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A study of problems associated with the delivery of enteral feed in critically ill patients in five ICUs in the UK

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Abstract *Objectives:* To describe the incidence of problems associated with enteral feeding in different patient groups and intensive care units (ICUs). To compare this incidence with specific feeding protocols and volumes of feed delivered. To identify for future study any interventions likely to improve delivery of enteral feed and to manage or eliminate problems.
Design: A prospective, descriptive study of problems associated with enteral feeding in five ICUs over a period of 9 months.
Setting: ICUs in two district general and three university hospitals.
Patients: ICU patients (age > 18 years) who received enteral feeding for a period > 24 h.
Measurements and results: 193 patients were studied for a total of 1929 patient-days. On average, only 76 % of the quantity of feed prescribed was delivered to the patient. The two main problems preventing delivery of feed were gut dysfunction and elective stoppage for procedures. ICUs with well-defined feeding protocols delivered significantly greater volumes of feed ($p < 0.0001$) than those without. Feeding was abandoned in 11 % of patients, half of these due to gastric dysfunction. Only 2 of 193 patients were fed jejunally.
Conclusions: The major factors associated with the interruption in delivery of feed are problems with gut function and stopping feed prior to a procedure. Use of specific feeding protocols is clearly associated with a greater volume of feed delivered and a greater percentage of the prescription delivered. These should be an integral part of all ICU protocols.

Key words Enteral feeding · Nutrition · Gut dysfunction

Introduction

Lack of enteral nutrition has been shown to be associated with degeneration of gut structure and possible translocation of organisms [1–3]. Early enteral feeding appears to attenuate part of the stress response in particular groups of patients. This has been demonstrated in animal studies and a few small patient studies [4–6]. The ability to manipulate the patient's immune response using specific enteral nutrients (immunonutrition) has also provoked considerable interest [7–11].

The potential advantages to the critically ill patient of enteral nutrition suggest that considerable attention and effort should be spent on improving techniques to support enteral nutrition in the critically ill. However, as yet, little work has been carried out and delivery of enteral nutrition continues to be a traditional and often highly variable technique. Furthermore, few studies have assessed the quantity of feed delivered against that prescribed.

The aims of this study were to describe the incidence of problems associated with enteral feeding in different patient groups and centres, to compare the relationship

Table 1 Details of ICUs studied and feed protocols (*DGH* district general hospital)

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
Hospital type	DGH	DGH	Teaching	Teaching	Teaching
No. of beds	5	4	12	8	22
No. of patients/year	400	500	900	400	1200
No. of hours fed/day	18	18	18–20	24	24
Starter regimen	Set volume over 18 h, usually 500 ml, increased daily	Usually 30 ml/h for 4 h, 60 ml/h for 4 h, then increase up to full rate	30 ml/h water for 4 h, 30 ml/h feed for 4 h, then increase to full rate	50 ml/h, nurse-led, often no prescription initially	30 ml/h, 4-hourly increments of 30 ml/h until full rate is reached
Set policies	No	No	Yes	No	Yes
Cut-off point for stopping or reducing feed	No set point	Usually 120 ml	150 ml	No set point	200 ml
Dietician input	No	No	Yes	Occasionally	Yes

Table 2 Diagnostic groups (*ARDS* adult respiratory distress syndrome)

Diagnostic groups	No. of patients (n = 193)
General medicine	36
General surgery	21
Respiratory failure	41
Cardiovascular failure	31
Trauma	21
ARDS/sepsis	27
Oncology	16

between the problems observed and volumes of feed delivered, and to identify interventions likely to improve delivery of enteral feed and to manage or eliminate problems.

Methods

A prospective, descriptive study of enteral feeding methods and problems in critically ill patients from five intensive care units (ICUs) situated in or close to London was carried out. Details of the participating units are given in Table 1. Data collection took place over a period of 9 months, from August 1993 to March 1994.

Standardised data collection was carried out with the help of link nurses in each centre. Each centre was visited regularly to deal with any problems that arose. Background data were collected on unit-specific feeding protocols, indicators used to determine gut function, and the total number of patients admitted to the unit during the study period.

Data collected on each patient included demographic details, diagnosis (Table 2), the number of days without nutrition or receiving parenteral nutrition prior to the start of enteral nutrition, and any starter feeding regimen employed.

Data were collected on a daily basis on the volume and type of feed prescribed and delivered in a 24-h period, the incidence and severity of gastrointestinal problems, mechanical or operational problems affecting delivery, the volumes of aspirate obtained, and whether these were returned to the patient, the length of time feed was discontinued and reasons for so doing.

