Bacterial contamination of enteral feeds

C J Patchell, A Anderton, A MacDonald, R H George, I W Booth

Abstract

Enteral nutrition is increasingly used to provide nutritional support for children in hospital and at home. No suitable formula is available for preschool children, however, and until recently a modular feed has been prepared. The hypotheses were examined that the use of a modular feed is associated with increased bacterial contamination, and that contamination is more common in the home than in hospital. Thirty five children receiving enteral nutrition initially in hospital and subsequently at home were allocated randomly to receive either a modular feed or a newly available sterile ready to use paediatric feed. Samples of feed were taken from the nutrient container immediately after filling and at the end of feeding. The results show that feed contamination is common in hospital and at home, but significantly more so at home. The data indicate the importance of hygiene training for parents and the desirability of a ready to use formula.

(Arch Dis Child 1994; 70: 327-330)

An increasing emphasis on early hospital discharge and self care means that many children who require nutritional support are now fed at home.¹⁻³ Until recently no polymeric enteral feed has been available which is nutritionally suitable for children between the ages of 1 and 5 years (or weighing 8-20 kg). In common with other centres, our practice at The Children's Hospital has been to use an adult enteral feed (Isocal, Mead Johnson) modified to meet the nutritional needs of small children by dilution with water, and the addition of glucose polymer powder (Maxijul, Scientific Hospital Supplies (SHS)) and long chain fat emulsion (Calogen, SHS) to achieve an energy density of 1 kcal/ml.

Bacterial colonisation, infection, and septicaemia with organisms such as *Enterobacter cloacae* and *Klebsiella* spp have been reported in patients receiving enteral feeds contaminated during handling.⁴⁻⁷ The practice of modifying an enteral feed increases handling and therefore increases the risk of microbial contamination; this may be more common in patients fed at home. To date no studies have compared the contamination of a modified feed with a ready to use feed in hospital and at home. In 1988 a joint working party of the parenteral and enteral nutrition group and the paediatric group of the British Dietetic Association published guidelines for the desired nutritional analysis of a sterile, ready to use enteral feed for children aged between 1 and 5 years or weighing between 8 and 20 kg.⁸

Nutrison Paediatric (Cow and Gate), a sterile ready to use feed, was produced as a result of these guidelines. The availability of this product therefore provided the opportunity to define further the mechanisms producing feed contamination and the setting in which it occurs.

Subjects and methods

SUBJECTS

Thirty five children who were inpatients at The Children's Hospital and who received at least 50% of their energy needs from continuous nasogastric or gastrostomy feeds were enrolled. Eligible subjects were either between 1 and 5 years of age or weighed between 8 and 20 kg. Children requiring special feeds, total parenteral nutrition, or who were fed for less than one week were excluded. The modular feed (modified Isocal) group consisted of nine boys and seven girls with a mean age of 43 months (median 23 months; range 14-118 months). The ready to use feed (Nutrison Paediatric) group consisted of 12 boys and seven girls with a mean age of 37 months (median 26 months; range 12-133 months). Children were followed up for 12 weeks or until feeding was no longer indicated, whichever was sooner.

METHODS

Feeds and feeding systems

The feeds used were Nutrison Paediatric (Cow and Gate) supplied in 200 ml crown capped glass bottles or Isocal (Mead Johnson), an adult enteral formula supplied in 250 ml ring pull cans. This was modified for children in hospital in a special feed unit by decanting the required volume of feed into a plastic jug, adding cooled boiled water, and the required amount of Calogen (SHS) and Maxijul supplied in 140 g sachets. Neither Maxijul powder nor Calogen is declared sterile. All equipment was heat treated at 100°C for three minutes before use.

The modified Isocal was mixed with a metal whisk and decanted into a screw top plastic container for delivery to the ward. It was then stored in a refrigerator at <4°C. Before discharge home, carers were shown how to mix the feed by the special feed unit staff. They were advised to purchase plastic bowls, whisks, and jugs for use in the home. A recommendation was also given to soak all equipment in a disinfecting solution (for example Milton) before each use. The feeding system used was the Kangaroo system (Sherwood Medical) consisting of a 1 litre nutrient container bag and giving set.

