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Parenteral Nutrition in Pancreatitis is Passé: But Are We Ready for Gastric Feeding?

A Critical Evaluation of the Literature–Part I

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Pancreatitis is a very costly disease state, not only to those individuals affected by it, but also to society as a whole. Fortunately, the majority of cases are mild with predictable resolution within five-to-seven days. The remaining 20%–30% of patients progress to more severe illness associated with increased morbidity and mortality; patients in this category often require nutritional support. Although parenteral nutrition was the accepted means to accomplish this end, in recent years jejunal feeding has proven to be safer and less expensive. Even more recently, gastric feeding has now challenged jejunal feeding. Albeit an intriguing idea, the data is far from compelling. This article reviews what the literature does, and does not, say regarding parenteral and enteral (gastric versus jejunal) nutrition support in the patient with complicated pancreatitis.

INTRODUCTION—NUTRITIONAL IMPLICATIONS OF PANCREATITIS

Every year over 200,000 patients with acute pancreatitis are admitted to hospitals in the United States (1). The cost of care is substantial, with estimates of total direct and indirect costs ranging from $3.6 billion to $6 billion annually (2) (http://www.medscape.com/viewarticle/535110). Seventy to eighty percent of patients who are hospitalized with pancreatitis have mild disease, which resolves in five-to-seven days with conventional therapy including fluid resuscitation, pain management, and pancreatic rest by withholding oral intake. The remaining 20%–30% of patients progress to a more severe illness associated with increased infections, length of stay, systemic inflammatory response syndrome (SIRS), multi-

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system organ failure and mortality (1). This systemic inflammatory response results in an acute increase in calorie expenditure and protein breakdown (3).

Patients with mild, uncomplicated and self-limiting pancreatitis who have normal nutrition status on admission do not experience symptoms of malnutrition. The best method for providing nutrition support in patients with severe pancreatitis remains a topic of widespread discussion. Despite evidence showing jejunal enteral nutrition (EN) to be superior to parenteral nutrition (PN) in this patient population, recent research has challenged the practice of achieving gut rest by jejunal feeding and suggested rather, that patients could be fed into the stomach (4,5).

MALNUTRITION IN PATIENTS WITH PANCREATITIS

In the 25% of patients who develop severe acute pancreatitis, and its complications (1), length of hospital stay may extend beyond two weeks, and frequently includes ICU admission (6). The increased duration of hospitalization and the extended period of intolerance to oral intake further increase the risk of malnutrition, and thus the need for nutrition support in patients with severe disease. Severe pancreatitis also increases the likelihood of local pancreatic complications such as necrosis, pseudocyst and abscess, with an increased incidence of secondary infections (1). The development of local complications or secondary infections can produce a "second wave" of nutritional insult that can persist after the initial severe stage of pancreatic inflammation resolves. Local complications and secondary infections may extend the period of hypermetabolism and catabolism beyond that seen from the initial pancreatic inflammation alone. Clinically, we have noted that persistent abdominal pain, anorexia, pain medications, rehospitalization, and need for endoscopic and/or surgical procedures serve as more apparent barriers to achieving or maintaining nutrition status in patients with complicated pancreatitis. In addition, some patients with complicated acute pancreatitis exhibit features that adversely affect nutrition status and are more commonly associated with chronic pancreatitis. These include complications such as hyperglycemia, pancreatic exocrine insufficiency, and gastric outlet obstruction, which have all been described in patients with acute pancreatitis (7).

Laboratory Parameters and Nutritional Status

It is not uncommon to encounter patients with reduced serum proteins in the setting of pancreatitis; however, reduced serum proteins do not reflect nutrition status or a need for nutrition support during inflammatory states. The systemic inflammatory response of pancreatitis causes a reprioritization of hepatic protein synthesis, and transcapillary losses of serum proteins result in rapid decreases in the levels of serum albumin, transferrin and prealbumin (8). In a randomized study of patients with acute pancreatitis, there was no significant difference in transferrin levels between those patients receiving full calories and protein from PN, compared to patients receiving no nutrition support (9).

NUTRITIONAL SUPPORT IN PANCREATITIS

The availability of total PN in the 1970's coincided with other improvements in supportive care for pancreatitis that resulted in a decrease in the incidence of mortality from acute pancreatitis. Several investigators reported that the use of PN improved nutrition status, and was associated with improved survival (10). PN was described as "a standard component of therapy" by the 1980's, and one study reported that failure to achieve a positive nitrogen balance in patients with pancreatitis was associated with a tenfold increase in mortality (11). Although retrospective and observational reports suggested that PN had a beneficial effect in the management of pancreatitis, there were no randomized studies that allowed an understanding of the full risk/benefit nature of the routine use of PN until 1987.