Any adult patient admitted to the ICUs who was receiving enteral nutrition for more than 24 h could be included in the study. However, with only two link nurses at the remote sites, it proved impossible to include all enterally fed patients over the 9-month period. Patients requiring parenteral nutrition were excluded, although if they had received enteral nutrition for any period, these data were included. Approval for the study was obtained from the Ethical Committee at each hospital.

In view of the descriptive nature of the study and with the agreement of the Ethics Committees, consent was not sought from the patient. An information leaflet describing the study and its aims in the appropriate language was provided for the family. The majority of statistical analyses consisted of chi-square testing to determine significant differences between groups. Student's t-test was used to distinguish between groups with cardinal level data. A p value of < 0.01 was taken as the level of statistical significance.

Results

Data were collected for a total 1929 days of enteral feeding in 193 patients on five hospital ICUs. There were 126 ICU survivors (65 %) and 122 hospital survivors (63 %). All patients in the study were fed by the nasogastric route except for 2 who were fed by the nasojejunal route.

On the 1410 days (73 %) where feeding was established for a full 24-h period (excluding start-up regimens, overnight feeds, and incomplete last days), an average (± SD) of 1778 ± 402 ml was prescribed and 1359 ± 557 ml (76.4 % of prescription) was delivered. On 927 days (48 %) feeding was established for a 24-h period and there were no recorded problems with absorption or stoppages for procedures. On these days, an average of 1784 ± 383 ml was prescribed and 1557 ± 476 ml (87.2 % of prescription) was delivered. Table 3 shows the discrepancy between prescribed and delivered feed by ICU.

As there was enormous variation between prescribed volumes of feed in different ICUs, a calculation of pa-

Table 3 Discrepancy between prescribed and delivered feed by centre

Centre	No. of days	Mean (SD) amount prescribed (kcal/day)	Mean (SD) amount delivered (kcal/day)	Mean (SD) protein delivered (g/day)	Range
1	56	1179 ± 400	1151 ± 408	42.6 ± 21.0	500–2000
2	36	1831 ± 743	1748 ± 797	70.0 ± 31.9	720–3000
3	185	1749 ± 338	1536 ± 548	54.5 ± 30.4	1000–2250
4	54	1657 ± 625	1234 ± 787	49.2 ± 31.8	720–3000
5	596	1860 ± 259	1619 ± 343	60.8 ± 14.1	1080–3000

Table 4 Prescription and delivery of feed as a percentage of optimal energy requirements[a]

Centre	Per cent optimal energy requirements prescribed	Per cent optimal energy requirements delivered	Per cent actual prescription delivered
1	76	75	96
2	83	80	95
3	93	82	87
4	96	67	75
5	102	90	86

[a] Optimal energy requirement was defined as 25 kcal/kg per day for women, 30 kcal/kg per day for men

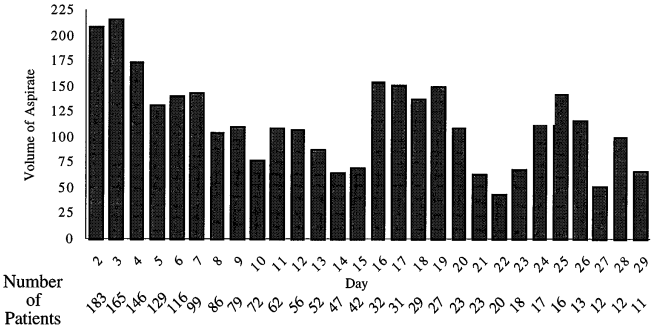

Fig. 1 Average daily gastric aspirate volumes (ml)

tients' optimal feed requirements was made. Volumes of feed prescribed in these units could then be compared. Optimal caloric requirements based on the rough guide of 25 kcal/kg per day for women and 30 kcal/kg per day for men were calculated [12]. Establishing energy needs in critically ill patients is a very imprecise calculation, the only accurate method being the use of indirect calorimetry, which is not available in most ICUs. The use of an average figure without adjustment for factors which increase and decrease energy requirements gives only an idea of the basic needs of each patient. In most cases it is likely to underestimate individual energy requirements. Thus, although the term "optimal prescription" is used, this may well reflect the bottom of the range of energy requirements for critically ill patients.

The calculated energy requirement shown in Table 4 is an average for each group of patients and is then compared with the average calories actually prescribed and delivered. Patients rarely received 100 % of prescribed enteral feed. Much of this was due to the problems preventing delivery. Two major areas were identified as causes of feed suspension: (a) problems related to gut dysfunction and (b) elective interruption to allow investigative procedures or operations (Table 5).

The vast majority of patients (85 %) were either discharged from the ICU, died while being fed enteral feed, or were weaned onto an oral diet. Only 22 patients (11 %) had to abandon enteral feeding, 20 of whom started on parenteral nutrition.

