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Benefits of Immediate Jejunostomy Feeding after Major Abdominal Trauma—A Prospective, Randomized Study

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Benefits of immediate postinjury nutritional support remain ill defined. Seventy-five consecutive patients undergoing emergent celiotomy with an abdominal trauma index (A.T.I.) > 15 were randomized prospectively to a control group (no supplemental nutrition during first 5 days) or enteral-fed group. The enteral patients had a needle catheter jejunostomy (N.C.J.) placed at laparotomy with the constant infusion of an elemental diet (Vivonex HN) begun at 18 hours and advanced to 3,000 ml/day (3,000 kcal, 20 gm N_2) within 72 hours. Control and enteral-fed groups were comparable with respect to demographic features, trauma mechanism, shock, colon injury, splenectomy, A.T.I., and initial nutritional assessment.

Twenty (63%) of the enteral patients were maintained on the elemental diet > 5 days; four (12%) needed total parenteral nutrition (T.P.N.). Nine (29%) of the control patients required T.P.N. Nitrogen balance was markedly improved ($p < 0.001$) in the enteral-fed group. Although visceral protein markers and overall complication rate were not significantly different, septic morbidity was greater ($p < 0.025$) in the control group (abdominal infection in seven and pneumonia in two) compared to the enteral-fed patients (abdominal abscess in three). Analysis of patients with A.T.I. 15–40 disclosed sepsis in seven (26%) of the control versus one (4%) of the enteral-fed group ($p < 0.01$).

Our clinical experience demonstrates the feasibility of immediate postoperative enteral feeding via N.C.J. after major abdominal trauma, and suggests this early nutrition reduces septic complications in critically injured patients.

The early postinjury period is characterized by a hypermetabolic state in which accelerated substrate mobilization is required for energy supply, host defense, and wound repair. Although modest substrate needs are met by skeletal muscle breakdown, excessive requirements—not supported by exogenous nutrients—may erode visceral protein, compromise immune function, and eventuate in multiple organ failure (5, 10, 12, 13, 20, 44). This prospective study was designed to ascertain the impact of immediate enteral feeding in critically injured but previously well-nourished patients.

MATERIAL AND METHODS

During the 2½-year period ending November 1983, all patients undergoing emergency celiotomy at the Denver General Hospital (D.G.H.) with an abdominal trauma index (A.T.I.) > 15 were empaneled in a prospective, randomized study. The A.T.I. was calculated by a method we have described previously (26). In summary, the index was based on intraoperative findings. A severity-of-injury estimate (1–5) was assigned to each system involved and multiplied by a predetermined complication risk factor (1–5) for that system. The sum of the individual organ scores (risk × severity) comprised the final index score. Seventy-five (20%) of the 371 injured patients requiring laparotomy during the study period had A.T.I. > 15. Such patients were randomized, by computer assignment, to either a control or enteral-fed group.

Control patients were administered conventional D_5W (approximately 100 gm/day) intravenously during the first 5 postoperative days, and then begun on high nitrogen (calories: nitrogen = 133:1) total parenteral nutrition (T.P.N.) by central vein if they were not tolerating a regular oral diet at that time. The enteral group had a needle catheter jejunostomy (N.C.J.) placed just before abdominal closure. A polyurethane catheter (Vivonex Kit, Norwich-Eaton Pharmaceuticals) was introduced into the jejunum 15 cm distal to the ligament of Treitz, or comparable distance beyond a gastroenterostomy or Roux-en-Y jejunostomy (Fig. 1). Technical details of this procedure have been reviewed elsewhere (25). Infusion of an elemental diet (Vivonex HN, calories: nitrogen = 150:1) was begun via the N.C.J. at 12 to 18 hr postoperatively. The solution was initiated at one-quarter strength (0.25 kcal/ml) and at a rate of 50 ml/hr. Patients were observed for abdominal distention as the rate and concentration were increased at 8-hour intervals to deliver full-strength solution at 125 ml/hr, the targeted goal at 72 hr. Infusions were continued until the patients tolerated adequate oral intake. This protocol was approved by the D.G.H. Human Research Committee and explained to the patients as soon as feasible postoperatively.

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Management of abdominal trauma was uniform throughout the study period. Patients with blunt trauma were explored promptly for signs of peritoneal irritation or unexplained blood loss, and evaluated by diagnostic peritoneal lavage if equivocal findings existed. Stab-wound patients, without overt signs of visceral injury, underwent selective laparotomy based on local wound exploration and peritoneal lavage. Gunshot-wound patients, on the other hand, were routinely explored unless the missile tract was unequivocally superficial to the peritoneum. Broad-spectrum antibiotics were administered in the emergency department and discontinued after two postoperative doses, except in the presence of distal ileal or colonic injury when they were maintained for 5 days. Abdominal fascia was approximated with a continuous O-polypropylene suture. The skin and subcutaneous fat were left open for delayed primary closure in the presence of gross contamination. Supplemental albumin was not administered to these trauma patients in the first week postinjury.

