported in most elective surgical populations. The 2019 Cochrane review by Herbert et al. demonstrated that initiating enteral feeding within 24 hours after lower gastrointestinal surgery reduced hospital stay by approximately two days, although the certainty of evidence was considered low and the effects on individual postoperative complications remained inconclusive [10]. More recently, Shi et al. confirmed through a meta-analysis of 30 randomized studies that EEN consistently shortens hospital stay while reducing infectious complications across a broad range of surgical procedures [12]. Evidence from emergency abdominal surgery is more limited but supports a similar trend. Burcharth et al. reported that EEN was associated with lower postoperative mortality following major emergency abdominal surgery, although the available evidence was insufficient to draw definitive conclusions regarding hospital length of stay [14].

The greater reduction in hospital stay observed in the present study is likely attributable to the unique characteristics of patients with penetrating bowel injury treated in a conflict setting. Compared with elective surgical patients, these individuals frequently present with extensive tissue destruction, severe contamination, substantial physiological stress, and prolonged operative procedures, all of which markedly increase metabolic demands and delay postoperative recovery [4,15]. In addition, the absence of standardized Enhanced Recovery After Surgery (ERAS) pathways and the limited availability of perioperative resources in conflict-affected hospitals may amplify the adverse consequences of delayed nutritional support. Within this context, timely restoration of enteral feeding may have a proportionally greater impact on recovery than that observed in well-resourced elective surgical practice, highlighting the importance of early nutritional intervention in trauma patients with limited physiological reserve.

The mechanisms through which early enteral nutrition improves postoperative recovery are well established and provide a biologically plausible explanation for our findings. Penetrating bowel injury and emergency laparotomy trigger a profound metabolic stress response characterized by hypermetabolism, accelerated protein catabolism, and

systemic inflammation, all of which impair tissue repair and delay recovery [16,17]. In addition, disruption of the intestinal mucosal barrier increases permeability, facilitating bacterial translocation and exacerbating systemic inflammatory responses [7]. Early enteral nutrition helps interrupt this process by preserving intestinal mucosal integrity, maintaining tight-junction function, and stimulating gastrointestinal motility, thereby reducing postoperative ileus and promoting earlier recovery of bowel function [12,18]. Adequate nutritional support also enhances immune function, supports collagen synthesis and wound healing, and may reduce infectious complications, ultimately facilitating earlier mobilization, faster progression to oral feeding, and shorter hospitalization [12,16]. These physiological benefits are particularly relevant in patients with penetrating bowel injury, whose nutritional reserves are often compromised by severe trauma and the hypercatabolic response associated with emergency surgery.

The clinical implications of these findings are especially important for trauma care in conflict-affected and resource-limited settings. Current ESPEN guidelines consistently recommend re-establishing oral or enteral nutrition as early as clinically feasible after abdominal surgery while avoiding unnecessary postoperative fasting [8,16]. Similarly, the ERAS Society recognizes early oral feeding as a key component of enhanced postoperative recovery pathways [9]. However, most evidence supporting these recommendations has been derived from elective gastrointestinal surgery in high-income countries [19]. Our findings extend this evidence to penetrating bowel trauma managed under the challenging conditions of a conflict zone, where patients often present with more severe injuries and healthcare resources are limited. In such settings, a median reduction of six hospital days represents not only a meaningful improvement in patient recovery but also a substantial reduction in healthcare utilization, including hospital bed occupancy, nursing workload, antibiotic use, and overall treatment costs. Importantly, implementing an early enteral feeding protocol requires minimal additional resources, making it a practical and cost-effective intervention for hospitals with limited infrastructure. These findings support incorporating structured early enteral nutrition into standard postoperative management following emergency bowel surgery and reinforce the importance of nutritional care within trauma surgery protocols in low- and middle-income countries affected by conflict.

This study has several limitations. First, its retrospective observational design precludes causal inference, and although multivariable regression was used to adjust for important clinical confounders, residual confounding cannot be excluded. Second, the study was conducted at a single tertiary trauma center in Yemen, which may limit the generalizability of the findings to other healthcare settings. Third, the relatively small number of patients in the delayed enteral nutrition group reduced the statistical power for some secondary outcomes. Fourth, the timing of enteral nutrition was determined by treating surgeons rather than by random allocation, introducing the potential for confounding by indication. Finally, detailed data on nutritional adequacy, caloric and protein intake, and long-term postoperative outcomes were unavailable. Despite these limitations, the study represents one of the largest cohorts of penetrating bowel injury from a conflict-affected setting and provides important real-world evidence supporting early enteral nutrition in trauma patients

Conclusion

Early enteral nutrition initiated within 48 hours after emergency laparotomy was independently associated with a significantly shorter hospital stay in patients with penetrating bowel injury treated in a conflict-affected, resource-limited setting. Patients who received early enteral nutrition also demonstrated earlier recovery of bowel function, lower rates of intensive care unit admission and reoperation, and no in-hospital mortality compared with those receiving delayed feeding. These findings support the growing body of evidence that timely restoration of enteral nutrition is an important component of postoperative care and suggest that its benefits extend to penetrating bowel trauma in austere environments. Given its low cost, feasibility, and minimal resource requirements, early enteral nutrition should be considered a standard component of postoperative management whenever clinically appropriate. Prospective multicenter studies and randomized controlled trials are warranted to confirm these findings, evaluate long-term outcomes, and further inform evidence-based nutritional guidelines for trauma patients in low- and middle-income countries.

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