Average daily gastric aspirates were higher on the first few days of feeding, as it became apparent which patients failed to tolerate gastric feeding (Fig. 1). The aspirate volumes then settled to a steady state at an average of 105 ± 34 ml/day. Even 3 weeks after the start of feeding, some aspirate volumes were in excess of 100 ml/day. Volumes of aspirate varied considerably throughout the course of illness.

Abdominal problems were reported on 325 days (20 %) of the total recorded (Table 5). The average feed prescribed for these patient days was 1722 ± 421 kcal, but only 887 ± 488 kcal was delivered.

Where an ICU had a specific feeding protocol, the average volume of feed delivered was 1418 ± 505 ml, the percentage of optimal feed prescribed was 100 ± 21 %, and the percentage of optimal feed delivered was 78 ± 31 %. In the ICUs without a feeding protocol the average volume of feed delivered was 1179 ± 674 ml, the percentage of optimal feed prescribed was 87 ± 36 %, and the percentage of optimal feed delivered was 66 ± 34 %.

Discussion

There is no doubt that frequent problems are associated with the delivery and tolerance of enteral nutrition in the critically ill patient. Discrepancies exist between the delivered and prescribed volume of feed. Previous reports [13–16] have given a mean of only 69–87 % of prescribed calories actually received by the patient. Suggested causes included onset of diarrhoea and nursing workload.

Table 5 Causes of reduced or interrupted delivery of enteral feed

	Incidence	Patient days affected
Problems related to gut function		
Slowed due to high gastric aspirates	56	156
Nausea/vomiting	50	112
Abdominal distension	28	62
Stopped due to high gastric aspirates	26	35
Abdominal pain	7	20
Gastrointestinal bleeding	11	17
Diarrhoea	11	16
Other physiological problems[a]	12	15
Other gastrointestinal problems[b]	6	6
Investigative procedures or operations		
Extubation	46	55
Other procedures[c]	26	46
Intubation	34	44
Tracheostomy	32	36
Operative procedure	25	34
Off-unit procedures[d]	35	39
Head-down procedures[e]	4	6
Miscellaneous problems		
Tube pulled out	28	37
Other operational problems[f]	14	18
Procedures not done[g]	11	12
Tube blocked	10	12
Problems with delivery system	7	8

[a] Fluid restriction, fluid overload, pulmonary oedema, cardiac arrest, ?aspiration

[b] Paralytic ileus, anastomosis leak, fistula, hourly nasogastric aspirate

[c] Minitracheostomy, DC cardioversion, independent lung ventilation set-up, physiotherapy, prone positioning, self-extubation, T-piece, change tracheostomy tube, off when trying to cap tracheostomy, air in stomach during CPAP, enema, Sengstaken tube insertion, nasal airway removed, on Hayek oscillator, on jet ventilator

[d] Computed tomography (CT), endoscopy, ultrasound, hospital transfer, barium swallow, arteriogram, lung biopsy

[e] Pulmonary artery catheter insertion, line change, postural drainage, ECCO2R lines inserted

[f] Nasogastric (NG) tube kinked, feed not available from pharmacy, no giving sets available, unable to tolerate NG tube, stopped while feed changed, feed stopped by CT surgeon, difficult to pass N/G tube, unable to see new NG tube on chest X-ray, placement of jejunostomy tube, ran out of feed, NG tube perished, NG tube needed replacing in theatre, feed off 9 h by mistake, tube curled in mouth

[g] Extubation, intubation, tracheostomy

In this study, problems which prevented feeding were related to gut dysfunction or the patient undergoing procedures requiring an empty stomach. Mechanical or operational problems caused only 14 % of delivery interruptions and 40 % of these were due to accidental removal of the tube. Gut dysfunction consisted primarily of high gastric aspirates, vomiting, and abdominal distension, which occurred on 73 % of occasions and interrupted feed delivery on 17 % of days recorded.

The mean discrepancy found was 24.6 % due to feeding problems or other factors. It is possible that the effect of the study itself may improve the delivery of feed. When delivery on days without reported problems was compared to prescription, there was still a mean discrepancy of 13 %. This could be related to human error in failing to record problems. Alternatively, interruption of feeding may occur even when no problems are evident, perhaps due to routine checks of gastric residual volumes or as a precaution during interventions likely to increase the risk of aspiration. In most cases there was no apparent attempt to increase the rate of delivery following interruption in order to regain the overall feeding goal. There appears to be some reluctance to increase feeding rates to greater than 120 ml/h, although there is no evidence to suggest this limit in patients who are tolerating enteral feed. Frequent (2–4 h) checks of residual volume would be required to ensure aspiration did not become an increased risk in these patients.