Nutritional-immunologic assessment was performed within 12 hr of laparotomy and repeated by the same individual (T.N.J.) from the D.G.H. Nutritional Support Team. Anthropometric measurements included triceps skinfold thickness (T.S.T.) with Lange calipers, and midarm circumference (M.A.C.), both determined at the midposition of the nondominant upper arm with the patient supine. The arm muscle circumference (A.M.C.) was then derived: A.M.C. = M.A.C. − (T.S.T. × 0.314). These indices were compared to normal values stratified for age and sex, and are reported as per cent of standard (4). Total serum protein (T.S.P.) and albumin were determined on an automated 12-step blood analyzer (S.M.A. 12 Profile); serum transferrin was measured directly by a nephelometer (Hyland PDQ) and plasma fibronectin (37) by immunoturbidimetric assay 340 UV method (Mannheim, West Germany). Total lymphocyte count (T.L.C.) was calculated from the differential of the peripheral white blood cell count. Four recall antigens were applied for skin testing: *Candida albicans*, mumps, coccidioidin, and tuberculin. Delayed hypersensitivity (D.H.) was considered intact if >5 mm induration occurred with any antigen within 48 hr. Urine was collected for 24 hr to determine urea nitrogen, creatinine, and 3-methylhistidine concentration. Urea nitrogen was quantitated by the rate conductivity method on an Astra 8 analyzer. Creatinine-height index (C.H.I. = measured urinary creatinine per 24 hr/ideal urinary creatinine per 24 hr) was calculated as an additional marker of somatic protein mass. The 24-hr total body nitrogen (N_2) loss was estimated from the urine urea nitrogen (U.U.N.) by the following equation (22):

$$N_2 \text{ loss (gm/day)} = \frac{\text{UUN mg}^{+} \times \text{urine vol. L/day}}{100} + 20\% \times \text{total UUN} + 2 \text{ gm.}$$

Nitrogen balance was calculated as N_2 intake minus N_2 loss. Basal energy expenditure (B.E.E.) was derived from the Harris-Benedict equation (B.E.E.: Male = 66 + (13.7 × Wt) + (5.0 × Ht) − (6.8 Age); Female = 655 + (9.6 × Wt) + (1.9 × Ht) − (4.7 × Age). The 3-methylhistidine excretion was measured as an indicator of obligatory protein breakdown (44). Patients' hospital costs were actual bills sent to them directly from the D.G.H. accounting office.

Data are presented as the mean ± S.E.M. Statistical analysis was done by Student's *t*-test for continuous variables, and Chi-square for discrete data. Statistical significance was assumed when the level of confidence was 95%.

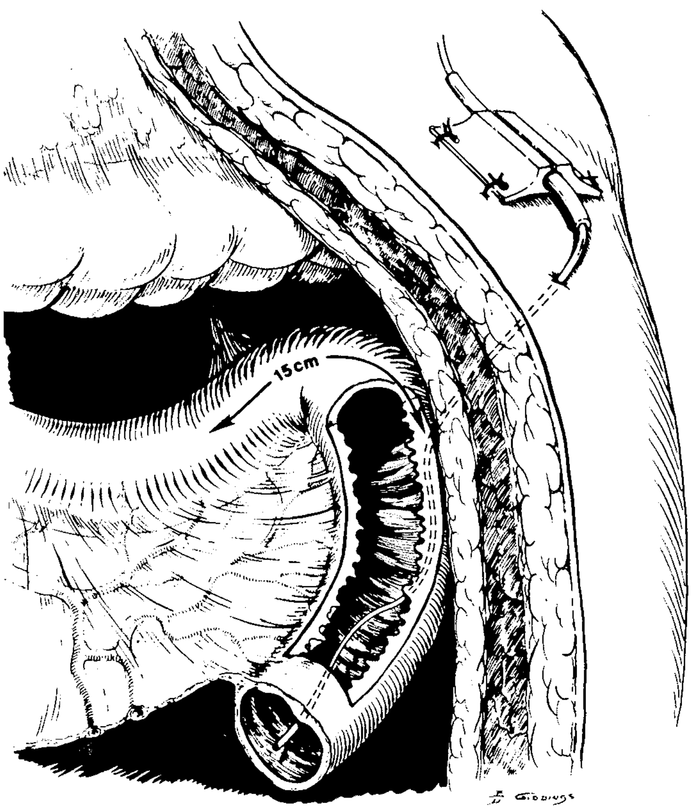

FIG. 1. A needle-catheter jejunostomy was placed at initial laparotomy in patients with an abdominal trauma index > 15 (Reproduced with permission from Moore, E.E.: Needle catheter jejunostomy. *In* Moore, E.E., Eiseman, B., Van Way, C. eds: *Critical Decisions in Trauma*. St. Louis, Mosby, 1985, pp. 564–567).