In a randomized study Sax reported that the early institution of PN did not reduce pancreatic complications nor hasten resolution of pancreatitis compared to conventional therapy with intravenous fluids (9). The PN group experienced a significantly greater incidence of catheter-related infections and had a significantly longer hospitalization than the group receiving intravenous fluids. Routine use of PN in patients with relatively mild pancreatitis appears to have a net negative effect without any measurable clinical benefits.

ENTERAL NUTRITION SUPPORT—JEJUNAL FEEDING

As early as 1974, case reports suggested that enteral nutrition into the jejunum was feasible in the setting of acute pancreatitis (12,13). However, EN was generally avoided out of concern that EN might somehow slow the resolution of pancreatitis. In 1997 the first randomized study of jejunal EN compared to PN in acute pancreatitis demonstrated that not only was jejunal EN safe and effective, but in fact, resulted in decreased infectious complications and reduced cost compared to PN (14). In the decade that has followed this landmark study, more than eight randomized trials have demonstrated the advantages of jejunal EN over PN in the setting of acute pancreatitis (14–21).

Additional support for jejunal EN over PN has been demonstrated by two meta-analyses (22,23). The first, a meta-analysis of six randomized trials of jejunal EN compared to PN in acute pancreatitis concluded that EN was associated with a reduced incidence of infection, decreased surgical interventions and a shorter length of stay (22). A second meta-analysis of seven randomized studies concluded that jejunal EN was associated with a significant reduction in infections (RR = 0.46 95% CI, 0.29–0.74; $p < 0.001$) and length of hospital stay (weighted mean difference = –3.94 95% CI –5.86 to –2.02; $p < 0.001$) compared to PN (23).

Jejunal EN is the preferred route of nutrition support in patients with acute pancreatitis that have a functional gastrointestinal tract. In our institution, all patients receive a trial of jejunal EN before PN is considered; the exceptions are those patients in whom access is not attainable.

ENTERAL NUTRITION SUPPORT—GASTRIC FEEDING

Traditionally, gastric EN was avoided during acute pancreatitis based on studies that demonstrated stimulation of pancreatic secretions during gastric feeding (24–26). Several studies have suggested that gastric EN *may* be possible during bouts of acute pancreatitis, these studies are worthy of closer scrutiny as the details and limitations are not insignificant (See Table 1) (27).

A non-randomized feasibility study attempted nasogastric (NG) feeding in 26 patients with acute pancreatitis (APACHE II score >6) (28). The investigators reported that 22 out of 26 patients appeared to tolerate a semi-elemental feeding formula gastrically infused without apparent exacerbation of pancreatitis. However, the lack of a control group in this study disallows any comparison of outcomes in this study.

A second study from the same institution randomized 50 patients to receive either NG feeding or feeding into the proximal jejunum. The investigators reported that feeding tolerance, C-reactive protein (CRP), APACHE II, pain score and analgesia requirements were not significantly different between the two groups. An important point is that this study did not have an adequate number of participants to detect differences in mortality. In addition, the use of endoscopically positioned nasogastric tubes as jejunal tubes (5) (one-half of tubes affixed with an Endoclip (http://www.endot.com/products/innerduct_endoclip.asp) suggests that the "jejunal" group may have received feedings in a more proximal portion of the small bowel, permitting pancreatic stimulation thus resulting in similar outcomes between the two groups. Finally, the median pain scores and pain medication requirement were *near zero* in both groups by day three of the study, suggesting that many of the patients had mild disease and therefore may not have required nutrition support. However this appears inconsistent with the high overall mortality found in this study. It is also worth noting that the overall mortality of 24.5% is greater than expected given the actual disease severity in these patients.

Kumar, et al randomized 31 patients with acute pancreatitis to receive either nasojejunal (NJ) or nasogastric semi-elemental EN (4). EN was started 48–72 hours after admission with a slow feeding advancement that required seven days to progress from 250 to 1,800 calories per day. The investigators reported that only one patient in each group experienced reoccurrence of pain, however, partial PN was provided to four NJ- and six NG-fed patients because of "inability to tolerate" EN. There was no significant difference in outcomes (surgery, discharge, mortality), but this study was also inadequately powered to detect differences in these outcomes. The overall mortality for a population with a mean APACHE II score of 10 was 30%, which is higher than expected for this level of illness.

