ENTERAL FEEDING TOLERANCE IN CRITICALLY ILL PATIENTS

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Objective. To assess tolerance of enteral feeding in intensive care unit (ICU) patients.

Design. A prospective study conducted over 8 months (1 March - 31 October 1997).

Setting. ICU at King Edward VIII Hospital, Durban, a tertiary referral hospital.

Patients. Haemodynamically stable patients with a normal or functioning gastro-intestinal tract were enrolled immediately. Those with ileus were commenced on enteral feeding when the nasogastric output was < 500 ml/24 hours and bile was clear. Bowel sounds did not influence commencement of feeding. Patients were fed commercial semi-elemental or polymeric diets. Feeds were commenced at 20 ml/hour and the maximum rate was 80 ml/hour. Residual gastric volumes were measured daily. The endpoints of the study were discharge from the ICU, cessation of feeds because of intolerance, and death.

Results. There were 96 patients (male/female ratio 2:1). Mean age was 34 ± 17.2 years. Mean time to commencement of feeds was 4.5 ± 3.7 days. Forty-five patients had no bowel sounds at commencement of feeding. Mean duration of feeding was similar in patients with intestinal anastomosis (18.24 ± 17.40 days) and those without (13.09 ± 9.77 days) (P = 0.287). Twenty-two patients (23%) suffered feed-related complications, such as abdominal distention (13), vomiting (10) and diarrhoea (3). Feeding had to be stopped in 4 patients. Residual volumes were 35.95 ± 61.62 ml in patients with complications and 20.71 ± 35.25 ml in those without complications (P = 0.094). Twenty-nine patients died (30%).

Conclusion.The majority of ICU patients tolerate enteral feeding, which may be commenced in the absence of bowel sounds. There was no significant difference in gastric residual volumes in patients with complications compared with those without complications. The presence of intestinal anastomosis did not influence duration of feeding.

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Enteral nutrition is preferred to total parenteral nutrition (TPN) for a number of reasons. Enteral access is easy, gut integrity and motility are preserved and the stress response is attenuated.[1-6] In contrast, TPN may result in mucosal atrophy, bacterial translocation and catheter-related complications.[1,3-7] These advantages of enteral nutrition over TPN have led to an aggressive application of enteral tube feeding in the intensive care setting. Complications cited as a result of patients receiving enteral tube feeds, however, include gastro-intestinal symptoms such as diarrhoea, vomiting, abdominal distension, colonisation of the gastro-intestinal tract, infection and aspiration pneumonia, as well as prolonged hospital stay and increased mortality.[8-10]

There is a paucity of studies designed to test the tolerance of enteral feeding in critically ill patients. We therefore undertook this prospective study in the intensive care unit (ICU) at King Edward VIII Hospital, Durban, to determine tolerance of patients to enteral feeding and to describe the incidence of complications.

PATIENTS AND METHODS

A total of 96 consecutive ICU patients were enrolled over an 8-month period (1 March 1997 - 31 October 1997). The study included haemodynamically stable patients with a normal or functioning gastro-intestinal tract. Enteral feeding was commenced as soon as possible after admission to the ICU. Haemodynamically unstable patients were not fed until they achieved haemodynamic stability. Feeding was commenced in patients with ileus when the nasogastric aspirate was < 500 ml per 24 hours. The presence of clear bile in the nasogastric aspirate was no contraindication to feeding. Enteral feeding was not commenced if the nasogastric aspirate was cloudy or contained debris. The presence or absence of bowel sounds did not influence commencement of enteral feeding. There were no exclusions from the study.

Enteral feeding was delivered through a fine-bore polyurethane nasogastric feeding tube (Flocare, 8 French, 110 cm long, Nutricia, Netherlands) with the tip placed in the stomach or via a jejunostomy tube (14 French Foley's catheter). The position of the tube in the stomach was confirmed by chest radiograph which was performed routinely as part of normal patient management and not for the purpose of the study.

Feeding was in the form of commercial semi-elemental or polymeric enteral feeds. Patients without concurrent medical disease were given regular polymeric (isotonic) feeds like Nutrison Standard (Nutricia, Netherlands), Osmolite (Abbott Laboratories, USA) or Peptison (pre-digested) (Nutricia, Netherlands). Glucerna (Abbott Laboratories, USA) was given to diabetic patients, Suplena (Abbott Laboratories, USA) to those with chronic renal failure and Pediasure (Abbott Laboratories, USA) to children. Residual gastric volumes were

measured daily during the patients' stay in the ICU by stopping the feeds at approximately the same time and aspirating the contents of the stomach to dryness.