RESULTS

Of the 75 qualified patients, 12 were excluded from analysis within the first 72 hr postinjury because of reoperation (six), death (four), or transfer to another hospital (two). The remaining control (31) and enteral-fed (32) groups were comparable with respect to: age (29.3 ± 2.1 vs. 30.5 ± 2.2 yr), sex (80% vs. 75% men), race (13 C, 12 H, 5 B, 1 A, vs. 16 C, 7 H, 9 B), injury mechanism (77% vs. 69% penetrating), shock = S.B.P. < 90 mm Hg at admission (29% vs. 34%), colon wound (29% vs. 31%), splenectomy (19% vs. 19%), and A.T.I. (29.0 ± 2.1 vs. 30.6 ± 2.2). The groups were also equivalent according to their initial nutritional assessment: weight (71.4 ± 1.9 vs. 75.8 ± 2.9 kg), T.S.T. (91 ± 7 vs. 96 ± 7%), A.M.C. (102 ± 2 vs. 108 ± 2%), B.U.N. (10.7 ± 0.7 vs. 11.5 ± 1.0 mg%), T.S.P. (5.3 ± 0.2 vs. 5.1 ± 0.1 gm%), B.E.E. (1,668 ± 38 vs. 1,721 ± 58 kcal/day), albumin (Table I), transferrin (Table I), C.H.I. (Table I), and nitrogen balance (Table I). Twenty-four (77%) of the control patients and 28 (88%) of the enteral-fed group were anergic in the immediate postoperative period. Plasma fibronectin ranged from 175 to 550 μg/ml (mean, 312 ± 23) in the 25 patients in whom it was measured. The 3-methylhistidine excretion was from 260 to 969 μm/day (mean, 558 ± 42) in 14 patients.

Twenty (63%) of the 32 enteral patients were maintained on the elemental diet 5 or more days (range, 5 to

TABLE I
Control (D_5W) versus enteral-fed groups following major abdominal trauma

	Alb. (mg%)	Tran. (mg%)	C.H.I.	T.L.C. (mm^3)	N_2 bal. (gm/day)	Sepsis
Control (31)						
Day 1	3.3 ± 0.1	223 ± 7	115 ± 5	1,408 ± 158	−13.2 ± 0.5	9 (29%)
Day 4	3.1 ± 0.1	187 ± 5	109 ± 3	1,175 ± 176	−11.4 ± 0.7	
Day 7	3.3 ± 0.1	213 ± 9	103 ± 4	1,482 ± 138	−11.1 ± 0.7	
Enteral (32)						
Day 1	3.3 ± 0.1	223 ± 6	124 ± 4	1,831 ± 206	−13.7 ± 0.7	3* (9%)
Day 4	3.2 ± 0.1	184 ± 7	107 ± 6	1,344 ± 166	−3.9 ± 1.6*	
Day 7	3.2 ± 0.1	211 ± 10	105 ± 5	2,054 ± 164*	−5.2 ± 1.2*	

Alb = albumin. T.L.C. = total lymphocyte count. Tran. = transferrin. N_2 bal = nitrogen balance. C.H.I. = creatinine height index. ± = S.E.M., * = $p < 0.05$.

20; mean, 9 days); four (12%) received total parenteral nutrition (T.P.N.). Nine (29%) of the 31 control patients required T.P.N. for a mean duration of 21.8 days (range, 5 to 83 days). Comparison of nutritional data between the groups was done immediately following laparotomy (day 1), and on postoperative days 4 and 7. At day 4 the control patients received 36 ± 2% of their B.E.E. compared to 156 ± 11% in the enteral fed, and at day 7 the results were 35 ± 3% and 138 ± 12%, respectively. Anthropometric indices were not statistically different between the control and enteral-fed patients. At the end of 1 week body weight was 69.4 ± 2.3 vs. 70.2 ± 2.6 kg, T.S.T. 88 ± 8 vs. 85 ± 7%, and A.M.C. 98 ± 3 vs. 102 ± 2%. Repeat skin testing at 7 days disclosed anergy in 24 (77%) of the control group and 23 (72%) of the enteral fed. Results of serum albumin, transferrin, C.H.I., T.L.C., and nitrogen balance are summarized in Table I. The only significant changes occurred in nitrogen balance at day 4 ($p < 0.025$) and 7 ($p < 0.001$) and in T.L.C. at day 7 ($p < 0.05$) in the enteral-fed group. Disparity in cumulative nitrogen balance is illustrated in Figure 2.

