The impact of postoperative enteral nutrition on duodenal injury outcomes: A post hoc analysis of an Eastern Association for the Surgery of Trauma multicenter trial

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BACKGROUND: Leak following surgical repair of traumatic duodenal injuries results in prolonged hospitalization and oftentimes nil per os treatment. Parenteral nutrition (PN) has known morbidity; however, duodenal leak patients often have complex injuries and hospital courses resulting in barriers to enteral nutrition (EN). We hypothesized that EN alone would be associated with (1) shorter duration until leak closure and (2) less infectious complications and shorter hospital length of stay compared with PN.

METHODS: This was a post hoc analysis of a retrospective, multicenter study from 35 level 1 trauma centers, including patients older than 14 years who underwent surgery for duodenal injuries (January 2010 to December 2020) and endured postoperative duodenal leak. The study compared nutrition strategies: EN versus PN versus EN-PN using χ^2 and Kruskal-Wallis tests; if significance was found, pairwise comparison or Dunn's test were performed.

RESULTS: There were 113 patients with duodenal leak: 43 EN, 22 PN, and 48 EN-PN. Patients were young (median age, 28 years) males (83.2%) with penetrating injuries (81.4%). There was no difference in injury severity or critical illness among the groups; however, there were more pancreatic injuries among PN groups. Enteral nutrition patients had less days nil per os compared with both PN groups (12 days [interquartile range, 23 days] vs. 40 [54] days vs. 33 [32] days, $p = <0.001$). Time until leak closure was less in EN patients when comparing the three groups (7 days [interquartile range, 14.5 days] vs. 15 [20.5] days vs. 25.5 [55.8] days, $p = 0.008$). Enteral nutrition patients had less intra-abdominal abscesses, bacteremia, and days with drains than the PN groups (all $p < 0.05$). Hospital length of stay was shorter among EN patients versus both PN groups (27 days [24] vs. 44 [62] days vs.

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45 [31] days, $p = 0.001$). When controlling for predictors of leak, regression analysis demonstrated that EN was associated with shorter hospital length of stay ($\beta = -24.9$; 95% confidence interval, −39.0 to −10.7; $p < 0.001$).

CONCLUSION: Enteral nutrition was associated with a shorter duration until leak closure, less infectious complications, and shorter length of stay. Contrary to some conventional thought, PN was not associated with decreased time until leak closure. We therefore suggest that EN should be the preferred choice of nutrition in patients with duodenal leaks whenever feasible. (*J Trauma Acute Care Surg.* 2024;97: 928–936. Copyright © 2024 Wolters Kluwer Health, Inc. All rights reserved.)

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Traumatic duodenal injuries are often associated with high morbidity and mortality. Duodenal leak following surgical repair of traumatic duodenal injuries further prolongs hospitalization and complicates the delivery of adequate nutrition. Optimizing nutritional strategies for patients with duodenal leaks is of paramount importance. Despite current literature and existing nutritional guidelines, the optimal approach to nutritional delivery has yet to be studied in this patient population. In both elective and emergent postoperative patient populations, the choice between enteral nutrition (EN), parenteral nutrition (PN), or a combination of both EN-PN has prompted a debate. There are data about the advantages of EN in maintaining the gut integrity, stimulation of the immune system, and providing a physiological means of nutrient delivery.[1–4] In contrast, the role of PN is emphasized in cases where enteral feeding may be challenging, such as bowel obstructions or severe malabsorption issues.[3–5]

The existing body of literature presents varying perspectives on the optimal timing of introducing feeds following laparotomy;[6] the majority deemed EN to be associated with fewer septic complications, decreased morbidity, and decreased length of hospital stay when compared with PN.[3,7–10] This consensus was echoed in the surgical oncology literature in a meta-analyses of patients who specifically underwent pancreaticoduodenectomy;[11] however, it is important to note that some studies noted PN's superiority over EN following pancreaticoduodenectomy.[12,13] In the intensive care unit (ICU) population, Heidegger et al.[14] emphasized that a combination of EN and supplemental PN should be tailored to individual patient needs, especially in cases where an oral or enteral diet cannot be tolerated or absorbed, as EN alone may not provide sufficient nutrition. Another meta-analysis by Lewis et al.[15] revealed no statistical significant differences among EN, PN or a combination of EN-PN in length of ICU stay.