Caloric requirements in this study were not specifically calculated for individual patients and they were not based on indirect calorimetry or formulae such as the Harris-Benedict equation. Feeds were given according to a locally devised protocol, which is reviewed on a yearly basis by our dietetic department.

The objective of the protocol is to provide a maximum of between 1 500 and 2 000 Kcal per day. Full-strength feeds are commenced at 20 ml/hour (500 ml/24 hours) and this delivers 20 g protein and 500 Kcal of energy. The maximum rate is 80 ml/hour (2 000 ml/24 hours) which delivers 80 g of protein and 2 000 Kcal. In children the above parameters are again taken into consideration but in addition the patients' age and weight are considered. Children below the age of 8 years are given Pediasure, while those 8 years or older are given adult formulas. Feeding is started at 10 ml/hour (250 ml/24 hours) and continued till the maximum rate for age is reached as per the enteral feeding protocol (Table I).

It is policy in our ICU to use polymeric feeds and we reserve semi-elemental diets for patients with hypoalbuminaemia as well as those with small-bowel absorptive abnormalities. Patients with diabetes mellitus, renal failure, hepatic failure and hypoalbuminaemia are given disease-specific diets as advised by a dietician. The polymeric feeds indicated for tube feeding are not comparable to those previously used for oral feeding. The new high-fat energy-dense semi-elemental feeds were not available at the time of the study.

Complications documented were abdominal distension (abdominal changes on daily physical examination with tympany and/or absence of bowel sounds), diarrhoea (> 5 liquid stools or ≥ 2 000 ml/24 hours), vomiting (enteral formula ejected from the mouth) and enteral regurgitation (enteral formula found in oral or nasal cavities). Development of complications was not considered an endpoint as the feeds were either reduced or stopped temporarily. High gastric residual volumes (> 200 ml) were not considered a complication in this study if patients remained asymptomatic.

The endpoints of the study were discharge from the ICU, persistent gastro-intestinal complications (abdominal distension, vomiting, and diarrhoea) and death. Patients who developed diarrhoea were investigated for other causes of diarrhoea such as *Clostridium difficile* and drugs, and if excluded a diagnosis of feed-related diarrhoea was then made.

Of the 96 patients, 65 were male (male/female ratio 2:1). Their ages ranged from 1 year to 87 years, with a mean of 34 ± 17.2 years. The different diagnoses are shown in Table II and the reasons for admission to the ICU are shown in Table III. Twenty-five patients had abdominal sepsis, 25 had multiple organ dysfunction syndrome (MODS) and 19 had some form of intestinal anastomosis distal to the tip of the feeding tube. Ninety-five patients were fed through the nasogastric route and 1 was fed through a feeding jejunostomy. Seventy-three patients (76%) received Nutrison Standard, Osmolite or Peptison, 12 (12.5%) were diabetic and therefore received Glucerna, 7 had chronic renal failure and received Suplena, and 4 children received Pediasure. There were 9 children (younger than 12 years). Only 4 received Pediasure. According to our protocol Pediasure is given to children under the age of 8. The other 5 children ranged in age from 8 to 11 years and therefore were offered adult nutrition in the form of Nutrison Standard.

The chi-squared test was employed to determine the significance of duration of feeding in the different groups. The Mann-Whitney *U*-test was used for residual volumes and mean commencement of feeds. A *P*-value of < 0.05 was considered significant.

RESULTS

Mean commencement of feeds was 4.5 ± 3.7 days after admission to the ICU (range 2 - 28 days). The average duration of enteral feeding was 14 ± 11.8 days (range 2 - 68 days). There were 21 patients with anastomosis and 75 without. Mean duration for those with intestinal anastomosis was 18.24 ± 17.40 days (range 3 - 66) compared with 13.09 ± 9.77 days (range 2 - 45 days) in those without anastomosis ($P = 0.287$) (chi-squared). Mean time to commencement of feeding was 4.55 ± 3.91 days (range 2 - 13 days) for those with anastomosis

Table I. Maximum rates for feeding according to age

Age group (yrs)	Feed	Maximum rate (ml/h)	Daily intake (ml)	Daily protein intake (g)	Daily calorie intake (Kcal)
1	Pediasure	40	948	28.4	-
≤ 2	Pediasure	50	1 185	35.5	-
3 - 4	Pediasure	60	1 422	42.6	-
5	Pediasure	70	1 659	49.7	-
6 - 7	Pediasure	80	1 896	56.8	-
8 - 12	Nutrison Std	80	2 000	80	2 000
Adults	Nutrison Std	80	2 000	80	2 000