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A recent study of 50 patients *predicted* to have severe acute pancreatitis randomized patients to early nasogastric EN (n = 24) or PN (n = 26) (29). The nutrition goal was to provide 25 calories/kg within 72 hours. The primary endpoint of the study was intestinal permeability measured by the excretion of polyethylene glycol in the urine. Antiendotoxin core antibodies for immunoglobulin M (indirect marker for intestinal permeability) and IL-6, IL-8 and C-reactive protein were also measured. The researchers reported no significant difference between the EN and PN groups in the major endpoint of intestinal permeability. There were also no significant differences in antiendotoxin core antibodies, or markers of inflammation between the groups after the baseline measurements. However, even though the PN group had a significantly greater incidence of hyperglycemia, the EN group had a significantly greater incidence of total complications (10 of 26 [40%] in PN and 16 of 23 [70%] in EN). Furthermore, it is worth noting that several of the most common complications during the first three days of the study (pleural effusions and peripancreatic fluid collections) are precisely the nature of complications that one would expect during an exacerbation of acute pancreatitis; however, these were reported separately, and not included in the "pancreatitis complication" category. Pulmonary complications were also significantly greater in the EN group.

The increased rate of complications associated with gastric EN, when compared to PN, and the relatively high mortality rates reported in studies of jejunal EN versus gastric EN, should discourage the routine use of gastric EN in severe acute pancreatitis until further (and more robust) evidence is available. Furthermore these studies were underpowered and therefore could have missed differences in outcomes. Due to challenges of placing jejunal tubes past the Ligament of Treitz it is possible that some of the patients who were assigned to the jejunal group still experienced pancreatic stimulation because the jejunal tubes were not placed distal enough. Table 1 summarizes the evidence to date comparing PN, EN and gastric feeding in pancreatitis.

WHEN IS PARENTERAL NUTRITION INDICATED?

Although jejunal EN is the preferred method of providing nutrition support during pancreatitis, there are clearly patients that require PN to prevent severe malnutrition when EN is not feasible. Several factors that should be evaluated when considering the risk/benefit of PN is the nutrition status of the individual patient, the length of time that the patient has already been without nutrition (including hospital days at outside hospital prior to transfer to tertiary hospitals), and the projected time until the patient is likely to tolerate adequate EN or oral intake.

Well-nourished patients do not experience negative consequences from periods of seven-to-ten days of minimal nutrition (9,30). However, those patients that are admitted with significant malnutrition may benefit from PN if there is a delay in providing jejunal EN for more than three-four days. Patients that have persistent ileus, or those patients that experience exacerbation of pancreatitis after EN with a properly positioned feeding tube, should be considered for PN. Transient nausea, abdominal pain, or diarrhea while initiating EN should not be interpreted as intolerance to EN or as an indication to begin PN. Occasionally, a healthcare professional will state that a patient has abdominal pain, but when investigated further, it is no different than the pain experienced without enteral feeding. Pancreatitis is a painful process; therefore, the clinician will need to look for other overt clinical signs of intolerance such as increased distension, fever, increasing white count, worsening CT, etc.

Use of Lipid Emulsions

Several studies have determined that in patients with pancreatitis and mild hypertriglyceridemia (<400 mg/dL), the use of lipid emulsions with PN do not have negative consequences (31,32). When the amount of lipid in PN is limited to less than one gram of fat per kg, AND glucose control is maintained, the occurrence of hypertriglyceridemia during PN is rare (33). When hypertriglyceridemia occurs in the setting of pancreatitis it is frequently related to familial dyslipidemia and/or hyperglycemia. Lipoprotein lipase (the enzyme responsible for clearing triglycerides from the bloodstream) activity decreases when serum glucose exceeds 150 mg%. In an observational study only those patients with a history of hypertriglyc-

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Table 1
Studies Comparing Various Feeding Methods in Patients with Pancreatitis

Author	*Design*	*N/Route*	*Formula*
Jejunal vs Conventional IV fluids			
Powell (2000)	Prospective, randomized comparison	NJ - 13 IV - 14	Polymeric vs Conventional IV fluids
Nasojejunal vs Parenteral Nutrition			
Abou-Assi (2002)	Prospective randomized comparison	NJ - 26 vs PN - 27	Elemental
Gupta (2003)	Prospective, randomized study	NJ - 8 vs PN - 9	Polymeric
Kalfarentzos (1997)	Prospective randomized comparison	NJ -18 PN - 20	Semi-Elemental
McClave (1997)	Prospective randomized comparison	NJ -16 PN -16	Elemental
Modena (2004)	Prospective, non-randomized comparison	2 stages: PN - 43 Oct '98–Dec '01 vs NJ - 44 Jan '01–Sept '03	PN vs Polymeric
Olah (2002)	Prospective, randomized comparison	2 phases - #1: NJ - 41 PN w/ NG decompression tube - 48 #2: NJ - 92 with prophylactic IV imipenem	Elemental
Petrov (2006)	Prospective, Randomized comparison	NJ - 35 vs PN - 34	Semi-Elemental vs PN