Because of this lack of clarity in existing literature regarding EN versus PN versus EN-PN and the lack of data in patients with duodenal leak, we sought to evaluate the optimal mode of nutrition in this patient population. Our study assessed patients with traumatic duodenal injuries requiring operative management who endured a postoperative leak from the duodenal repair site. We aimed to provide more clarity on the mode of nutrition delivery and facilitate a more informed approach to nutritional strategies in postoperative care specifically for this patient cohort. We hypothesized that EN alone would be associated with (1) shorter duration until leak closure and (2) less infectious complications and shorter hospital length of stay compared with PN.

PATIENTS AND METHODS

Patient Cohort

This study is a post hoc analysis of an observational retrospective, multicenter study from 35 level 1 trauma centers in the United States, Canada, and Greece including patients older than 14 years who underwent surgery for duodenal injuries between January 2010 and December 2020.[16] This particular analysis was limited to patients who developed postoperative duodenal leak, and therefore, patients who died within 24 hours of admission were excluded. Institutional review board approval was obtained by all participating centers along with a waiver of informed consent.

Data Collection and Imputation

The objective of this study was to analyze modes of nutritional support in patients after duodenal repair complicated by postoperative leak and correlate nutritional approach with patient outcomes. Three distinct strategies for nutritional support in this population were compared: EN, PN, or a combination of EN-PN. Enteral nutrition was defined as any nutrition delivered via the gastrointestinal tract including a diet by mouth or tube feeds. Patient data are reported from index hospitalizations, as data following hospital discharge were mostly unavailable.

Data were collected in a retrospective manner using each center's trauma registry and/or *International Classification of Diseases, Ninth and Tenth Revision*, codes to identify patients with duodenal injuries who required surgical interventions. A data collection instrument was used to capture standardized patient data from each participating site's electronic medical records system for storage in a secure web-based application (Research Electronic Data Capture).[17,18] Data points that were collected included demographics, mechanism of injury, admission hemodynamics, Injury Severity Score, massive transfusion protocol, duodenal and pancreatic American Association for the Surgery of Trauma injury grades, repair strategy (primary repair alone vs. complex repair with adjunctive measures), duration of nutrition strategy, complications, and surgical feeding tube placement. Outcomes evaluated included duration until leak closure, length of stay, infectious complications, and mortality. To minimize the impact of missing data, variables with >30% missingness were removed, and Multiple Imputation by Chained Equation was used to impute data for the remaining categorical and continuous variables.[19–21]

Statistical Analysis

Univariate analysis was performed to identify significant differences in baseline demographics, injury characteristics and severity, hospitalization events, and outcomes. Parametric and nonparametric variables were compared via Student's t and Kruskal-Wallis tests, respectively, followed by pairwise multiple comparisons with a Bonferroni correction. Categorical variables were compared using the χ^2 test for proportions followed by post hoc pairwise proportion testing.

A multiple logistic regression model was created based on univariate variable significance or author consensus using injury characteristics, severity, and hospitalization events to identify factors significantly associated with eligibility for enteral feeding versus parenteral or combination nutrition. Multiple linear regression was used to model factors associated with hospital length of stay. All data manipulation and statistical analysis were conducted in R (The R Project for Statistical Computing, Vienna, Austria).

Because this was a retrospective post hoc analysis, there was a predetermined sample size comparing EN versus PN versus EN-PN patients with duodenal leaks following operative intervention for traumatic duodenal injuries. With a total sample size of 113, our analysis was capable of detecting an effect size of 0.3 with 60% power at the 0.010 α level. The STrengthening the Reporting of OBservational studies in Epidemiology guideline was used to ensure proper reporting (Supplemental Digital Content, Supplementary Data 1, http://links.lww.com/TA/D806).

RESULTS

All Patients

Of the 861 patients enrolled with traumatic duodenal injury who underwent surgical repair, 113 (15.1%) suffered postoperative duodenal leaks (Table 1). This patient population was primarily young (median, 28 years; interquartile range [IQR], 17 years) males (94 [83.2%]) and presented following penetrating mechanisms of injury (92 [81.4%]). Of these patients, 43 (38.1%) received EN, 22 (19.5%) received PN, and 48 (42.5%) received EN-PN.