High gastric residual volumes or aspirates after a period of rest from feeding is used as a marker of gastric intolerance. In general, a range of residual volumes from 50 to 150 ml have been recommended [14, 17–18] as cut-off points for discontinuation of enteral delivery. Little research has been published apart from that by McClave et al. [18], who compared 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 feeding. Traditionally, the nasogastric tube is placed in one of the least tolerant areas of the gut [19]. Gastric motility is affected by many factors which may cause dysfunction and intolerance of feed. A number of experts in nutrition in the critically ill feed their patients preferentially by the jejunal route [20–22]. The main difficulty for the majority of ICU patients is finding an effective and reliable method of bedside placement, and this is reflected by the finding in this study that only two jejunal tubes were used.

Diarrhoea is invariably blamed on enteral feed. However, Kandil et al. [23] 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/h. 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 (antibiotic and other drug therapy, feed formula, contamination of feed [24–26]), although few have been clearly associated with the development of diarrhoea in critically ill patients, and it seems likely that there are other more complex factors involved.

Feeding was generally started by day 2 from admission and most delays greater than this were due to gut dysfunction as a result of surgical intervention or major disorder of the gastrointestinal tract. This seems a good result in view of the priority commonly given to nutrition in the past. The current interest in immediate en-

teral feeding was not evident in this study, as most patients were not started on feed until the second or third day. The lack of jejunostomy or nasojejunal approaches may in part be responsible for the limited use of immediate enteral feeding. Units 2 and 5 had the shortest mean time to starting feeding. Unit 5 had dietician input on the ward round and a written feeding protocol, while unit 2 had neither. It is difficult, therefore to associate any effect from dietetic input and written protocols on the speed of starting feed.

Centres which delivered feed over 18 h with a 6-h pause appeared to use some of the rest period to catch up. They delivered on average 95–96 % of prescribed feed compared with 75–88 % in the other centres. However, the prescribed volume in one centre delivering 96 % was, on average, only 1200 ml. This amount is much easier to deliver but is considerably less feed than that prescribed by any other centre and much less than patient requirements. Use of a rest period seems an effective way of ensuring the patients receive the prescribed amount of feed; however, this requires further investigation.

The percentage of prescribed feed delivered depends on the volume of the prescription. When smaller volumes are prescribed, the percentage delivered is higher. It is easier to complete delivery of 1200 ml over 24 h than to complete 2000 ml. Average delivery of enteral feed in two centres was less than 75 % of the estimated requirement for the patient by weight. In one centre this was due to an average prescription for only 76 % of the patients' requirement by weight. In the other centre, major discrepancies between prescription and delivery resulted in only 75 % of the prescription being delivered on average. This centre had no written feeding protocols, infrequent dietician input, and feeding was usually nurse-led. By contrast, the centres with an appropriate prescription (> 90 % of optimum) and delivery > 85 % of prescription had written protocols and dietician input on the ward round. Written protocols have been found to improve delivery of enteral feed in hospital patients [27] and are a simple and effective method of increasing enteral feed delivery in intensive care.

As expected in the acute intensive care environment, 50 % of patients were fed for 7 days or less. The vast majority of patients (85 %) discontinued feeding to start an oral diet, were discharged on enteral feeding, or died. Only 11 % of patients had to abandon enteral feeding, and in all but one case this was due to major gut dysfunction. It appears that in the majority of intensive care patients, the enteral route is a successful method of feeding, but further study is required to identify early markers for patients who will not tolerate it.

Volumes of gastric aspirate were higher in the first few days of feeding as those patients who failed to tolerate gastric feeding become apparent. Aspirate volumes did not appear to decrease as feeding continued, remaining at between 50 and 150 ml/day. This seems a very small amount in view of the average volumes of feed delivered (1151–1748 ml/day) as well as the approximate 2 litres of gastric secretions produced [28]. Variation in aspirate volume rates can continue throughout the course of illness, therefore regular checks are advisable at a minimum of 8-hourly intervals. Although beyond the scope of this study, it is possible that the volume of aspirate is associated with the severity of the patients' illness and would benefit from further investigation.

Different methods of start-up in the centres were compared. Fast start-up feeding regimens were not associated with an increased incidence of abdominal problems. In fact, there was a significantly decreased incidence of recorded abdominal problems in fast start-up regimens. This may be related to the fact that protocols were in use for two of the three centres using fast start-up regimens with very clear limits to levels of aspirate and step-up rates of feed volumes. There does not seem to be an increase in complications associated with fast start-up regimens.

Enteral feeding is one of the most effective methods of supporting nutritional needs, immune function, and gastrointestinal function in the critically ill patient. The conclusions from this study show clear evidence of the need for considerable further work to develop improved methods of delivery of enteral feed. One of the most important and simple methods of optimising enteral feed delivery is the use of a feeding protocol. This should be set up in each unit and can be modified to suit unit requirements. The methods of support for gastrointestinal function require investigation, as do alternative methods of delivery.

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