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Results	*Comments*
• No significant effect of EN feeding on markers of inflammatory response (CRP, IL-6, TNF) • NJ group only met 21% of estimated needs	• Mean APACHE II score: 11 (range 7-32). • EN/IV fluids • Small N • 1 "NJ" was actually nasoduodenal and 1 randomized to NJ feeding refused tube placement and was put into conventional arm • Majority of pts resumed oral diet after median of 4 days • 3 patients received PN during study period: 1 NJ and 2 IV • All patients were eating by day 10
NJ group had: • Less hyperglycemia ($p < 0.03$) • Fewer septic complications ($p < 0.01$) • Decreased days of nutrition support ($p < 0.03$) • Fewer hospital costs ($p < 0.0001$)	• APACHE II not reported; 87.3% with mild pancreatitis, 3.2% with severe pancreatitis by Ranson's criteria • EN group received hypocaloric feeding (49% of estimated needs), which may have favorably influenced glucose control and infectious outcomes • 15% mortality overall
• NJ group had significantly shorter hospital stay ($p = <0.05$) • Faster return of bowel motility ($p = 0.01$)	• Mean APACHE II score - 9 (range 6–14) • Very small number of patients (15 total) • Patients received enteral feeding within 6 hours of admission
• Both EN & PN were well-tolerated • Decreased morbidity in EN group ($p < 0.05$) • Fewer septic complications in EN group	• Mean APACHE II score: 12 (range 8–15) • PN group had 2 x the incidence of hyperglycemia (>200 mg/dl), which could influence infectious outcomes • Overall mortality – 7.9%
• 4 x greater cost of therapy for PN compared to EN • Decreased incidence of hyperglycemia in EN group • Similar resolution of clinical symptoms in both groups	• Patients had mild pancreatitis (based on APACHE 3 scores; APACHE II scores not available) • PN group with compromised glucose control, which could account for increased infections
• Organ failure and patients requiring surgery was greater in the PN group vs EN group ($p = < 0.001$) • Less pancreatic necrosis infection in EN vs PN group ($p = <0.001$) • Mortality was greater in PN vs EN group ($p = 0.001$)	• Mean APACHE II score: 14.6 (range 3–26). • Hyperglycemia was not accounted for • Due to the design of this study, confounding from historical controls may also have influenced outcomes
• Although not statistically significant, the NJ group had: – Fewer infectious complications – Decreased multiple organ failure – Decreased mortality • NJ fed patients in phase 2 of the study had less pancreatic necrosis than PN fed patients in phase 1 ($p = < 0.04$)	• APACHE II not reported. Exclusions: – Patients with biliary tract disease – Patients who repeatedly removed their feeding tubes or who did not tolerate jejunal feedings • In phase 2 of the study, the patients from the first phase served as historical controls • Hyperglycemia was not accounted for in either phase
NJ vs PN *had less:* • Pancreatic infections ($p=<0.02$) • Extrapancreatic infections ($p=<0.044$) • Organ failure after the first week ($p=<0.01$) • Multiple organ failure ($p=<0.02$) • Mortality ($p=<0.003$) • Noninfectious complications (tube dislodgement, diarrhea, abdominal bloating) were greater in the NJ group ($p = <0.04$)	• APACHE II score: 12.25 (range: 10–16) • Fed 30 kcal/kg and 1.5 g protein/kg IBW within 24 hours of enrollment ×7 days • Hyperglycemia was noted to be > in the PN group vs the NJ group, however, serum levels and insulin treatment were not reported

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Table 1 (continued)
Studies Comparing Various Feeding Methods in Patients with Pancreatitis

Author	*Design*	*N/Route*	*Formula*
Windsor (1998)	Prospective, randomized comparison	Severe grp: NJ - 6 CPN -7; or Mild-Mod grp: Oral - 10 Mid-lines - 11	Polymeric EN (severe) or oral clear liquids w/ standard liquid supplement (mild-mod) vs. PN
Zhao (2003)	Prospective, randomized comparison	NJ - 55 PN - 41	Semi-Elemental vs. PN
Nasogastric vs Other			
Eatock (2005)	Prospective randomized comparison	NG - 27 NE -22	Semi-Elemental
Eckerwall (2006)	Prospective, randomized comparison	NG - 24 PN - 26: • 2 - CPN • 24 - PPN	Polymeric vs PN
Kumar (2006)	Prospective randomized comparison	NG - 16 NE -14	Semi-Elemental
Retrospective/Observational Studies			
Eatock (2000)	Prospective, single arm feasibility study	NG - 26	Semi-Elemental
Hamvas (2001)	Retrospective, observational	NJ - 12 vs PN - 7	Polymeric vs. Hypocaloric PN
Makola (2006)	Retrospective review	PEG/J - 126	Polymeric

