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World J Gastroenterol 2005;11(25):3935-3938
World Journal of Gastroenterology ISSN 1007-9327

• *BRIEF REPORTS* •

Application of dietary fiber in clinical enteral nutrition: A meta-analysis of randomized controlled trials

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Received: 2004-05-29 Accepted: 2004-06-24

Abstract

AIM: To evaluate the effects of dietary fiber (DF) as a part of enteral nutrition (EN) formula on diarrhea, infection, and length of hospital stay.

METHODS: Following electronic databases were searched for randomized controlled trials about DF: Chinese Biomedicine Database (CBM), MEDLINE, EMBASE and Cochrane Controlled Trials Register. RevMan 4.1 was used for statistical analysis.

RESULTS: Seven randomized controlled trials with 400 pat-ients were included. The supplement of DF in EN was compared with standard enteral formula in five trials. Combined analysis did not show a significant reduction in occurrence of diarrhea, but there were valuable results for non-critically ill patients. Combined analysis of two trials observing the infection also did not show any valid evidence that DF could decrease the infection rate, though the length of hospital stay was reduced significantly.

CONCLUSION: Based on the current eligible randomized controlled trials, there is no evidence that the value of DF in the diarrhea can be proved. Though length of hospital stay was shortened by the use of DF, there is no available evidence in preventing infection by DF. Further studies are needed for evaluating the value of DF in EN.

Key words: Dietary fiber; Enteral nutrition; Meta-analysis

Yang G, Wu XT, Zhou Y, Wang YL. Application of dietary fiber in clinical enteral nutrition: A meta-analysis of randomized controlled trials. *World J Gastroenterol* 2005; 11(25): 3935-3938
http://www.wjgnet.com/1007-9327/11/3935.asp

INTRODUCTION

Dietary fiber (DF) is a category of carbohydrates that cannot be ingested by endogenic digestive enzymes in human body[1]. Nevertheless, DF can be fermented into methane, hydrogen, CO_2, and short-chain fatty acid (SCFA) by bowel microflorae. SCFA, a primary important energy substance for colonal mucosal epithelium, is essential to maintain the metabolism and regeneration of epithelia, protect the structure and function, promote absorption of water and sodium, and regulate the function of bowel[2-6]. Recent studies also suggest that SCFA can protect the intestinal barrier and prevent bacterial translocation[7-9]. So DF has been widely recommended as an essential component of enteral nutrition (EN) in the last 20 years[10-13]. It is believed that DF may play an important role in controlling diarrhea associated with EN, improving restoration of bowel function, reducing infection and improving prognosis of critically ill patients[14-18]. But the conclusions of existing trials are controversial. The practical value of DF in clinical EN lacks evidence. This review is to evaluate the value of DF in clinical EN with the method of meta-analysis and to seek the best evidence for clinical EN.

MATERIALS AND METHODS

Data extraction and outcomes

We searched the following electronic databases for eligible trials: PubMed (from January 1980 to January 2003), EMBASE (from January 1989 to December 2002), Cochrane Controlled Trials Register and Chinese Biomedicine Database (from 1980 to 2002). The searching words were dietary fiber and enteral nutrition. Languages were restricted to English and Chinese.

The criteria were open or blind randomized studies. Patients were randomly allocated into receiving EN emented with DF or EN without DF, regardless of the type of DF.

Assessment of methodological quality

The assessment of methodological quality was undertaken by two of the authors independently, differences in assessment were solved by consensus. From each study, data were extracted on the type of patients, the method of administration of EN. Outcomes were the occurrence of diarrhea, infection of any type and length of hospital stay.

Jadad score and allocation concealment were adopted to evaluate the methodological quality of each trial: 0 for non-randomized controlled trials, 1-2 scores for poor-quality trials and 3-5 scores for high-quality trials. The concealment of allocation also was divided into three grades: A for adequate concealment, B for unclear concealment, C for inadequate concealment.

Analysis

RevMan 4.1 software supplied by Cochrane Collaboration

was used. The effect size of categorical variables was odds ratio (OR). For numerical variables, if the unit was identical, weighed mean difference (WMD) was used, and standardized mean difference was used when the unit was different. The homogeneity of adopted trials was tested before meta-analysis. If the heterogeneity had no statistical significant difference, a fixed effect model was used during meta-analysis. In contrast, we used a random effect model and subgroup analysis. Sensitivity analysis was also proceeded after the non-blinded, inadequate concealed trials were excluded.