Fifteen (48%) of the 31 control patients developed postoperative complications. Nonseptic morbidity consisted of pancreatic fistulae in two, and biliary fistula, hepatitis, pleural effusion and recurrent pneumothorax in one patient each. Fourteen (44%) of the 32 in the enteral-fed group had complications which included pneumatosis intestinalis, pancreatitis, small bowel obstruction in two patients each, and pericardial effusion, fat emboli, intraperitoneal hemorrhage, axillary vein thrombosis, and posterior tibial artery graft thrombosis in one patient each. We believe pneumatosis intestinalis was related to enteral feeding via the N.C.J., and have discussed this issue previously (9). The small bowel obstructions, on the other hand, were not attributed to the N.C.J. Both incidents were in patients with A.T.I. > 25, and occurred on postoperative days 21 and 26, respectively. Although the overall complication rate was similar, septic morbidity was significantly greater ($p < 0.025$) in the control group (Table I). Nine (29%) of the control patients developed postoperative infections; seven had abdominal abscesses necessitating reoperation and two had bacterial pneumonia. The mean A.T.I. of these nine individuals was 31. Three (9%) of the enteral-fed group had postoperative sepsis, all were intraperitoneal abscesses. These patients had sustained gunshot wounds and their mean A.T.I. was 48. Two of the control and one of the enteral group died from sepsis-induced multiple organ failure. Average hospital stay for the control group was 28.6 ± 6.1 days and 25.3 ± 5.8 days for the enteral fed. Hospital cost for the 31 control patients was $609,000 (mean, $19,636 ± 3,396) compared to $505,000

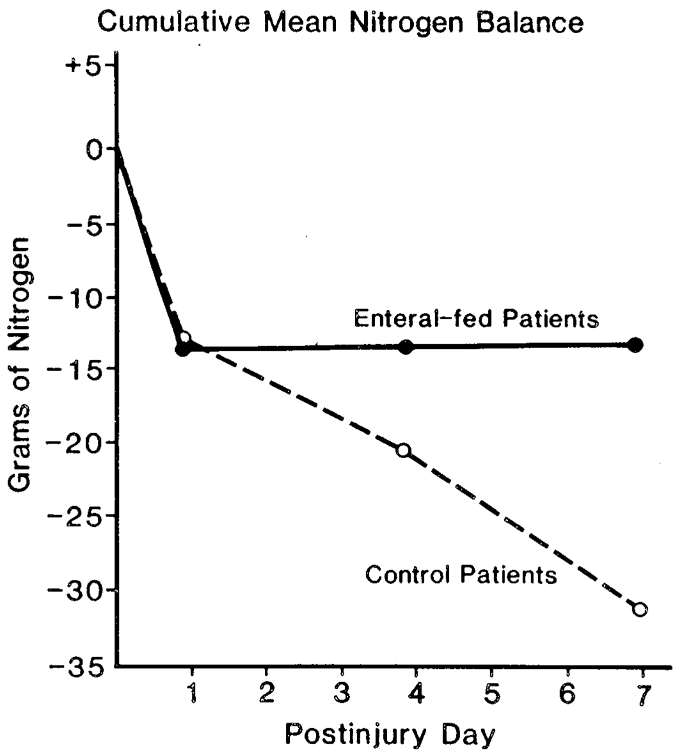

FIG. 2. Cumulative nitrogen balance in control (D_5W) versus enteral-fed groups during first week postinjury.

(mean, $16,280 ± 2,146) for the 32 in the enteral-fed group.

Twelve enteral-fed patients were intolerant of full-scale jejunostomy feeding. Stratification by trauma severity disclosed that five of the six patients with an A.T.I. >40 could not be maintained on the elemental diet. Comparison of the remaining patients with an A.T.I. < 40 failed to demonstrate significant differences between the 19 patients tolerating jejunal feeding and the seven intolerant, with respect to age (31.8 ± 2.5 vs. 29.0 ± 3.1 yr), A.T.I. (24.7 ± 1.4 vs. 26.9 ± 2.3), postoperative serum albumin (3.3 ± 0.1 vs. 3.3 ± 0.1 mg%), or small bowel injury distal to the N.C.J. (21% vs. 17%). Due to the prohibitive intolerance of jejunal feeding when the A.T.I. was greater than 40, the impact of early enteral feeding was analyzed in the randomized study subjects with an A.T.I. < 40.

Fifty-three patients had an A.T.I. between 15 and 40. The control and enteral-fed groups (27 and 26, respectively) were comparable with respect to age (29.4 ± 1.8 vs. 30.5 ± 2.0 yr), injury mechanism (74% vs. 62% penetrating), shock at admission (Table II), colon wound (Table II), and A.T.I. (Table II). Nineteen (73%) of the enteral patients were maintained on the elemental diet 5 or more days (range, 5 to 20; mean, 9 days); two (8%) received T.P.N. Seven (26%) of the control patients required T.P.N. for a mean duration of 14.9 days (range, 5 to 36 days). Comparison of nutritional data is summarized in Table II. As in the overall analysis, the only significant changes occurred in nitrogen balance at day 4 and 7 and in T.L.C. at day 7. Overall complication rate was similar for the control (11 = 41%) and enteral-fed (9 = 35%) groups, but septic morbidity was much greater in the control patients (Table II). The seven (26%) infections in the control group included intraperitoneal infection in five and bacterial pneumonia in two. The single (4%) infection in the enteral-fed group was a subphrenic abscess in a patient requiring splenectomy with adjacent gastric and pancreatic injury.