Results	*Comments*
• Significant reduction in CRP & APACHE II scores in EN group ($p = <0.005$ and $p = <0.0001$) respectively • Serum IgM Endo Cab antibodies increased in PN group ($p < 0.05$) • Increased antioxidant capacity in EN group ($p = <0.05$) • SIRS significantly ↓'d from in EN vs PN group ($p < 0.05$)	• Mean APACHE II score: 8.75 (range 6–13) • Enteral group received 1200 non-protein kcal (1430 total) vs 1800 *non-protein* kcal (2035 total) in PN group (990 kcal—55% fat non-protein as LCT)
• Body weight and prealbumin increased over 2 weeks in treatment group • APACHE II, CRP, TNF, IL-6 decreased earlier • No significant differences in pancreas lesions based on CT scores	• Mean APACHE II score: 8.25 (±0.65) • EN therapy was confounded by *3 stages:* 1) Glutamine supplemented PN 2) Ileus subsided → both PN and EN 3) EN alone • Glycemic control not reported
• No significance difference in pain score, opiate requirement, CRP or mortality between groups	• *Median* APACHE II score: 10 (range 4–28) • Study compared NG to ND feeding (tube secured with endo-clip) • Overall mortality of 24.5% (15% expected) • To compare mortality between groups, 854 patients would be needed
• PEG, Endocab, CRP, IL-6, and gastrointestinal symptoms or abdominal pain did not significantly differ between groups • Incidence of hyperglycemia was significantly higher in PN patients. • Total *and* pulmonary complications within the first 3 days were significantly more frequent in EN patients	• *Median* APACHE II score: 11 (range 8–13) • Underpowered • 11 PN vs 23 EN had pancreatic processes, but they were all reported separately, hence NS • Median blood glucose levels were 16 mmol/L (290 mg%) when insulin therapy was initiated; and not all patients with hyperglycemia received insulin • No signs of aspiration however, study was not designed to detect this
• All patients received goal of 1800 calories within one week • No significant difference in outcomes, infection, or tolerance between groups	• Mean APACHE II score: 11 (±4.3) • Endoscopic placed NJ tubes; unclear if feeding ports were beyond LOT (no re-check of tube position) • PN was initially provided to 4 NJ and 6 NG patients • Overall mortality of 31% high for severity of illness
• 85% of patients appeared to tolerate NG feeding • Median time to achieve caloric goal was 36 hours • Mortality was 15.3%	• *Median* APACHE II score: of 10 (range 4–28) • A feasibility study with no control group
• NJ group had a faster healing rate ($p = <0.045$) and were operated on less than PN group (NS)	• APACHE II scores not reported • Retrospective study over a 5-year period with very small groups • Patients included were those with *chronic* pancreatitis
• Patients with complicated pancreatitis (82% pseudocyst, 22% necrotizing) appeared to tolerate standard polymeric jejunal feeding with improvements in CT Severity Index over 4.4 months	No APACHE II reported; 65.6 % with mild pancreatitis, 13.5% with severe pancreatitis by CT severity index • Retrospective study with no control group

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eridemia experienced significantly increased serum triglycerides (TG) during PN (33). Our experience has been that achieving glucose control with an insulin drip will normalize TG levels within 48 hours in the majority of patients.

PERIPHERAL PARENTERAL NUTRITION ("PN LITE")

There are no randomized studies on the use of peripheral parenteral nutrition (PPN) in the setting of pancreatitis. In practice, we have found that there are a (very) limited number of patients in which PPN can serve as a "bridge" and help to avoid the need for central line placement. In those patients with severe malnutrition that experience a delay in obtaining enteral access, PPN can prevent further nutrition losses and allows the clinician to begin the refeeding process. In those patients with existing malnutrition, initial feeding should be hypocaloric to minimize the severity of refeeding syndrome; therefore a dilute PN solution is *not* a limitation. Of course, the reality is that those patients with severe malnutrition frequently present with extremely tenuous peripheral IV access, and often require a central line for antibiotics, electrolytes and other medications. Our experience is that the vast majority of patients either do not need nutrition support or are candidates for jejunal EN.

There is ongoing debate and investigation into the role of glucose control as a driving factor in the increased infectious complications resulting from the use of PN compared to EN. Strict glucose control appears to reduce infectious complications in select populations (34). Furthermore, the randomized studies of patients with pancreatitis that reported significantly more infectious complications in the PN compared to EN groups had suboptimal glucose control in the PN group (15,17,19). In the absence of randomized studies that can characterize the role of glucose control in PN-related infections, our approach is to optimize glucose control in those patients with pancreatitis in whom the use of PN is unavoidable. However, even if outcomes were equal in PN versus EN, PN is still significantly more expensive, invasive (central access) and requires more intensive/expensive monitoring (frequent labs).