Stratification by Nutritional Approach

The majority of patients (91 [80.5%]) received EN at some point during their hospitalization, either alone (43 [38.1%]) or in combination with parenteral supplementation (48 [42.5%]). Twenty-two patients (20%) were considered ineligible for enteral feeding and therefore received only parenteral support. After stratifying patients according to nutritional strategy, there were no significant differences in baseline demographics, injury mechanism, Injury Severity Score, hemodynamic stability, or type of surgical intervention (Table 1). Pancreatic injury occurred in 25.6% of EN, 43.8% of EN-PN, and 54.6% of PN patients (p = 0.051).

The timing of nutritional intervention, namely, days without nutrition (p = 0.730) and postoperative day nutrition was started, did not significantly differ between the nutritional approach groups (p = 0.734). The duration of enteral feeding was similar in both the EN and EN-PN groups (18.5 days [IQR, 24.8 days] vs. 18 [25.3] days, p = 0.529). However, patients receiving PN alone required a significantly greater duration of intravenous nutrition compared with patients receiving EN-PN (45.5 [62.8] days vs. 17 [35.5] days, $p < 0.001$) and had fewer surgical feeding tubes placed (9 [40.9%] vs. 40 [83.3%], p = 0.003).

While injury characteristics and initial interventions did not vary substantially, there were significant differences in hospitalization events and outcomes across the three nutritional approaches (Table 2). Time until leak closure was less in EN patients when comparing the three groups (EN, 7 days [IQR, 14.5 days] vs. PN, 15 [20.5] days vs. EN-PN, 25.5 [55.8] days; p = 0.008). Enteral nutrition patients had the lowest rates of acute kidney injury ($p < 0.001$), septicemia (p = 0.017), and abdominal abscess (p = 0.017). Overall, hospital length of stay was shorter among EN patients versus both PN groups (27 [24] days vs. 44 [62] days vs. 45 [31] days, p = 0.001). Compared with EN patients, patients receiving PN and EN-PN were maintained with nil per os restrictions longer (12 [23] days vs. 40 [54] days vs. 33 [32] days, $p < 0.001$).

Multiple linear regression was used to examine the influence of nutritional route on hospital length of stay after controlling for potential differences in injury severity (Table 3). This analysis demonstrated that EN was significantly associated with a shorter length of stay (−24.9 days; 95% confidence interval [CI], −39.0 to −10.7; $p < 0.001$). In addition, heart rate exhibited a moderate but significant effect on length of stay (0.57 days; 95% CI, 0.303–0.826; $p < 0.001$). A second multiple linear regression model assessing duration until leak closure did not reveal EN to be significantly associated.

Predictors of EN

In addition to assessing the impact of nutrition on outcome, we sought to identify factors that may be predictive of

TABLE 1. Demographics, Injury Mechanism, and Severity Among Trauma Patients With Operative Duodenal Injuries Complicated by Duodenal Leak Stratified by Nutrition Strategy

	All Duodenal Leak Patients n = 113	EN n = 43	PN n = 22	EN-PN n = 48	p
Age, median (IQR), y	28 (17)	27 (15)	28.5 (13)	27.5 (20.3)	0.934
Sex, male, n (%)	94 (83.2)	34 (79.1)	16 (72.7)	44 (91.7)	0.095
BMI, mean (SD), kg/m^2	28.2 (24.6–31.8)	28.0 (8.2)	29.3 (6.2)	27.8 (6.8)	0.713
Penetrating mechanism	92 (81.4%)	33 (76.7%)	19 (86.4%)	40 (83.3%)	0.579
Systolic blood pressure, median mmHg (IQR)	113 (98–129)	118 (30)	107 (47)	113 (47)	0.231
Heart rate	99 (86–112)	101 (24)	101 (24)	97 (28)	0.443
ISS	24 (18–31)	25 (15)	22 (22)	24 (11)	0.923
Massive transfusion protocol	54 (47.8%)	17 (39.5%)	15 (68.2%)	22 (45.8%)	0.086
Duodenal injury AAST grade	3 (2–4)	2 (1)	3 (1)	3 (1)	0.173
Pancreatic injury	44 (38.9%)	11 (25.6%)	12 (54.6%)	21 (43.8%)	0.051
Pancreatic injury AAST grade		2 (2)	2.5 (2)	2 (2)	0.692
Primary repair alone	43 (38.1%)	21 (48.8%)	8 (36.4%)	14 (29.2%)	0.153
Complex repair with adjunctive measures	70 (61.9%)	22 (51.2%)	14 (63.6%)	34 (70.8%)	

AAST, American Association for the Surgery of Trauma; BMI, body mass index.