DISCUSSION

Timing of nutritional support in the severely injured but previously well nourished individual is a critical unresolved issue. The neuroendocrine response to major trauma induces a hypermetabolic state characterized by skeletal muscle breakdown to provide amino acids for energy supply, host defense, and wound repair. This obligatory carcass turnover may suffice for moderate stress, but excessive demands—not supported by exogenous nutrients—will erode visceral protein, impair organ function, compromise immune defense, and delay healing (5, 10, 12, 13, 20, 44). While conventional practice is to delay caloric and protein replenishment until 3 to 5 days postinjury (1), experimental work (24, 28, 29) and recent studies in burned patients (3) suggest immediate feeding is beneficial.

Our clinical investigation of when to initiate nutritional support in the critically injured patient has evolved over the past 8 years (11, 18, 25–27). Initial efforts were directed at selecting the high-risk patient in whom early feeding may impact on outcome. Anthropometric measurements confirm that young injured patients arriving at an urban trauma center are nutritionally sound despite their indigent environment (27). Visceral protein levels and immunologic testing, on the other hand, are distorted by tissue disruption, shock, blood loss, and operative stress (30, 43). Standard nutritional assessment (4, 6) in the immediate postinjury period is therefore unreliable to govern decision-making regarding nutritional support. For this purpose we devised the abdominal trauma index (A.T.I.). Despite its simplicity, this anatomic index has

TABLE II
Control (D_5W) versus enteral-fed groups with Abdominal Trauma Index 15–40

	Control (n = 27)			Enteral-fed (n = 26)		
A.T.I.	24.6 ± 1.3			25.3 ± 1.1		
Shock (<90 mm Hg)	9 (33%)			11 (42%)		
Colon injury	9 (33%)			10 (39%)		
Enteral ≥5 days	...			19 (73%)		
T.P.N.	7 (26%)			2 (7%)*		
	Day 1	Day 4	Day 7	Day 1	Day 4	Day 7
Albumin (mg%)	3.4 ± 0.1	3.1 ± 0.1	3.3 ± 0.1	3.3 ± 0.1	3.2 ± 0.1	3.3 ± 0.1
Transferrin (mg%)	227 ± 8	191 ± 5	217 ± 10	223 ± 8	189 ± 8	219 ± 10
T.L.C. (mm^3)	1,427 ± 180	1,300 ± 186	1,589 ± 136	1,676 ± 126	1,476 ± 178	2,384 ± 254*
N_2 bal. (gm/day)	−13.2 ± 0.6	−12.1 ± 0.7	−12.0 ± 0.7	−13.8 ± 0.8	−3.4 ± 1.7*	−1.1 ± 1.2*
Sepsis	7 (26%)			1 (4%)*		
Cost/patient	$17,557 ± 3,370			$14,763 ± 2,035		

T.L.C. = total lymphocyte count. ± = S.E.M. N_2 bal. = nitrogen balance. * = $p < 0.05$.

proved sensitive and reasonably specific for predicting septic morbidity following abdominal injury (18, 26).

Concurrent with this work, we performed clinical studies to ascertain the feasibility of immediate enteral feeding after major abdominal trauma. Enteral feeding was selected rather than total parenteral nutrition (T.P.N.) via central vein because of the physiologic advantages (2, 14, 17, 19, 23, 35), safety, and cost effectiveness (16, 32, 38). Stimulated by reports of Page and others (31, 32, 36), we employed needle-catheter jejunostomy (N.C.J.) for access (Fig. 1). Vivonex HN was the chosen elemental diet because of its low viscosity, relatively normal pH, and low fat content. The latter two features were believed important to minimize biliopancreatic stimulation (33). Our preliminary clinical studies demonstrated the safety of jejunal feeding in the presence of pancreatic and distal intestinal injury (11, 25). Equipped with a system to identify high-risk patients and a method to deliver low-risk nutrition, we embarked on this prospective randomized study to ascertain the cost:benefit of immediate postinjury nutritional support.

The current study provides well matched patient groups according to the trauma severity, nutritional, and immunologic indices measured. Failure to demonstrate significant changes in serum albumin and transferrin between the groups, despite a clear difference in nitrogen balance, may be due to the relatively large body pool and long half-life of these transport proteins (40) as well as hepatic protein synthesis reprioritization (39) and fluid compartment shifts in these critically injured patients (21). The rise in total lymphocyte count among enteral-fed patients may reflect an immunologic/metabolic function of the gut (35, 41). Alexander et al. (24) have ameliorated postburn hypermetabolism experimentally via early enteral feeding, and postulate bowel mucosal integrity is an important barrier to mediators of catabolic hormone secretion. Wilmore et al. (42) have demonstrated enhanced amino acid uptake with oxidation to glutamine in the intestinal tract of stressed animals, and suggest the gut regulates interorgan substrate flux. Thus the gastrointestinal tract may be more important for metabolic control and preventing bacterial translocation than simply providing a more efficient conduit for nutrients to reach the hepatic machinery.