CONCLUSION

Well-nourished patients with mild pancreatitis rarely require nutrition support. Routine use of PN is unnecessary, and may have a "net" negative effect in mild pancreatitis. The current studies of gastric feedings in pancreatitis have methodological limitations and raise concerns about the relatively high mortality rates of patients with severe pancreatitis fed into the stomach. There is insufficient data to conclude that gastric feeding is safe or effective in severe acute pancreatitis. In patients with severe pancreatitis, and those with existing malnutrition that require nutrition support, the weight of current evidence supports jejunal enteral nutrition as the preferred route of nutrition support. ■

References

1. Swaroop VS, Chari ST, Clain JE. Severe acute pancreatitis. *JAMA*, 2004;291:2865-2868.
2. Draganov P, Forsmak C. Diseases of the pancreas: Acute pancreatitis. In: Dale D, Federman D, Eds. Gastroenterology, New York: ACP Medicine Online. 2002; 2002 WebMD Inc.;2006.
3. Meier R, Ockenga J, Pertkiewicz M, et al. ESPEN Guidelines on Enteral Nutrition: Pancreas. *Clin Nutr,* 2006;25:275-284.
4. Kumar A, Singh N, Prakash S, et al. Early enteral nutrition in severe acute pancreatitis: a prospective randomized controlled trial comparing nasojejunal and nasogastric routes. *J Clin Gastroenterol,* 2006;40:431-434.
5. Eatock FC, Chong P, Menezes N, et al. A randomized study of early nasogastric versus nasojejunal feeding in severe acute pancreatitis. *Am J Gastroenterol,* 2005;100:432-439.
6. Soran A, Chelluri L, Lee KK, et al. Outcome and quality of life of patients with acute pancreatitis requiring intensive care. *J Surg Res,* 2000;91:89-94.
7. Andersson E, Andersson R. Exocrine insufficiency in acute pancreatitis. *Scand J Gastroenterol,* 2004;39:1035-1039.
8. Banh L. Serum Proteins as Markers of Nutrition: What are we treating? *Practical Gastroenterology,* 2006;XXX (10); 46-64.
9. Sax HC, Warner BW, Talamini MA, et al. Early total parenteral nutrition in acute pancreatitis: lack of beneficial effects. *Am J Surg,* 1987;153:117-124.
10. Feller JH, Brown RA, Toussaint GP, et al. Changing methods in the treatment of severe pancreatitis. *Am J Surg,* 1974;127:196-201.
11. Sitzmann JV, Steinborn PA, Zinner MJ, et al. Total parenteral nutrition and alternate energy substrates in treatment of severe acute pancreatitis. *Surg Gynecol Obstet,* 1989; 168:311-317.
12. McArdle AH, Echave W, Brown RA, et al. Effect of elemental diet on pancreatic secretion. *Am J Surg,* 1974;128:690-692.
13. Voitk A, Brown RA, Echave V, et al. Use of an elemental diet in the treatment of complicated pancreatitis. *Am J Surg,* 1973;125: 223-227.
14. McClave SA, Greene LM, Snider HL, et al. Comparison of the safety of early enteral versus parenteral nutrition in mild acute pancreatitis. *J Parenter Enteral Nutr,* 1997;21: 14-20.
15. Abou-Assi S, Craig K, O'Keefe SJ. Hypocaloric jejunal feeding is better than total parenteral nutrition in acute pancreatitis:

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Table 1 (continued)
Studies Comparing Various Feeding Methods in Patients with Pancreatitis

Author	*Design*	*N/Route*	*Formula*
Nakad (1997)	Prospective, observational study	NJ -21	Semi-Elemental
Pupelis (2006)	Prospective, single arm feasibility study	Oral - 29	Low-fat polymeric
Stanga (2005)	Retrospective	PEG/J - 57	Semi-Elemental
Yoder (2002)	Retrospective review of home course	PEG/J - 33	Polymeric (97%); Elemental (3%)
Nasojejunal vs Nasojejunal			
Hallay (2001)	Non-randomized comparison	NJ - 16 (9 vs 7) w/ NGT for decompression	Polymeric, Glutamine-rich Stresson Multifibre vs. Nutrision Fibre
Oral vs Nasojejunal			
Pandey (2004)	Prospective, randomized comparison	Oral -15 NJ -13	Low fat oral or EN (8–18% fat)