TABLE 2. Outcomes Among Trauma Patients With Operative Duodenal Injuries Complicated by Duodenal Leak Stratified by Nutrition Strategy

	All Duodenal Leak Patients n = 113	EN n = 43	PN n = 22	EN-PN n = 48	*p*
Days without nutrition, median (IQR)	4 (4)	3 (2)	4 (4)	4 (4)	0.730
Postoperative day nutrition started	4 (4)	4 (2)	4 (4)	4 (4)	0.734
Days of EN	18 (27.3)	18.5 (24.8)	-	18 (25.3)	0.529
Days of intravenous nutrition	30 (50)	-	45.5 (62.8)	17 (35.5)	0.006
Days NPO	24 (35)	12 (23)	40 (54)	33 (32)	<0.001 EN to PN = <0.001 EN-PN to EN = <0.001 EN-PN to PN = 0.185
Days to regular diet	29.5 (34)	18 (18)	33.5 (34)	39.5 (48.8)	0.002 EN to PN = 0.057 EN-PN to EN = 0.001 EN-PN to PN = 1.000
AKI	43 (38.1%)	7 (16.3%)	12 (54.6%)	24 (50%)	<0.001 EN to PN = 0.007 EN-PN to EN = 0.005 EN-PN to PN = 0.924
Bacteremia or fungemia	30 (26.5%)	5 (11.6%)	7 (31.8%)	18 (37.5%)	0.017 EN to PN = 0.199 EN-PN to EN = 0.029 EN-PN to PN = 0.848
Abdominal abscess	76 (67.3%)	23 (53.5%)	14 (63.6%)	39 (81.3%)	0.017 EN to PN = 0.605 EN-PN to EN = 0.027 EN-PN to PN = 0.391
Days with drains	38 (42)	26 (41)	38 (32)	49 (51)	0.045 EN to PN = 0.249 EN-PN to EN = 0.038 EN-PN to PN = 0.965
Feeding tube placement	76 (67.3%)	27 (62.8%)	9 (40.9%)	40 (83.3%)	0.002 EN to PN = 0.157 EN-PN to EN = 0.095 EN-PN to PN = 0.003
Days until leak closure	14 (38)	7.0 (14.5)	15.0 (20.5)	25.5 (54.8)	0.008 EN to PN = 0.094 EN-PN to EN = 0.010 EN-PN to PN = 1.000
ICU LOS (days)	15 (28)	8 (16)	21 (25)	24 (34)	0.004 EN to PN = 0.152 EN-PN to EN = 0.003 EN-PN to PN = 1.000
Ventilator days	8 (18)	5 (9.5)	13 (19)	11 (23)	0.024 EN to PN = 0.428 EN-PN to EN = 0.020 EN-PN to PN = 1.000
Hospital LOS	38 (31)	27 (24)	44 (62)	45 (31)	0.001 EN to PN = 0.015 EN-PN to EN = 0.002 EN-PN to PN = 1.000
Mortality, n (%)	11 (9.7)	5 (11.6)	2 (9.1)	4 (8.3)	0.864

AKI, acute kidney injury; NPO, nil per os.

EN alone (Table 4). Based on univariate analysis, the presence of pancreatic injury and requirement for massive transfusion were more common in PN and EN-PN groups compared with EN ($p < 0.100$). Multiple logistic regression using select injury characteristics as variables of interest demonstrated that pancreatic injury alone was significantly associated with reduced odds of EN (odds ratio, 0.368; 95% CI, 0.139–0.915; $p = 0.036$). Notably, injury mechanism and severity, hemodynamic stability, and repair strategy were not significantly associated with mode of nutrition.