In hospital sufficient feed for four hours was decanted into the feeding system and the volume topped up every four hours with feed

The Children's
Hospital, Birmingham
C J Patchell
A MacDonald
R H George

Institute of Child
Health, University of
Birmingham
I W Booth

Department of
Bioscience and
Biotechnology,
University of
Strathclyde, Glasgow
A Anderton

Correspondence to:
Dr C J Patchell, The
Children's Hospital,
Ladywood Middleway,
Ladywood, Birmingham
B16 8ET.

Accepted 11 January 1994

which had been stored in a refrigerator. At home, carers were advised to carry out a similar procedure in the daytime. At night, they were advised to pour feed for six to 12 hours into the giving set so that they did not need to check the feed during the night. The hanging time of the feeds therefore ranged from four hours to 14 hours (median eight hours).

Microbiological quality of feeds and feed ingredients

SAMPLING PROCEDURE

Inpatients

Samples of modified adult feed were collected daily: (a) immediately after preparation in the special feed unit; (b) from the lower end of the giving set before use, immediately after the feed had been decanted and the giving set assembled by the nursing staff (start of administration); and (c) from the nutrient container at the end of feeding. This sample was collected by a researcher spraying the giving set with 70% methylated spirits (Pearce Laboratories) and cutting the portion of the giving set immediately below the nutrient container and above the drip chamber with alcohol treated scissors. This sampling procedure minimised the risk of any contamination from retrograde migration of micro-organisms.

Samples of the ready to use feed were collected: (a) from the nutrient container immediately before use (start of administration); and (b) from the nutrient container at the end of feeding by a researcher spraying the giving set with 70% methylated spirits and cutting the portion of the giving set immediately below the nutrient container and above the drip chamber as described earlier.

All samples were collected in sterile universal containers and were refrigerated immediately after collection. Microbiological analysis was carried out within 12 hours of collection. Refrigerator temperatures were regularly checked to ensure that samples were stored at $<4^{\circ}\text{C}$.

Patients receiving treatment at home

Samples of modified adult feed (modified Isocal) were collected every two weeks (a) from the nutrient container immediately before use (start of administration) and (b) from the nutrient container at the end of feeding. This sample was collected by a researcher using the method described for inpatient samples.

Carers were shown how to take samples at the start of administration and were asked to close the flow regulator to prevent retrograde contamination and to keep the entire giving set to be sampled by a researcher at the end of administration.

All samples were stored in a refrigerator until collected by the researcher on a home visit. Samples were never stored for more than 12 hours before collection. The temperatures of the refrigerators were regularly checked to ensure that a reading of $<4^{\circ}\text{C}$ was maintained.

Samples were transported to the hospital laboratory in a cool box with ice packs. Samples were analysed within 12 hours of collection.

PRELIMINARY EXPERIMENTS

Preliminary experiments were carried out to check that no micro-organisms were introduced during the feed sampling procedure. A 200 ml volume of Nutrison Paediatric was decanted into a sterile Kangaroo feeding system by a researcher wearing sterile gloves. Both the feed bottle and the bottle opener were sprayed with 70% industrial methylated spirit (Pearce Laboratories) before opening. This control system was then sampled using the standard procedure used in the study. Hands were washed using Hibiscrub (ICI) and the Ayliffe method,⁹ the portion of the giving set immediately below the nutrient container was sprayed with alcohol, cut using alcohol treated scissors, and a sample of feed collected in a sterile universal container. This sample was then sent for microbiological analysis. This experiment was repeated 15 times.

At the start of the study microbiological analyses were carried out on samples of Nutrison Paediatric, Isocal, Maxijul, and Calogen. Viable counts were made on samples of these feeds and feed ingredients (reconstituted in sterile water where appropriate) plated onto horse blood agar and incubated for 48 hours at 37°C .