RESULTS

Characteristics of trials and patients

Eight hundred and eleven papers were obtained by searching the databases, 587 in English, 224 in Chinese. Seventeen trials, all in English, were identified for further evaluation after the title and abstract were read. Seven measured up to the criteria and were included[19-25]. There were no repetitive studies and meta-analysis. Seven of the 17 included trials, three were conducted in Germany[19,20,24], one in USA[22], one in Australia[25], one in Belgium[21] and Singapore[23]. Two included critically ill patients[22,25], three included postoperative patients[19,20,23], one included sepsis[21] and the other included a variety of diseases[24]. The earliest study was published in 1990[25], all were published in the past 14 years.

Methodological quality of trials

Of the seven trials, three were of a high quality (one had five scores according to Jadad, one had four scores, one had three scores), the other four were of a poor quality. Computerized random number was used in two trials, sealed envelopes in two, no randomization method in three. Four trials were double-blinded. The baselines of included subjects were compared in all studies, and no statistically significant differences existed. Table 1 gives the details of the seven trials.

Outcomes

Effect of DF on diarrhea in EN The occurrence of diarrhea in 276 patients receiving EN supplemented with or without DF was observed in five trials. There was no heterogeneity ($P = 0.087$) and fixed effect model was used. The combined OR was 0.61, 96% confidence interval was from 0.36 to 1.05 ($P = 0.07$) (Table 2). Subgroup analysis of two trials on uncritically ill patients showed that the combined OR was 0.33 (from 0.13 to 0.87, $P = 0.03$).

Effect of DF on infection The risk of infection was reported in two trials. The types of infection included pneumonia, sepsis, abdominal infection, urinary infection and incision infection. Two trials had homogeneity. Combined OR was 0.44 when the fixed effect model was used (0.20-1.00, $P = 0.05$).

Effect of DF on length of hospital stay Three trials reported the length of hospital stay of 124 postoperative patients. Among the three trials, one was excluded because it did not supply the standard deviation. Two adopted trials had homo-geneity, combined WMD was -2.85 (from -3.76 to -1.93, $P<0.00001$).

Sensitivity analysis

Three high-quality trials on diarrhea of 160 cases in EN were included. There was no heterogeneity among them ($P = 0.069$). Combined OR was 0.83 (0.43-1.60, $P = 0.6$). The result was identical with the previous analysis (Table 3). Sensitivity analysis was abandoned for the quality of trials about infection and length of hospital stay was poor.

DISCUSSION

Diarrhea is the most frequent complication in EN. Infusion speed, temperature, osmolality, bacterial contamination, hypoalbuminemia and antibiotics may play a part in diarrhea[26]. Laboratory studies suggested that DF and SCFA, fermentation products of DF, were able to improve the rhythm of bowel peristalsis, promote absorption of water and sodium, and

Table 1 Characteristics of RCTs about EN supplemented with DF

	Number of patients (intervention / control)	Methodological quality	Patients	Diarrhea	Infection	Days of hospital stay (mean±SD)
Schultz 2000	44(22 / 22)	C: A J: 5	Critically ill	6 / 7	NR	NR
Dobb 1990	91(45 / 46)	C: B J: 4	Critically ill	16 / 13	NR	NR
Spapen 2001	25(13 / 12)	C: A J: 3	Sepsis	6 / 11	NR	NR
Rayes 2002	64(32 / 32)	C: B J: 2	Liver transplantation	NR	11 / 15	36±2.7 / 39±0.5
Rayes 2002(2)	60(30 / 30)	C: B J: 2	Abdominal surgery	NR	3 / 9	15±7.4 / 16±5.5
Homann 1994	100(50 / 50)	C: B J: 2	Inpatients	6 / 15	NR	NR
Khalil 1998	16(8 / 8)	C: B J: 2	Postoperative	1 / 2	NR	NR

C = concealment of allocation; J = Jadad score; NR = not reported.

Table 2 Effect of EN with DF on diarrhea

Study	Favors DF-supplement n / N	Favors DF-free n / N	Weight %	OR (95%CI fixed)
Dobb 1990	16 / 45	13 / 46	24.0	1.40 [0.58,3.40]
Homann 1994	6 / 50	15 / 50	38.3	0.32 [0.11,0.91]
Khalil 1998	1 / 8	2 / 8	5.1	0.43 [0.03,5.99]
Schultz 2000	6 / 22	7 / 22	14.8	0.80 [0.22,2.94]
Spapen 2001	6 / 13	11 / 12	17.9	0.08 [0.01,0.79]
Total(95%CI)	35 / 138	48 / 138	100.0	0.61 [0.36,1.05]

Test for heterogeneity chi-square = 8.13, df = 4, $P = 0.087$; Test for overall effect $z = -1.79$, $P = 0.07$.