Focused Analysis of Pancreatic Injury

Given the significance of pancreatic injury to nutritional strategy, we compared injury patterns and outcomes in patients with and without pancreatic injury (Table 5). Patients with pancreatic injury (44 [38.9%]) recorded significantly greater ISS

TABLE 3. Multiple Linear Regression Modeling the Effect of Nutritional Route and Injury Severity on Hospital Length of Stay

	Regression Coefficient (95% CI)	*p*
EN	−24.895 (−39.044 to −10.746)	<0.001
Age (years)	−0.017 (−0.513 to 0.478)	0.946
Penetrating mechanism	3.361 (−15.853 to 22.574)	0.732
Heart rate	0.565 (0.303–0.826)	<0.001
Systolic blood pressure	0.031 (−0.173 to 0.235)	0.765
ISS	0.172 (−0.479 to 0.824)	0.606
Massive transfusion protocol	7.451 (−8.292 to 23.195)	0.356
Duodenal injury AAST grade	0.553 (−7.559 to 8.665)	0.894
Pancreatic injury	10.827 (−3.192 to 24.846)	0.133
Complex repair with adjunctive measures	−12.869 (−27.901 to 2.162)	0.096

AAST, American Association for the Surgery of Trauma.

(25 [17] vs. 17 [14], $p = 0.028$) but had no significant difference in demographics, injury mechanism, or hemodynamic stability. Pancreatic injury was associated with prolonged nil per os duration (38 [59] days vs. 19 [31] days, $p = 0.003$), duration of extraluminal drains (49 [42] days vs. 30 [41] days, $p = 0.003$), time until duodenal leak closure (24 [52] days vs. 12 [33] days, $p = 0.015$), and hospital stay (42 [37] days vs. 34 [29] days, $p = 0.026$). Eleven (25.0%) received EN, 12 (27.3%) received PN, and 21 (47.7%) received EN-PN (Table 6). Neither injury pattern nor mode of surgical repair differed across the nutritional groups. Notably, in patients with pancreatic injury, those receiving EN-PN had nutrition started later than PN alone (5 [4] vs. 2 [1] days postoperative, $p = 0.013$) and had a higher rate of feeding tube placement (20 [95.2%] vs. 6 [50.0%], $p = 0.027$). Despite these differences, there was no difference in outcomes.

DISCUSSION

Optimizing postoperative feeding in patients with abdominal trauma is critical to ensuring adequate nutrition required for wound healing, immune function, and overall recovery. Stress-induced catabolism increases the metabolic rate and nutritional requirements of acutely ill and/or injured patients.[22,23] Poor nutritional status has repeatedly been associated with increased risk of postoperative complications, including infection, and increased hospital length of stay.[24–26] In this study, we examined the patterns of nutritional support used in patients with surgically repaired duodenal injury complicated by postoperative duodenal leak and assessed the impact of nutritional strategy on outcomes. This study found that PN did not decrease time until leak closure. Enteral nutrition was associated with a shorter duration until leak closure, less infectious complications, and shorter hospital length of stay compared with patients who received EN-PN or PN.

In critically ill and injured patients, enteral feeding has been shown to be a safe and effective mode of nutritional support.[9,27] While evidence surrounding the impact of EN on mortality has been conflicting, numerous studies report a beneficial effect on reducing the risk of infectious morbidity.[28,29] In the current analysis, we demonstrated that EN alone was associated with a significant reduction in the incidence of septicemia and abdominal abscesses as well as reduced duration of intensive care and ventilatory support compared with those receiving EN-PN.

TABLE 4. Multiple Logistic Regression Modeling Predictors of EN

	Odds Ratio (95% CI)	*p*
Age (years)	0.979 (0.947–1.011)	0.209
Penetrating mechanism	0.379 (0.104–1.325)	0.130
Heart rate	1.009 (0.991–1.028)	0.315
Systolic blood pressure	1.011 (0.998–1.026)	0.112
ISS	1.034 (0.991–1.080)	0.129
Massive transfusion protocol	0.451 (0.160–1.234)	0.128
Duodenal injury AAST grade	0.641 (0.361–1.094)	0.113
Pancreatic injury	0.368 (0.139–0.915)	0.036
Complex repair with adjunctive measures	0.697 (0.265–1.826)	0.460

AAST, American Association for the Surgery of Trauma.