NJ = nasojejunal; NG = nasogastric; NE = nasoenteric; PEG/J = percutaneous endoscopic gastrostomy-jejunostomy
PN = parenteral nutrition; CPN = central parenteral nutrition; PPN = peripheral parenteral nutrition

Citations Excluded:

- Austrums E, Pupelis G, Snippe K. Postoperative enteral stimulation by gut feeding improves outcomes in severe acute pancreatitis. *Nutrition* 2003;19:487-491. **All post-op patients; reported surrogate markers only.**
- Bodocky G, Harsanyi L, Pap A, et al. Effect of enteral nutrition on exocrine pancreatic function. *Am J Surg* 1991;161:144-148. **Described only the volume and composition of pancreatic secretions in postoperative patients, did not report clinical outcomes.**
- Kudsk K, Campbell S, O'Brien T, et al. Postoperative jejunal feedings following complicated pancreatitis. *Nutr Clin Pract* 1990;5:14-17. **All post-op patients; retrospective review, small number of patients.**
- Pupelis G, Selg G, Austrums E, et al. Jejunal feeding, even when instituted late, improves outcomes in patients with severe pancreatitis and peritonitis. *Nutrition* 2001;17:91-94. **Study population only included post-op patients with secondary peritonitis or failed conservative therapy of severe pancreatitis.**

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Results	*Comments*
• EN tolerated in all patients without exacerbation of disease	• Mean APACHE II score: 7.62 (±2.1) • No comparison group, observational study without control • Patients had gastric decompression with jejunal feeding
• Oral sip feeding started at a median of 2 days (range-1–8 days) after admission • Only 4 patients reported bloating, epigastric pain or diarrhea	• Mean APACHE II score: 5.72 (range 0–13) • Patients received a median of only 533 calories/day (range 243–1057 calories)
• PEG/J feeding provided for a mean of 113 days (range, 3–180) • Abdominal pain and GI side effects decreased from 96% to 23% and 90% to 14.6% in patients respectively • Nutrition status improved after PEG/J feeding	• No APACHE II score (chronic pancreatitis) • Retrospective study with no control group
• EN was well-tolerated • 77% of patients achieved nutrition goals • Reported GI complications did not hinder EN delivery • 61% of patients maintained or gained weight	• No APACHE II score (chronic pancreatitis) • Retrospective review of patients with pancreatic pseudocyst/s discharged home with PEG/J feedings
• Significant ↑ in serum IgG, RBP	• APACHE II score of both groups: 2.7 • Small N • Outcomes reported, however they were not part of the study design and too few patients to reach significance
• 4 patients in oral group and 0 in the NJ group had pain relapse (NS) • In the 4 patients who had pain relapse, total duration of pain and CT scores (p = 0.02), total hospital stay (p = 0.004) and hospital stay after refeeding was significantly greater in the oral group (p = 0.001) over NJ group	• Mean APACHE II score at 48 hours—4 (±1.8) • Underpowered • "Refeeding" started when patient was pain free and ileus had subsided (could be anywhere from onset of symptoms *up to 30 days*) • 16 patients did not fulfill inclusion criteria for unclear reasons