Table 3 Sensitivity-analysis of effects of EN with DF on diarrhea

Study	Favors DF-supplement n / N	Favors DF-free n / N	Weight %	OR (95%CI fixed)
Dobb 1990	16 / 45	13 / 46	24.0	1.40 [0.58,3.40]
Schultz 2000	6 / 22	7 / 22	14.8	0.80 [0.22,2.94]
Spapen 2001	6 / 13	11 / 12	17.9	0.08 [0.01,0.79]
Total(95%CI)	28 / 80	31 / 80	100.0	0.83 [0.43,1.60]

Test for heterogeneity $\chi^2 = 5.34$, df = 2, $P = 0.069$, Test for overall effect z = -0.56, $P = 0.6$.

regulate the inhibitor feedback mechanism[27-31]. Accordingly, DF may have potentials beneficial to controlling diarrhea in EN[32-35]. But the existing clinical trials did not show identical results, so strict evaluation is essential. The occurrence of diarrhea in trials adopted in this review was 30.01%, combined OR was 0.61, 95% confidence interval was from 0.36 to 1.05 ($Z = -1.79$, $P = 0.07$). The difference was not statistically significant. Subgroup analysis revealed that DF was beneficial to diarrhea in non-critically ill patients but uncertain in critically ill patients. Critically ill patients were apt to complicate severe hypoalbuminemia and superinfection, which could lead to refractory diarrhea[34,35]. In the review, diarrhea occurred in 34.78% of critically ill patients, far higher than that in the non-critical patients (20.69%).

Diarrhea diagnosis is lack of objective criteria. Three trials in the review adopted Hatt and Dobb diarrhea score, which records defecation by volume and consistency. Diarrhea was defined as the scores more than 12. This score was convenient to compare different trials.

High attention has been paid to intestinal bacterial translocation leading to a considerable amount of infections. A series of animal experiments suggested that DF could effectively reduce the intestinal bacterial translocation in stress status[36]. The mechanism remains unclear. DF is able to maintain the structure and function of epithelia, regulate immunological reactions, promote secretion of IgA and mucus, all these may play a role in diarrhea[37-39]. Administration of DF can reduce the infection theoretically. However, analysis of the seven trials failed to show the anticipated results (combined OR 0.44, $P = 0.05$). The review suggests that DF could significantly shorten the length of hospital stay of patients who had undergone liver transplantation or abdominal surgery.

There is little evidence from these trials that DF is beneficial to diarrhea and infection of critically ill patients. It is necessary to design more large size and high-quality randomized controlled trials. The effect of DF on a variety of patients should also be further studied.

REFERENCES

1 **Englyst HN,** Quigley ME, Hudson GJ. Definition and measurement of dietary fibre. *Eur J Clin Nutr* 1995; **49**(Suppl 3): S48-62

2 **Cummings JH,** Macfarlane GT. Role of intestinal bacteria in nutrient metabolism. *JPEN J Parenter Enteral Nutr* 1997; **21:** 357-365

3 **Spaeth G,** Gottwald T, Hirner A. Fibre is an essential ingredient of enteral diets to limit bacterial translocation in rats. *Eur J Surg* 1995; **161**: 513-518

4 **Kanauchi O,** Suga T, Tochihara M, Hibi T, Naganuma M, Homma T, Asakura H, Nakano H, Takahama K, Fujiyama Y, Andoh A, Shimoyama T, Hida N, Haruma K, Koga H, Mitsuyama K, Sata M, Fukuda M, Kojima A, Bamba T. Treatment of ulcerative colitis by feeding with germinated barley foodstuff: first report of a multicenter open control trial. *J Gastroenterol* 2002; **37**(Suppl 14): 67-72

5 **Wisker E,** Daniel M, Rave G, Feldheim W. Fermentation of non-starch polysaccharides in mixed diets and single fibre sources: comparative studies in human subjects and *in vitro*. *Br J Nutr* 1998; **80:** 253-261