The cost savings accrued by early enteral feeding in this study is probably conservative because patient billing at the D.G.H. is substantially lower than that of private hospitals in the metropolitan Denver area. While others (6, 32, 38) have demonstrated the cost effectiveness of aggressive postoperative nutrition via the N.C.J., documenting an impact on patient outcome has been elusive. The similar frequency of nonseptic complications in our two groups is presumably due to a random injury pattern in which acute protein synthesis and host defense have a relatively minor influence. In patients with heavily contaminated intraperitoneal wounds, however, enteral feeding significantly reduced the incidence of clinical sepsis. Only one (4%) major infection occurred in patients with A.T.I. 15–40 fed by N.C.J. compared to 7 (26%) in the control group managed by conventional delayed T.P.N. While it is difficult to establish a 'standard' morbidity rate following acute abdominal injury, the A.T.I. was designed to stratify such patients into relative risk groups. In our previous work (26), the A.T.I. exceeded 15 in 17% of SW patients and 56% of those sustaining a GSW. In the same study, 26 (32%) of the 82 patients with A.T.I. > 15 had postoperative complications. Moreover, the morbidity for SW and GSW were equivalent when patients were analyzed in comparable A.T.I. groups.

Our current recommendation for nutritional support in the acutely injured is depicted in Figure 3. An A.T.I. > 15, or similar injury severity index, warrants N.C.J. insertion at initial laparotomy unless reexploration to

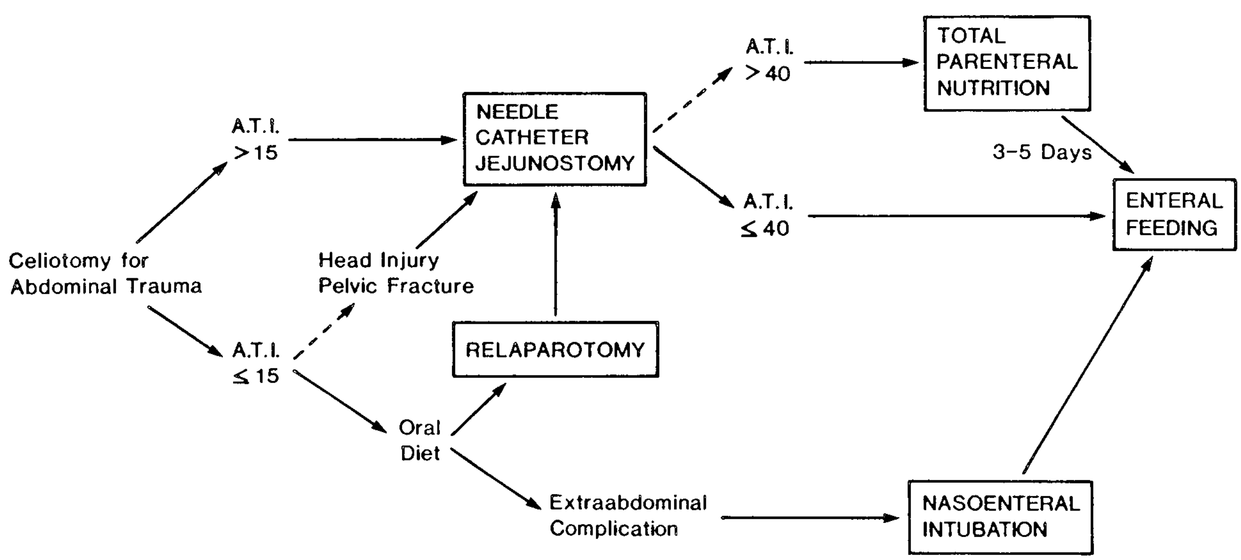

FIG. 3. Proposed nutritional support plan for patients sustaining acute major abdominal trauma based on the intraoperative abdominal trauma index (A.T.I.).

remove abdominal packing is planned within 48 hr. We now infuse a high branched-chain amino acid enteral diet (Vivonex T.E.N., Norwich Pharmaceuticals) although the advantages of this composition remain to be established (7). Due to the frequent difficulty with immediate jejunal feeding in patients with A.T.I. > 40, we would initiate T.P.N. and transition to enteral feeding in 3 to 5 days. Additionally, N.C.J. is appropriate for patients with A.T.I. < 15 in whom associated extra-abdominal trauma; i.e., severe head injury or major pelvic fracture, will prolong the catabolic period. We advance the diet more cautiously following massive pelvic crush due to occasional reflex small bowel atony (15). Finally, the N.C.J. is placed in patients undergoing reoperation for infection. Sepsis does not preclude effective jejunal feeding in this clinical setting (8).

In summary, our experience with nutritional support in the patients with major abdominal trauma indicates: 1) anatomic severity of injury is a superior predictor of postinjury septic morbidity than standard nutritional markers; 2) immediate postoperative feeding by N.C.J. is simple, safe, and feasible; and 3) early nutritional repletion decreases the incidence of septic morbidity, and is cost effective.