Table II. Diagnosis in 96 critically ill patients receiving enteral feeding

Diagnosis	Total	Complications	No complications
Polytrauma (excluding abdominal trauma)	26	4	22
Abdominal trauma*	25	5	20
Penetrating (13)			
Blunt (12)			
Anastomosis†	21	6 (27%)	15 (20%)
Peritonitis‡	13	5	8
Intestinal obstruction	6	0	6
Adhesive (3)			
Strangulated hernia (diaphragm) (2)			
Strangulated hernia (inguinal) (1)			
Soft-tissue injury (including burns)	5	1	4
Fasciitis (3)			
Burns (1)			
Sjambok injury (1)			
Laryngeal obstruction (carcinoma)	4	1	3
Carcinoma (3)			
Haemangioma (1)			
Tetanus	3	3	0
Stabbed heart	2	1	1
Puerperal sepsis	2	1	1
Myocardial infarction	2	0	2
Diabetic sepsis	2	1	1
Other	6	0	6
Splenectomy and cholecystectomy (1)			
Eclampsia (1)			
Meningitis (1)			
Post-aortobifemoral bypass (1)			
Post caesarean section (1)			
Transverse myelitis (1)			

* Two patients had an enterocutaneous fistula.
† These 21 patients with intestinal anastomoses were from the polytrauma and abdominal trauma groups.
‡ Three patients had an enterocutaneous fistula.

Table III. Indications for ICU admission in 96 patients receiving enteral nutrition

Indication*	*N*	%
Ventilation	80	83
Septic shock	15	16
Acidosis	12	12.5
Hypothermia	6	6
High care	2	2
Alkalosis	1	1

* Some patients had more than one indication.

and 4.27 ± 2.59 days (range 2 - 28 days) for those without anastomosis ($P < 0.001$) (Mann-Whitney *U*-test). Therefore it took longer to commence feeds in patients with intestinal anastomosis.

Twenty-two patients developed complications (23% complication rate). The complications were abdominal distension in 13 patients, vomiting in 10 and diarrhoea in 3 patients. In 1 patient the tube inadvertently came out and was re-introduced (1%). Five patients had two complications each. Three patients (3%) did not tolerate enteral feeding (all developed vomiting) and it had to be converted to TPN; 1 patient had had an intestinal anastomosis and the other 2 had tetanus. The original diagnoses in these patients were respiratory failure (2) and diabetic sepsis (1). One further patient with an intestinal anastomosis became haemodynamically unstable and feeding had to be stopped temporarily and the patient put on TPN with subsequent return to enteral feeding after achieving haemodynamic stability. The rest of the patients continued to be fed by regulating the feeding rate. Twenty-nine patients (30%) died from their original conditions for which they required intensive care, and not directly from the complications of feeding. The causes of death were multiple organ dysfunction syndrome (16), adult respiratory distress syndrome (3), sepsis (9) and severe head injury (1). The original diagnoses in the patients who died were peritonitis (6), polytrauma (5), respiratory

failure (4), soft-tissue injury (4), abdominal trauma (3), diabetic sepsis (2), stabbed heart (2), head injury (1) and vascular reconstruction (1). The median age of patients who developed complications was 35 years compared with 32 years in those without complications. Comparative characteristics of the two major groups (complications versus no complications) are shown in Table II. Six patients with intestinal anastomosis developed complications (29%) compared with 15 (20%) in those without intestinal anastomosis ($P = 0.401$). All the patients tolerated the feeds irrespective of age.

Residual volumes were measured daily and these ranged from 0 to 260 ml (mean 24 ± 45.6 ml). Mean residual volumes in patients with complications were 35.95 ± 61.62 ml (range 0 - 260 ml) compared with 20.71 ml (0 - 200 ml) in those without complications ($P = 0.094$) (Mann-Whitney test).

DISCUSSION

This study highlights the tolerance of enteral feeding in critically ill patients, including those patients recovering from gastro-intestinal tract surgery. Enteral feeding was commenced as soon as possible in patients following surgery, without waiting for return of bowel sounds, unless patients were haemodynamically unstable, in which case they initially received TPN. Many authors have advocated a policy of initiating enteral feeding early (usually within 48 hours), starting the formula at a low rate (10 - 25 ml/hour) and increasing the formula rate based on the patient's condition.[4,11] We subscribe to this policy.