MICROBIOLOGICAL ANALYSES

Viable counts were made on serial tenfold dilutions of feed samples in 1% peptone water and 0.1 ml of each dilution was spread over the surface of 5% horse blood agar, MacConkey, and CLED agar (Oxoid Ltd). Plates were incubated aerobically at 37°C for 48 hours; counts were expressed as colony forming units (cfu)/ml. Isolates were identified by standard techniques. Samples were initially examined for the presence of *Campylobacter* spp by microaerophilic incubation on Skirrow's medium using Campipack (Oxoid) at 42°C . *Campylobacter* spp were not isolated from 140 samples and no further samples were examined.

Results

PRELIMINARY EXPERIMENTS

No organisms were recovered in any of the preliminary control experiments.

SAMPLES FROM INPATIENTS

The hanging time for inpatient feeding systems ranged from nine to 24 hours (median 14 hours) for Nutrison Paediatric and from 12 to 24 hours (median 18 hours) for modified Isocal. A total of 119 samples was cultured.

Although no contamination of the modular feeds was detected immediately after mixing, 14% had evidence of contamination by the start of administration, which had increased to

Table 1 Number (%) of feeds contaminated

	Hospital			Home	
	After mixing	Start of administration	End of administration	Start of administration	End of administration
Modular feed (modified Isocal)					
In hospital (n=57)	0 (0)	8 (14) ^{a,c}	27 (47) ^a	16 (76) ^{d,f}	21 (100) ^{e,f}
At home (n=21)					
Ready to use feed (Nutrison Paediatric)					
In hospital (n=62)	—	1 (2) ^{b,c}	28 (45) ^b	8 (28) ^{d,g}	18 (62) ^{e,g}
At home (n=29)					

c, f_p<0.02; e, g_p<0.01; a, b, d_p<0.001.

nearly 50% by the end ($p<0.001$; table 1). Despite signs of less contamination at the start of administration (2%), the ready to use feeds were equally contaminated as the modular feed by the end of administration (45%; $p<0.01$). Levels of contamination (table 2) ranged from 10^1 to 10^8 cfu/ml. There was no significant difference in the level of contamination at the end of administration for either of the feeds.

A similar range of organisms was isolated from both feeds. They included coagulase negative staphylococci, streptococci (faecal and viridans), and various Gram negative bacilli. The modular feed also contained *Bacillus* spp but these organisms were not isolated from the ready to use feed. *Enterobacter cloacae* was isolated from a total of eight of the inpatient feeds over the period of the study; 22% of the contaminated modular and 7% of the contaminated ready to use feeds contained *E. cloacae*. Less commonly isolated Gram negative bacteria were *Acinetobacter* spp, *Klebsiella aerogenes*, *Citrobacter freundii*, and *Klebsiella oxytoca*.

SAMPLES FROM HOME TREATMENT

The hanging time for home feeding systems ranged from 10 to 24 hours (median 12 hours) for ready to use feeds and from 7.5 to 18 hours for modular feeds (median 12), with more than 50% hanging for less than 12 hours. A total of 50 samples was cultured.

As in hospital, the modular feeds were significantly more contaminated at the start of administration ($p<0.001$) with over 75% of feeds contaminated compared with 28% of ready to use feeds. This significant difference was maintained by the end of administration when all the modular feeds were contaminated compared with nearly two thirds of ready to use feeds ($p<0.01$) (table 1).

Levels of contamination are summarised in table 2; they ranged from 10^1 to 10^8 cfu/ml.

The modular feeds had significantly higher levels of contamination; 95% had counts greater than 10^5 cfu/ml at the end of administration ($p<0.01$). The range of organisms isolated was similar to that in hospital and included coagulase negative staphylococci, streptococci (faecal and viridans), and coliforms. Coliforms were isolated from 20 of the 21 modular feeds. Seventy six per cent of the contaminated modular feeds and 11% of the contaminated ready to use feeds contained *E. cloacae*.

Discussion

The study showed that despite our rigorous attempts to prevent contamination there were high levels of contamination during the use of both a sterile ready to use enteral feed and a modular adult feed in hospital and at home. The sterile ready to use feed had a significantly lower level of contamination at the start of administration both in hospital and at home. For children fed in hospital this advantage was lost as both feeds were equally contaminated at the end of administration. For children fed at home, the sterile ready to use feed remained significantly less contaminated, although there were still substantial levels of contamination at the end of administration.