Acknowledgments

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DISCUSSION

DR. WILLIAM STAHL (Lincoln Medical & Mental Health Center, Bronx, NY 10451): Thank you very much. I enjoyed this paper, and I congratulate Doctor Moore and his coworkers in Denver for carrying out this study. It is very difficult to do, as you can imagine. You have got sick patients. You have got a lot of data to collect, and I think they should be congratulated on this. I would like also to thank them for sending me a copy of the manuscript so that I had a chance to go over this beforehand.

The importance of nutrition, and its relationship to sepsis, morbidity, and mortality is obvious. Septic mortality is the big killer after the first 24 hours.

We know that the malnourished patient can be improved immunologically with feeding in most cases.

The question is, can the post-trauma patient be improved, and is early feeding, i.e., the first 5 days in this study, vital to that improvement?

The literature really doesn't say much about this. Negative nitrogen balance can be prevented by feeding patients. That was studied by Gotui and Mulholland in 1944, so that the fact that nitrogen balance can be improved is not new.

The question is: is immune function enhanced, and is septic morbidity reduced?

I would comment on the plan of the study. Of course, a study like this with needle catheter jejunostomy cannot be blinded because some patients have the jejunostomy and others do not. This may introduce bias that the investigators may not be aware of at that time.

Second, I am not sure that at present any one of us would keep the major trauma patient on only 400 calories per day for 5 days. It seems to me that the usual feeding regimen involves starting up TPN on the second or third day. Thus the control group that is compared to the fed group in this study is rather severely restricted in calories.

I would like to ask two questions about the patient selection. We do use the ATI. I think Doctor Moore should be complimented on providing us with that. We did not hear whether the number of stab wounds or gunshot wounds was equal. I think there are often other things involved in addition to the specific organ injured. In our experience the degree of soft-tissue injury, especially in the retroperitoneal musculature, when associated with transgression of the colon, for instance, has been a major factor in abdominal sepsis. I would like him to comment on that.

In addition, he had a lower lymphocyte count in his control group. I would like to ask him if there were patients in that group with total lymphyocyte counts under 1,500 and was that associated with the sepsis?

The third question pertains to the nutritional support itself. We know that every one has had some trouble using any method, nasoenteric, jejunostomy, or TPN, in the first 2 or 3 days. We are not told how many calories the treated group actually got, although they achieved 3,000 calories on the fourth day.

In addition, in the manuscript on day 7 it is indicated that the control group got only 35% of their caloric requirement as estimated by the Harris-Benedict formula. I am not sure why that should be so since we are told that the patients in the control group were put on TPN starting with day 6. I am a little worried, and I would like to ask Gene whether the nutritional support from day 5 on for the control group was adequate, or are we having a continued caloric deficit beyond that point?

Another comment: if this study should be repeated, and I think it should be repeated in other centers, measured energy expenditure by indirect calorimetry should be used now that we know that the errors in the Harris-Benedict formula are quite large.

Finally, looking at the septic complications, there isn't any question that those are there in the control group and not in the experimental group.

I am a little bit worried in saying that this is clearly demonstrated and that we should go across the country preaching early enteric alimentation. There are some risks to this. The only article in the literature on immune enchancement comes out of Albany reporting a group of major urologic procedures where an increase in fibronectin was shown with the Moss decompression and naso-enteric feeding tube. One of their patients developed pulmonary edema and died, and thus there can be risks to attempting early alimentation.

My analysis of the septic complications indicates that there is a statistically significant difference when you compare nine to three. However, should we compare only abdominal sepsis or should we compare all septic complications? I don't know the answer to this. Pneumonias, of course, come from a variety of causes, willingness to cough, other trauma, atelectasis, et cetera, and when you compare the abdominal sepsis, seven in one group and three in the other, that is not statistically significant.

I think we have had a very nice study shown to us. It is certainly highly suggestive that early enteral feeding is effective in reducing the septic complications, but I think a study like this one should be done in other centers.

Thank you. [Applause]

DR. E. PATCHEN DELLINGER (Harborview Medical Center, Seattle, WA 98104): That was a very nice study and one that we have all been looking for for quite a while to see some real differences other than just in lab measurements in a fed versus unfed group.

It seemed to me that your number of patients who did not tolerate enteral feeding was rather high, and I wonder if you might have done better if you had used one of the polymeric formulas which is less hyperosmotic and in many cases more easily tolerated in the postop period.

Additionally, your costs would have been even lower in your enteral group had you used one of the less expensive but equally nutritious available formulas.

DR. CHARLES E. LUCAS (Wayne State University, Detroit, MI 48201): Would you comment on how you think the introduction of calories into the gut will prevent intra-abdominal infections and pneumonia, both of which are complications of surgery and, second, postoperative care. Also, do you have any data to suggest that the calories are absorbed?

I would certainly like to see a group of patients all having your tube in place with one group getting calories and the other group getting a noncalorie solution.