TABLE 5. Demographics, Injury Mechanism and Severity, and Outcomes Among Trauma Patients With Operative Duodenal Injuries Complicated by Duodenal Leak and Stratified by Pancreatic Injury

	All Duodenal Leak Patients n = 113	No Pancreatic Injury n = 69	Pancreatic Injury n = 44	*p*
Age, median (IQR), y	28 (17)	27 (17)	28 (16)	0.452
Sex, male, n (%)	94 (83.2%)	57 (82.6%)	37 (84.1%)	1.00
BMI, mean (SD), kg/m^2	28.2 (24.6–31.8)	27.7 (7.9)	29.0 (6.0)	0.713
Penetrating mechanism	92 (81.4%)	56 (81.2%)	36 (81.8%)	1.00
Systolic blood pressure, median mmHg (IQR)	113 (98–129)	113 (38)	113 (42)	0.536
Heart rate	99 (86–112)	98 (27)	102 (28)	0.215
ISS	24 (18–31)	17 (14)	25 (17)	0.028
Massive transfusion protocol	54 (47.8%)	32 (46.4%)	22 (50.0%)	0.855
Duodenal injury AAST grade	3 (2–4)	3 (1)	3 (1)	0.415
Primary repair alone	43 (38.1%)	33 (47.8%)	10 (22.7%)	0.013
Complex repair with adjunctive measures	70 (61.9%)	36 (52.2%)	34 (77.3%)	
Days without nutrition, median (IQR)	4 (4)	4 (3)	4 (3)	0.425
Postoperative day nutrition started	4 (4)	4 (3)	3 (3)	0.235
Days NPO	24 (35)	19 (31)	38 (59)	0.003
AKI	43 (38.1%)	24 (34.8%)	19 (43.2%)	0.485
Bacteremia or fungemia	30 (26.5%)	43 (62.3%)	33 (75.0%)	0.218
Abdominal abscess	76 (67.3%)	9 (81.8%)	6 (50.0%)	0.232
Days with drains	38 (42)	30 (41)	49 (42)	0.003
Feeding tube placement	76 (67.3%)	43 (62.3%)	33 (75.0%)	0.232
Days until leak closure	13 (42)	12 (33)	24 (52)	0.015
ICU LOS	15 (28)	11 (24)	24 (27)	0.003
Ventilator days	8 (18)	6 (14)	10 (18)	0.145
Hospital LOS	38 (31)	34 (29)	42 (37)	0.026
Mortality, n (%)	11 (9.7)	6 (8.7)	5 (11.4)	0.888

AAST, American Association for the Surgery of Trauma; AKI, acute kidney injury; BMI, body mass index; NPO, nil per os.

TABLE 6. Demographics, Injury Mechanism and Severity, and Outcomes Among Trauma Patients With Operative Duodenal Injuries Complicated by Duodenal Leak and Pancreatic Injury Stratified by Nutrition Strategy

	All Pancreatic Injury Patients n = 44	EN n = 11	PN n = 12	EN-PN n = 21	p
Age, median (IQR), y	28 (16)	25 (9)	28.5 (11.8)	30 (18)	0.306
Sex, male, n (%)	37 (84.1%)	9 (81.8%)	10 (83.3%)	18 (85.7%)	0.956
BMI, mean (SD), kg/m^2	29.0 (6.0)	28.3 (5.1)	30.7 (6.9)	28.3 (6.0)	0.500
Penetrating mechanism	36 (81.8%)	9 (81.8%)	10 (83.3%)	17 (81.0%)	0.986
Systolic blood pressure, median mmHg (IQR)	113 (42)	118 (24)	104 (41)	112 (48)	0.681
Heart rate	102 (29)	106 (27)	104 (35)	98 (26)	0.695
ISS	25 (17)	25 (9)	32 (17)	25 (11)	0.404
Massive transfusion protocol	22 (50.0%)	4 (36.4%)	8 (66.7%)	10 (47.6%)	0.333
Duodenal injury AAST grade	3 (1)	2 (1)	3 (0)	3 (1)	0.504
Primary repair alone	10 (22.7%)	1 (9.1%)	4 (33.3%)	5 (23.8%)	0.378
Complex repair with adjunctive measures	34 (77.3%)	10 (90.9%)	8 (66.7%)	16 (76.2%)	
Days without nutrition, median (IQR)	4 (3)	3 (2)	2 (4)	4 (4)	0.343
Postoperative day nutrition started	3 (3)	3 (1)	2 (1)	5 (4)	0.015 EN to PN = 0.690 EN-PN to EN = 0.452 EN-PN to PN = 0.013
Days NPO	38 (59)	37 (34)	76 (79)	24 (32)	0.145
AKI	19 (43.2%)	2 (18.2%)	7 (58.3%)	10 (47.6%)	0.129
Bacteremia or fungemia	15 (34.1%)	1 (9.1%)	4 (33.3%)	10 (47.6%)	0.092
Abdominal abscess	33 (75.0%)	9 (81.8%)	6 (50.0%)	18 (85.7%)	0.062
Days with drains	49 (42)	53 (24)	45 (69)	50 (46)	0.981
Feeding tube placement	33 (75.0%)	7 (63.6%)	6 (50.0%)	20 (95.2%)	0.009 EN to PN = 0.812 EN-PN to EN = 0.068 EN-PN to PN = 0.027
Days until leak closure	24 (52)	24 (51)	26 (50)	21 (52)	0.795
ICU LOS	24 (27)	23 (32)	27 (25)	17 (25)	0.445
Ventilator days	10 (18)	7 (15)	18 (22)	8 (16)	0.301
Hospital LOS	42 (37)	30 (25)	66 (62)	44 (32)	0.122
Mortality, n (%)	5 (11.4%)	1 (9.1%)	2 (16.7%)	2 (9.5%)	0.794