6 **Demetriades H,** Botsios D, Kazantzidou D, Sakkas L, Tsalis K, Manos K, Dadoukis I. Effect of early postoperative enteral feeding on the healing of colonic anastomoses in rats. Comparison of three different enteral diets. *Eur Surg Res* 1999; **31:** 57-63

7 **Kripke SA,** Fox AD, Berman JM, Settle RG, Rombeau JL. Stimulation of intestinal mucosal growth with intracolonic infusion of short-chain fatty acids. *J Parenter Enteral Nutr* 1989; **13:** 109-116

8 **Bowling TE,** Raimundo AH, Grimble GK, Silk DB. Reversal by short-chain fatty acids of colonic fluid secretion induced by enteral feeding. *Lancet* 1993; **342:** 1266-1268

9 **Gomez Candela C,** de Cos Blanco AI, Iglesias Rosado C. Fiber and enteral nutrition. *Nutr Hosp* 2002; **17**(Suppl 2): 30-40

10 **Nakao M,** Ogura Y, Satake S, Ito I, Iguchi A, Takagi K, Nabeshima T. Usefulness of soluble dietary fiber for the treatment of diarrhea during enteral nutrition in elderly patients. *Nutrition* 2002; **18:** 35-39

11 **Wright J.** Total parenteral nutrition and enteral nutrition in diabetes. *Curr Opin Clin Nutr Metab Care* 2000; **3:** 5-10

12 **Coulston AM.** Clinical experience with modified enteral formulas for patients with diabetes. *Clin Nutr* 1998; **17**(Suppl 2): 46-56

13 **Sobotka L,** Bratova M, Slemrova M, Manak J, Vizd'a J, Zadak Z. Inulin as the soluble fiber in liquid enteral nutrition. *Nutrition* 1997; **13:** 21-25

14 **Hebden JM,** Blackshaw E, D'Amato M, Perkins AC, Spiller RC. Abnormalities of GI transit in bloated irritable bowel syndrome: effect of bran on transit and symptoms. *Am J Gastroenterol* 2002; **97:** 2315-2320

15 **Olah A,** Belagyi T, Issekutz A, Gamal ME, Bengmark S. Randomized clinical trial of specific lactobacillus and fibre supplement to early enteral nutrition in patients with acute pancreatitis. *Br J Surg* 2002; **89:** 1103-1107

16 **Parisi GC,** Zilli M, Miani MP, Carrara M, Bottona E, Verdianelli G, Battaglia G, Desideri S, Faedo A, Marzolino C, Tonon A, Ermani M, Leandro G. High-fiber diet supplementation in patients with irritable bowel syndrome (IBS): a multicenter, randomized, open trial comparison between wheat bran diet and partially hydrolyzed guar gum (PHGG). *Dig Dis Sci* 2002; **47:** 1697-1704

17 **Tonstad S,** Smerud K, Hoie L. A comparison of the effects of 2 doses of soy protein or casein on serum lipids, serum lipoproteins, and plasma total homocysteine in hypercholesterolemic subjects. *Am J Clin Nutr* 2002; **76:** 78-84

18 **Jenkins DJ,** Kendall CW, Vuksan V, Augustin LS, Li YM, Lee B, Mehling CC, Parker T, Faulkner D, Seyler H, Vidgen E, Fulgoni V. The effect of wheat bran particle size on laxation and colonic fermentation. *Am Coll Nutr* 1999; **18:** 339-345

19 **Rayes N,** Seehofer D, Hansen S, Boucsein K, Muller AR, Serke S, Bengmark S, Neuhaus P. Early enteral supply of lactobacillus and fiber versus selective bowel decontamination: a controlled trial in liver transplant recipients. *Transplantation* 2002; **74:** 123-127

20 **Rayes N,** Hansen S, Seehofer D, Muller AR, Serke S, Bengmark S, Neuhaus P. Early enteral supply of fiber and Lactobacilli versus conventional nutrition: a controlled trial in patients with major abdominal surgery. *Nutrition* 2002; **18:** 609-615

21 **Spapen H,** Diltoer M, Van Malderen C, Opdenacker G, Suys E, Huyghens L. Soluble fiber reduces the incidence of diarrhea in septic patients receiving total enteral nutrition: a prospective, double-blind, randomized, and controlled trial. *Clin Nutr* 2001; **20:** 301-305

22 **Schultz AA,** Ashby-Hughes B, Taylor R, Gillis DE, Wilkins

M. Effects of pectin on diarrhea in critically ill tube-fed patients receiving antibiotics. *Am J Crit Care* 2000; **9:** 403-411