DR. MICHAEL ROHMAN (Lincoln Medical & Mental Health Center, Bronx, NY 10451): This fact that the number of complications in the two groups was roughly the same, and yet the incidence of sepsis was so significantly higher in the untreated group, suggests that there were complications of a different nature in the enteric fed patients.

If so, what were the complications, and are they attributable to the procedure?

DR. HARRY DELANY (North Central Bronx Hospital, Bronx, NY 10467): I enjoyed the paper. One question. Have you had any experience using needle-catheter jejunostomy feeding in the presence of small bowel or colon injuries?

We have been doing some laboratory studies, and there is a suggestion that colonic bursting strength is influenced by enteral feeding.

DR. JOHN BORDER (142 Grider Street, Buffalo, NY 14215): I think this is a very important paper.

Anybody who starts out their comments by starting on calorie, inadequate calorie intake, is walking in the wrong alleyway to the wrong grave.

The problem is inadequate amino acid support of the gut mucosa. The problem is not total body negative nitrogen balance. It is the distribution of protein within the body.

Doctor Moore's paper makes perfect sense to me, and I just spent many months writing a 76-page paper on this same topic. It fits with basic biology once you know it.

DR. ERNEST E. MOORE (Closing): We would like to thank the discussants for their provocative comments. Doctor Stahl, we agree it would be optimal to have this study blinded as well as prospective and randomized. However, our Human Research Committee was opposed to placing the needle-catheter jejunostomy in all patients, arguing that one half of them may be subjected to an unnecessary risk. We selected the immediate 5-day postoperative window for hypocaloric feeding because at the inception of our study in 1980 this was the standard of care. I would submit that even today many groups wait 3 to 5 days before initiating aggressive nutritional support in the injured patient who was previously well nourished. With respect to the randomization, the two groups were well matched statistically according to any factor we could think of, including injury mechanism. The demonstrable rise in total peripheral lymphocyte count in the enteral group is an intriguing finding, and was evident in some of our earlier studies as well. Although the patients developing septic complications had a lower lymphocyte count, the number of patients was too small to permit a statistical analysis. Unfortunately, we only began to assess more extensive immunologic profiles in the latter stages of our study. The most suggestive trend has been in the helper to suppressor T-cell ratios. We were also concerned about the continued negative nitrogen balance in the TPN group at day 7. I think this is due to the obligatory time required to introduce TPN in these critical patients as well as the fact that a number of them had excessive nitrogen demand due to septic complications at this time. We acknowledge the limitations of the Harris-Bendict equation for quantitating caloric needs, and currently rely on indirect calorimetry obtained with a mobile metabolic cart. As to the speculated advantages of enteral vis-à-vis TPN, I believe the experimental work of Doctor Sheldon and his group in San Francisco, and Doctor Alexander and his associates in Cincinnati performed in guinea pigs as well as a recent study in burned children provide convincing data indicating benefits of the enteral route.

Doctor Dellinger, patients were qualified as intolerant to jejunal feeding if they could not be advanced to the full feeding schedule. In fact, nine of 12 such patients received sufficient elemental diet to satisfy their metabolic demands. I agree a polymeric diet may have been tolerated by our patients. We selected our elemental diet because of its relatively high pH and low fat content, minimizing biliopancreatic stimulation, which we feel is important in patients with major upper gastrointestinal trauma. Moreover, the low viscosity of this diet permits its introduction via small-bore jejunal catheters. Perhaps this is the reason you had relative difficulty with enteral feeding in your study.

Doctor Lucas has asked the important question of why the patients with immediate enteral feeding had less septic complications. Again, we did not perform sophisticated immunologic assays in this study, but the dramatic rise in lymphocyte count in the enteral group is provocative. Changes in transport protein levels were not helpful. We are now measuring the response of a variety of acute phase proteins. Again the work of Alexander as well as that of Wilmore suggest the gut is an important organ in host defense in the stressed patient.

Doctor Rohman, the overall complications not included in the discussion of septic morbidity included minor incidences such as sublobar atelectasis and intravenous site phlebitis. I would submit that such trivial complications are not impacted by postinjury nutritional support.

Doctor Delany, of course one of the pioneers in jejunal feeding, has raised the issue of enteral feeding in the patient with acute intestinal injury. The work he alluded to as well as that of others indicated that intraluminal feeding may in fact enhance gut healing. We have not been reluctant to administer enteral feeding proximal to small bowel or colon anastomosis, and have encountered no clinical difficulties that would alter this practice.

Finally, Doctor Border has raised the germane point of designing postinjury nutritional support on the basis of nitrogen demands rather than focussing on caloric needs. Of course, we acknowledge his long-standing interest in early nutritonal support and agree with his point. In fact, our enteral feeding schedule was primarily focused to render these patients in positive nitrogen balance, as our presentation has indicated. On a pragmatic level, nitrogen demand parallels caloric needs once the proper adjustment in the caloric:nitrogen ratio has been established.

Again we would like to thank the discussants for their comments and thank the Association for the privilege of the floor. [Applause]