AAST, American Association for the Surgery of Trauma; AKI, acute kidney injury; BMI, body mass index; NPO, nil per os.

While explanations for improved infectious outcomes in EN remain unclear, several multifactorial hypotheses have been proposed. Exclusive PN appears to be associated with loss of intestinal barrier integrity, villous atrophy, and increased intestinal epithelial cell apoptosis in both animal models and humans.[30–32] Moreover, PN was shown to induce unfavorable modifications of the gut microbiome, resulting in insulin resistance and impaired glucose metabolism,[33] which can increase risk for infectious complications. In contrast, EN helps to preserve and restore the intestinal epithelial barrier, stimulate splanchnic blood flow, induce the release of endogenous trophic factors,[34–36] and facilitate gut mucosal immunity by preserving gut-associated lymphoid tissue mass and stimulating secretory immunoglobulin A.[37–39] Notably, maintained mucosal immunity facilitated by enteral feeding was sufficient to protect from bacterial pneumonia compared with parenterally fed mice.[40] Our study examined a largely unstudied patient population, patients with duodenal leaks following surgical repair of traumatic duodenal injuries, and found congruent data with literature from other populations that EN was associated with less infectious outcomes as compared with PN. However, it is important to note that other studies have demonstrated associations and not causations of infectious complications related to PN. In addition, a randomized controlled trial completed in 33 ICUs analyzed 2,388 patients and did not find a difference in most outcomes, infectious complications, or mortality when comparing EN to PN in critically ill patients.[41]

There is general consensus to support enteral feeding in critically ill and injured patients whenever tolerable.[27] However, in trauma patients, contraindications to EN can include hemodynamic instability and major abdominal injury, resulting in discontinuity of the proximal gastrointestinal tract.[9] Duodenal leak is another circumstance that can result in reluctance of EN initiation. In the current study of duodenal injuries complicated by leak, the majority (80.5%) of patients were able to receive some form of EN, either alone or in combination with PN. However, 73.6% of those patients who received EN or EN-PN also had surgically placed feeding tubes; this was significantly more than PN-only patients (40.9%, $p = 0.002$). Because this was a post hoc analysis, the anatomic location of these feeding tubes in relationship to the duodenal leak is unclear along with whether EN was delivered proximally or distally to the leak. Feeding tube placement should be considered in patients high risk for leak to ensure EN delivery. Our prior work identified predictors of duodenal leak following surgical repair of duodenal injuries to include complex surgical repair with adjunctive measures (as compared with primary repair alone), higher body mass index, damage-control laparotomy, and increasing American Association for the Surgery of Trauma injury grade (grade II 3-fold, grade III 3.2-fold, and grade IV 4.7-fold increased odds of leak).[16] Prior to abdominal closure, patients presenting with these predictors of leak warrant discussion regarding the need for a nasally inserted feeding tube placed distal to the duodenal repair or a surgically placed feeding tube to facilitate EN.