23 **Khalil L,** Ho KH, Png D, Ong CL. The effect of enteral fibre-containing feeds on stool parameters in the post-surgical period. *Singapore Med J* 1998; **39:** 156-159

24 **Homann HH,** Kemen M, Fuessenich C, Senkal M, Zumtobel V. Reduction in diarrhea incidence by soluble fiber in patients receiving total or supplemental enteral nutrition. *J Parenter Enteral Nutr* 1994; **18:** 486-490

25 **Dobb GJ,** Towler SC. Diarrhoea during enteral feeding in the critically ill: a comparison of feeds with and without fibre. *Intensive Care Med* 1990; **16:** 252-255

26 **Burks AW,** Vanderhoof JA, Mehra S, Ostrom KM, Baggs G. Randomized clinical trial of soy formula with and without added fiber in antibiotic-induced diarrhea. *J Pediatr* 2001; **139:** 578-582

27 **Lin HC,** Zhao XT, Chu AW, Lin YP, Wang L. Fiber-supplemented enteral formula slows intestinal transit by intensifying inhibitory feedback from the distal gut. *Am J Clin Nutr* 1997; **65:** 1840-1844

28 **Bliss DZ,** Jung HJ, Savik K, Lowry A, LeMoine M, Jensen L, Werner C, Schaffer K. Supplementation with dietary fiber improves fecal incontinence. *Nurs Res* 2001; **50:** 203-213

29 **Bouin M,** Savoye G, Herve S, Hellot MF, Denis P, Ducrotte P. Does the supplementation of the formula with fibre increase the risk of gastro-oesophageal reflux during enteral nutrition? A human study. *Clin Nutr* 2001; **20:** 307-312

30 **Silk DB,** Walters ER, Duncan HD, Green CJ. The effect of a polymeric enteral formula supplemented with a mixture of six fibres on normal human bowel function and colonic motility. *Clin Nutr* 2001; **20:** 49-58

31 **Murray SM,** Patil AR, Fahey GC Jr, Merchen NR, Wolf BW, Lai CS, Garleb KA. Apparent digestibility and glycaemic responses to an experimental induced viscosity dietary fibre incorporated into an enteral formula fed to dogs cannulated in the ileum. *Food Chem Toxicol* 1999; **37:** 47-56

32 **Reese JL,** Means ME, Hanrahan K, Clearman B, Colwill M, Dawson C. Diarrhea associated with nasogastric feedings. *Oncol Nurs Forum* 1996; **23:** 59-66

33 **Kapadia SA,** Raimundo AH, Grimble GK, Aimer P, Silk DB. Influence of three different fiber-supplemented enteral diets on bowel function and short-chain fatty acid production. *J Parenter Enteral Nutr* 1995; **19:** 63-68

34 **Bass DJ,** Forman LP, Abrams SE, Hsueh AM. The effect of dietary fiber in tube-fed elderly patients. *J Gerontol Nurs* 1996; **22:** 37-44

35 **Lien KA,** McBurney MI, Beyde BI, Thomson AB, Sauer WC. Ileal recovery of nutrients and mucin in humans fed total enteral formulas supplemented with soy fiber. *Am J Clin Nutr* 1996; **63:** 584-595

36 **Nakamura T,** Hasebe M, Yamakawa M, Higo T, Suzuki H, Kobayashi K. Effect of dietary fiber on bowel mucosal integrity and bacterial translocation in burned rats. *J Nutr Sci Vitaminol* 1997; **43:** 445-454

37 **Caparros T,** Lopez J, Grau T. Early enteral nutrition in critically ill patients with a high-protein diet enriched with arginine, fiber, and antioxidants compared with a standard high-protein diet. The effect on nosocomial infections and outcome. *J Parenter Enteral Nutr* 2001; **25:** 299-308

38 **Tariq N,** Jenkins DJ, Vidgen E, Fleshner N, Kendall CW, Story JA, Singer W, D'Costa M, Struthers N. Effect of soluble and insoluble fiber diets on serum prostate specific antigen in men. *J Urol* 2000; **163:** 114-118

39 **Frankel W,** Zhang W, Singh A, Bain A, Satchithanandam S, Klurfeld D, Rombeau J. Fiber: effect on bacterial translocation and intestinal mucin content. *World J Surg* 1995; **19:** 144-148

Science Editor Wang XL and Li WZ **Language Editor** Elsevier HK