Although no symptoms of infection were shown to be directly attributed to the administration of contaminated feed, the potential for this to happen cannot be overlooked. The higher the incidence and levels of contamination found in the feeds sampled in patients' homes indicate that although the patients avoid exposure to the opportunistic pathogens present in hospital, the risk of bacteria gaining access to the feed actually increases. Although it is well recognised that prepared enteral feeds may be contaminated during preparation, children requiring enteral feeds in hospital are often nutritionally or immunologically compromised. Hospital prepared feeds have been suspected, but not proved, to be the cause of hospital acquired gastroenteritis^{10 11} and the number of organisms isolated in this study exceeds the levels estimated for bowel excretion and colonisation. In addition, there is evidence in other studies that organisms isolated from infected patients correspond to those found in contaminated food and in enteral feeds given to patients in intensive care units.^{12 13} The high level of feed contamination is therefore of considerable concern and it must only be a matter of time before contaminated feeds given to

Table 2 Feed contamination (%) at the end of administration

	Viable counts (cfu/ml)					
	$>10^5$	10^4	10^3	10^2	10^1	0
Hospital						
Ready to use feed (Nutrison Paediatric)	23	6	8	6	2	55
Modular feed (modified Isocal)	24	4	11	8	0	53
p Value	NS	NS	NS	NS	NS	NS
Home						
Ready to use feed (Nutrison Paediatric)	24	21	10	3.5	3.5	38
Modular feed (modified Isocal)	95	5	0	0	0	0
p Value	<0.001	<0.001	NS	NS	NS	<0.001

susceptible children are responsible for an infection with potentially serious consequences.

It is also well recognised that prepared enteral feeds may be contaminated during preparation. Bastow *et al* carried out a detailed comparison of bacterial contamination of feeds mixed in the diet kitchen with commercial feeds poured straight from the can on the ward.¹⁴ All the feeds prepared in the diet kitchen were contaminated with 10^2 – 10^3 organisms/ml immediately after preparation, but no growth was detected in the sterile commercial feed. Many patients are now being fed at home and their enteral feeds may therefore be contaminated by similar routes to other foods prepared in the home.¹⁵ This is a cause of concern as the private house is the centre of more outbreaks of food poisoning than all other locations (including hospitals, schools, and hotels) added together.¹⁶

The feeding protocol at The Children's Hospital requires that feeds are topped up every four hours using refrigerated feed. This procedure was adopted because the modular feed used was deemed to be not sterile, and was aimed at minimising the time for which feed was exposed to room temperature. Anderton showed, however, that refilling the nutrient container resulted in a continuous culture, with bacteria having no lag time in their growth when new feed was added.¹⁷ The protocol of topping up the feed every four hours was also being used for the sterile ready to use feed and the increased handling of the system may have resulted in micro-organisms being introduced during the topping up procedure.^{8 18 19}

A similar range of organisms was isolated from modular and ready to use feeds sampled in the hospital, mainly coagulase negative staphylococci and streptococci and less often coliforms. Twenty of the 21 samples of modular feeds from the home contained high numbers of coliforms, however, and 16 (76%) of these feeds contained *E. cloacae*. In contrast, only eight (7%) of the 115 hospital prepared feeds (including both ready to use and modular feeds) and three (11%) of the 28 ready to use feeds from homes contained *E. cloacae*.

No common source of *E. cloacae* was identified in the course of the study but this organism has been identified as a cause of infection in previous studies.^{6 7} An incident in which a detergent dispenser in a diet kitchen contaminated the blender, sieve, and jug used in the preparation of enteral feeds and led to a case of *E. cloacae* sepsis was reported by Casewell *et al* in 1981.⁴

Analysis of our data shows that much of the contamination in the home is attributable to mixing of the modular feed and that there is often contamination during decanting of the feeds and assembly of the giving sets.

The culture of modular feed made in hospital after preparation did not demonstrate

organisms, though culture results at the start of administration showed that 14% of modular feeds compared with 2% of ready to use feeds were contaminated. This may suggest initial contamination of modular feeds at low levels.