Concomitant pancreatic injury is common, and trauma surgeons are often concerned about EN with this injury pattern. Notably, we found that pancreatic injury was associated with a substantially lower odds of a patient receiving EN, increased duration until leak closure, and prolonged hospital length of stay. In patients with pancreatic injury, three quarters required PN support alone or as a supplement to EN. Historically, there has been hesitancy toward the initiation of EN in patients with pancreatitis and pancreatic trauma because of the purported risk of stimulating and exacerbating the injured pancreas, particularly with proximal feeding.[42,43] However, Moore et al.[44] reported safe enteral feeding of patients with pancreatic injury via jejunostomy without evidence of pancreatic stimulation. In addition, numerous trials and subsequent meta-analysis have demonstrated a clinically and statistically significant reduction in mortality, multisystem-organ failure, local and systemic infection, and need for operative interventions in patients with acute pancreatitis.[45,46] Moreover, EN was associated with a significantly higher rate of closure in patients with postoperative pancreatic fistula.[47] While we lacked data to determine the location of enteral feeding and markers of pancreatic stimulation, our results demonstrate that EN is not associated with higher risk of poor outcomes or mortality in patients with both duodenal leak and pancreatic injury. This suggests that EN, when otherwise appropriate, is a safe and effective means for nutritional support in the setting of concomitant pancreatic and duodenal injury.

Limitations

It is critical that we acknowledge this study's limitations, particularly those related to its nature as a post hoc analysis of a retrospective study. Therefore, we are lacking important information such as the rationale for the chosen mode of nutrition, specific timing of each mode, the anatomic location of feeding in relation to the duodenal leak site, and pancreatic leak. More explicitly, this study cannot evaluate causality, and associations identified in the study may be related to differences in injury/illness. In addition, as a multicenter trial, there may have been institutional variations in the approach to postoperative nutrition that may interfere with adequate comparison of outcomes. While there were 35 contributing centers, the sample size was ultimately small with 42% of patients receiving both EN and PN. Finally, this study primarily focused on the index hospitalization and therefore lacks long-term follow-up data. Recognizing these constraints, future research endeavors should aim for a nuanced understanding of extended implications of these nutritional strategies.

CONCLUSION

Patients with duodenal injury complicated by postoperative leak received nutritional support in the form of EN, PN, or a combination of EN-PN. This study's findings suggest that EN was associated with beneficial outcomes such as shorter duration until duodenal leak closure, lower rates of infectious complications, and shorter length of stay. Notably, PN did not decrease time until leak closure. We, therefore, suggest that EN should be the preferred choice of nutrition in patients with duodenal leaks whenever feasible.

AUTHORSHIP

R.L.C. contributed in the literature search, study design, data collection, data analysis, data interpretation, writing, and critical revision. M.J.S. contributed in the study design, data analysis, data interpretation, writing, and critical revision. A.L.T. and C.G.B. contributed in the data collection, data analysis, and critical revision. M.T.B.M. contributed in the data analysis, data interpretation, and critical revision. J.K. and C.P. contributed in the writing and critical revision. J.D.S., R.N.S., D.S.H., I.N.A., J.H.B., N.K.D., A.Z., M.G., R.J.D., O.L.G., A.A.S., B.L.S., C.S.C., J.K.R., L.A.H., D.N.H., G.C., M.J., K.E.-R., N.F., A.A., C.A.F., R.P.D., J.H.L., C.T.T., J.J.Y., J.B., J.P.H., C.J.M., R.A.-A., J.M.K., D.S.H., D.R.S., K.D., M.V., B.H., C.S., P.O.U., E.G.W., B.A.J., H.L., W.A.R., C.H.S., C.A., J.D.B., J.N., I.P., J.H.P., I.R., L.L.P., O.R.P., H.A., J.K., L.M.K., J.W., R.H., M.A.S., A.J.B., A.K., L.K.M., C.J.M., V.M., F.M., S.R.-G., C.F., C.H.P., D.A., H.K., and M.N. contributed in the data collection and critical revision.

DISCLOSURE

Conflicts of Interest: Author Disclosure forms have been supplied and are provided as Supplemental Digital Content (http://links.lww.com/TA/D807).

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