results of a randomized comparative study. *Am J Gastroenterol,* 2002;97:2255-2262.
16. Gupta R, Patel K, Calder PC, et al. A randomised clinical trial to assess the effect of total enteral and total parenteral nutritional support on metabolic, inflammatory and oxidative markers in patients with predicted severe acute pancreatitis (APACHE II > or = 6). *Pancreatology*, 2003;3:406-413.
17. Kalfarentzos F, Kehagias J, Mead N, et al. Enteral nutrition is superior to parenteral nutrition in severe acute pancreatitis: results of a randomized prospective trial. *Br J Surg,* 1997;84: 1665-1669.
18. Olah A, Pardavi G, Belagyi T, et al. Early nasojejunal feeding in acute pancreatitis is associated with a lower complication rate. *Nutrition*, 2002;18:259-262.
19. Petrov MS, Kukosh MV, Emelyanov NV. A randomized controlled trial of enteral versus parenteral feeding in patients with predicted severe acute pancreatitis shows a significant reduction in mortality and in infected pancreatic complications with total enteral nutrition. *Dig Surg,* 2006;23:336-344; discussion 344-335.
20. Windsor AC, Kanwar S, Li AG, et al. Compared with parenteral nutrition, enteral feeding attenuates the acute phase response and improves disease severity in acute pancreatitis. *Gut*, 1998;42: 431-435.
21. Zhao H, Lu HG, Shi YB, et al. Role of enteral nutrition supplemented with ebselen and EHEC in pancreatitis-associated multiple organ dysfunction in rats. *Inflamm Res*, 2006; 55:423-429.
22. Marik PE, Zaloga GP. Meta-analysis of parenteral nutrition versus enteral nutrition in patients with acute pancreatitis. *BMJ*, 2004;328:1407.
23. McClave SA, Chang WK, Dhaliwal R, et al. Nutrition support in acute pancreatitis: a systematic review of the literature. *J Parenter Enteral Nutr,* 2006;30:143-156.
24. Kaushik N, Pietraszewski M, Holst JJ, et al. Enteral feeding without pancreatic stimulation. *Pancreas*, 2005;31:353-359.
25. O'Keefe SJ, Lee RB, Anderson FP, et al. Physiological effects of enteral and parenteral feeding on pancreaticobiliary secretion in humans. *Am J Physiol Gastrointest Liver Physiol,* 2003;284:G27-G36.
26. Vu MK, van der Veek PP, Frolich M, et al. Does jejunal feeding activate exocrine pancreatic secretion? *Eur J Clin Invest,* 1999;29:1053-1059.
27. Parrish CR, Krenitsky J, McCray S. University of Virginia Health System Nutrition Support Traineeship Syllabus: University of Virginia Health System Nutrition Services; 2003.
28. Eatock FC, Brombacher GD, Steven A, et al. Nasogastric feeding in severe acute pancreatitis may be practical and safe. *Int J Pancreatol,* 2000;28:23-29.
29. Eckerwall GE, Axelsson JB, Andersson RG. Early nasogastric feeding in predicted severe acute pancreatitis: A clinical, randomized study. *Ann Surg,* 2006;244:959-965; discussion 965-957.
30. Perioperative total parenteral nutrition in surgical patients. The Veterans Affairs Total Parenteral Nutrition Cooperative Study Group. *NEJM*, 1991;325:525-532.
31. Stabile BE, Borzatta M, Stubbs RS, et al. Intravenous mixed amino acids and fats do not stimulate exocrine pancreatic secretion. *Am J Physiol,* 1984;246:G274-G280.
32. Burns GP, Stein TA. Pancreatic enzyme secretion during intravenous fat infusion. *J Parenter Enteral Nutr,* 1987;11:60-62.
33. Willcutts K, Krenitsky J, Banh L. Is Monitoring of Serum Triglycerides Indicated in All Parenterally Fed Patients? *Nutr Clin Pract,* 2005;20:142-N055.
34. van den Berghe G, Wouters P, Weekers F, et al. Intensive insulin therapy in the critically ill patients. *NEJM*, 2001;345:1359-1367.
35. Hallay J, Kovacs G, Szatmari K, et al. Early jejunal nutrition and changes in the immunological parameters of patients with acute pancreatitis. *Hepato-Gastroenterol,* 2001;48:1488-1492.
36. Hamvas J, Schwab R, Pap A. Jejunal feeding in chronic pancreatitis with severe necrosis. *J Pancreatitis,* 2001;2(3):112-116.
37. Makola D, Krenitsky J, Parrish CR, Dunston E, Shaffer HA, Yeaton P, Kahaleh M. Efficacy of Enteral Nutrition for the Treatment of Pancreatitis Using Standard Enteral Formula. *Am J Gastroenterol,* 2006;101:2347–2355.
38. Modena JT, Cevasco LB, Basto CA, et al. Total enteral nutrition as prophylactic therapy for pancreatic necrosis infection in severe acute pancreatitis. *Pancreatology*, 2004;6:58-64.
39. Nakad A, Piessevaux H, Marot J, et al. Is early enteral nutrition in acute pancreatitis dangerous? About 20 patients fed by an endoscopically placed nasogastrojejunal tube. *Pancreas*, 1998; 17:187-193.
40. Pandey SK, Ahuja V, Joshi YK, et al. A randomized trial of oral refeeding compared with jejunal tube refeeding in acute pancreatitis. *Indian J Gastroenterol,* 2004;23:53-55.
41. Powell JJ, Murchison JT, Fearon KCH, et al. Randomized controlled trial of the effect of early enteral nutrition on markers of the inflammatory response in predicted severe acute pancreatitis. *Br J Surg,* 2000;87:1375-1381.
42. Pupelis G, Snippe K, Plaudis H, et al. Early oral feeding in acute pancreatitis: an alternative approach to tube feeding—preliminary report. *Acta Chir Belg,* 2006;106(2): 181-186.
43. Stanga Z, Giger U, Marx A, et al. Effect of jejunal long-term feeding in chronic pancreatitis. *J Parenter Enteral Nutr,* 2005;29: 12-20.
44. Yoder AJ, Parrish CR, Yeaton P. A retrospective review of the course of patients with pancreatitis discharged on jejunal feedings. *Nutr Clin Pract,* 2002;17:314-320.