The sterile ready to use feed has been shown to be more acceptable for children fed at home. Such a feed has the advantage of requiring no modification and the risk of mistakes being made in its preparation is eliminated. The alarmingly frequent contamination of enteral feeds in hospital in this study appears to be due to bacteria introduced into the feeds during mixing of the modular feed, decanting of both feeds, and assembly of the giving sets, both in hospital and at home. We presume that the increase in the percentage of contaminated feeds during administration is the result of topping up, but further studies are needed to determine the precise sources and routes of this contamination and to devise training procedures to ensure that correct hygiene practices are used during the preparation and administration of the feeds in hospital and at home.

The authors wish to acknowledge Cow and Gate Nutricia for the financial support of this study.

- 1 Newmark SR, Simpson MS, Beskitt MP, Black J, Sublett D. Home tube feeding for long-term nutritional support. *Journal of Parenteral and Enteral Nutrition* 1981; 5: 76–9.
- 2 Adams MM, Wirsching RG. Guidelines for planning home enteral feedings. *J Am Diet Assoc* 1984; 84: 68–71.
- 3 Holden C. Home enteral feeding. *Paediatric Nursing* 1990; 2: 14–6.
- 4 Casewell MW, Cooper JE, Webster M. Enteral feeds contaminated with *Enterobacter cloacae* as a cause of septicaemia. *BMJ* 1981; 282: 973.
- 5 Anderton A. Microbiological aspects of the preparation and administration of naso-gastric and naso-enteric tube feeds in hospitals – a review. *Human Nutrition: Applied Nutrition* 1983; 37A: 426–40.
- 6 Levny J, VanLaethem Y, Verhaeghan G. Contaminated enteral nutrition solutions as a cause of nosocomial bloodstream infection: a study using plasmid fingerprinting. *Journal of Parenteral and Enteral Nutrition* 1981; 5: 76–9.
- 7 Thurn J, Crossley K, Gedts A, Mak MS, Johnson J. Enteral hyperalimentation as a source of nosocomial infection. *J Hosp Infect* 1990; 15: 203–7.
- 8 Anderton A, Howard JP, Scott EW. *Microbiological control in enteral feeding: a guidance document*. Birmingham: The Parenteral and Enteral Nutrition Group, The British Dietetic Association, 1986.
- 9 Ayliffe GAJ, Babb JR, Quoraishi AH. A test for hygienic hand disinfection. *J Clin Pathol* 1978; 31: 923.
- 10 Gill KJ, Gill P. Contaminated enteral feeds. *BMJ* 1981; 282: 1971.
- 11 Casewell M. Bacteriological hazards of contaminated enteral feeds. *J Hosp Infect* 1982; 3: 329–31.
- 12 Casewell M, Phillips I. Food as a source of klebsiella species for colonisation and infection of intensive care patients. *J Clin Pathol* 1978; 31: 845–9.
- 13 Casewell MW, Cooper JE, Webster M. Enteral feeds contaminated with *Enterobacter cloacae* as a cause of septicaemia. *BMJ* 1981; 282: 973.
- 14 Bastow MD, Greaves P, Allison SP. Microbial contamination of enteral feeds. *Human Nutrition: Applied Nutrition* 1982; 36A: 213–7.
- 15 Anderton A. Microbial aspect of home enteral nutrition – a discussion. *Journal of Human Nutrition and Diet* 1990; 3: 403–12.
- 16 Sheard JB. Food poisoning cases nearly double the level of 1970. *Environmental Health* 1987; 85: 10–5.
- 17 Anderton A. The potential of *Escherichia coli* in enteral feeds to cause food poisoning: a study under simulated ward conditions. *J Hosp Infect* 1984; 5: 155–63.
- 18 Anderton A, Aidoo KE. The effect of handling procedures on microbial contamination of enteral feeds. *J Hosp Infect* 1988; 11: 364–72.
- 19 Anderton A, Aidoo KE. Decanting – a source of contamination of enteral feeds? *Clinical Nutrition* 1990; 9: 157–62.