A number of studies have supported the administration of enteral feeds in the absence of bowel sounds.[2,12-15] These studies suggest that intestinal absorptive capacity is not inhibited in the immediate postoperative period and that it is feasible to feed patients without increasing morbidity from the first postoperative day if done in a careful manner. Indeed early enteral feeding can prevent or shorten the presence of postoperative ileus.[12,14] In the present study the presence of intestinal anastomosis did not adversely affect the delivery of feeds. This is supported by other authors. In a non-randomised prospective clinical trial of 66 patients undergoing bowel resection and 159 controls, Hedberg *et al.*[16] showed that early postoperative enteral feeding protocol was cost effective. In a study of 46 patients Velez *et al.*[6] concluded that early enteral nutrition (< 72 hours post event) was a useful and safe therapeutic alternative for postoperative management of gastro-intestinal surgery and suggested that it might contribute to faster recovery of bowel function and lead to a shorter hospital stay.

Increased gastric microbial growth associated with elevated gastric pH occurs in several clinical situations, including the use of enteral nutrition.[17,18] Strategies to lower or maintain acid gastric pH in enterally fed patients have therefore included the use of acidified feeds as well as intermittent feeding schedules.[18] Whether enteral feeds should be delivered using a continuous or intermittent regimen, however, remains controversial. In a randomised, controlled study of 16 patients Skiest *et al.*[19] showed that higher gastric pH was associated with gastric colonisation and that intermittent feeding reduced gastric pH. On the other hand in a study of 13 patients Spilker *et al.*[18] found that intermittent feeding did not consistently reduce gastric pH or gastric microbial growth. In the latter study, however, the study patients acted as their own controls and this may have led to bias. In a prospective randomised trial Van Berge Henegouwen *et al.*[20] looked at the effect of intermittent feeding on gastric function following pylorus-preserving pancreaticoduodenectomy. This latter group concluded that cyclical feeding was associated with a shorter period of enteral feeding, a faster return to normal diet and a shorter hospital stay. The policy for the delivery of enteral feeds in our unit is continuous feeding, commenced at a rate of 20 ml/hour to a maximum of 80 ml/hour.

High gastric residual volumes after a period of rest from feeding are used as a marker of gastric intolerance. Little research has been published recommending the ideal cut-off points for discontinuation of enteral administration. In general a range of 50 - 150 ml has been suggested by various authors.[2,3,21] McClave *et al.*[22] were the first to do a comparative study of residual volumes in healthy enterally fed volunteers and critically ill patients. They recommended a cut-off volume of 200 ml based on the level which would not prevent healthy subjects being fed, but which would identify those patients exhibiting intolerance of enteral feeding.

Recommendations regarding the frequency at which residual volumes should be measured have varied from 4-hourly[23] through 6-hourly[10] to daily.[3] While some authors have suggested that high gastric residuals were a common cause of disruption of tube feeding,[23] others noted that gastric volumes did not correlate with the development of complications.[3] In the present series we used daily measurements and found that the residual gastric volumes did not correlate with the development of complications and there was no difference in these volumes between patients who developed complications and those who did not.

The incidence of diarrhoea was 3% in this study. The reported incidence of diarrhoea in the literature ranges between 2.2% and 14.7%.[3,6,10] It is invariably assumed that the enteral feed is the cause of diarrhoea. Kandil *et al.*,[24] however, fed healthy volunteers ever-increasing rates of feed and found that diarrhoea did not appear until the volunteers were fed at rates greater than 275 ml/hour. This is a far greater rate than any patient is likely to receive, suggesting that it is unlikely to be the feed alone that is the cause. Other causes have been identified, such as antibiotics and other drugs, type of enteral feed and contamination of the feed,[3] although few have been

clearly associated with the development of diarrhoea in critically ill patients. It would appear therefore that there are other more complex factors involved. None of these causes could be attributed to the diarrhoea in these 3 patients in the present study.

The incidence of vomiting in this series was 13% and that for abdominal distention 10%. These incidences are reported in the literature to vary between 13 - 50%[3,6] and 10 - 28%[3,6] respectively. In 3% of patients in this study, the enteral feeds had to be terminated because of persistent gastro-intestinal complications. The figure reported in the literature is 11 - 15%.[3,10] Tube displacement occurred in only 1%, compared with 1.8 - 41% reported in the literature.[11,25]

Critically ill patients are hypermetabolic and have increased nutrient requirements.[2] However, not all critically ill patients are hypermetabolic and it is conceivable that there may be a certain amount of overfeeding. This has not been addressed in this study and may be a limitation. The other limitation of the study is that it is not randomised and there is an uneven distribution of the variables. Despite these limitations we feel that it has provided considerable insight into the ability of critically ill patients to tolerate enteral feeding.

This study has demonstrated that the majority of critically ill patients in an ICU setting tolerate enteral feeding well, including those in whom enteral feeding was commenced immediately following abdominal surgery. As reported in previous studies it appears to be safe to commence enteral feeds in the absence of bowel sounds. The results also suggest that residual gastric volumes do not correlate with the development of enteral feeding-related complications.

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