Discussion

FIBRE INTAKE

Our findings showed that the patients with diverticular disease had a lower crude-fibre intake than matched controls. Tables are not yet available to assess the total dietary fibre content of foods,[10] and crude fibre is mainly a measure of the cellulose and lignin content of the food and considerably underestimates the total dietary fibre because it does not take the hemicelluloses into account.[11]

The accuracy of a dietary history depends on the reliability of the subject and this applied equally to both groups, who were assessed by the same dietitians. Our control group showed a fairly typical distribution pattern, and the mean fibre intake of 5·2 g compared with reported crude-fibre intakes in Britain of 4 to 8 g/day.[12 13]

Questioning disclosed no obvious evidence that patients with diverticular disease had changed their diet after the emergence of symptoms, and none had been advised to alter their fibre intake because of other disease—for example, peptic ulcer. Only the patients with gall stones had a lower fibre intake than the rest of the group. Some of the controls may have been exposed to pro-fibre propaganda, but there was no evidence that their fibre intake had changed. Possibly the small difference between the mean fibre intake of our controls and Robertson's figure of 4·2 g/day for the general population[12] might have been due to an increased dietary health consciousness among the controls. Nevertheless, there seemed to be a genuine difference in fibre intake between the patients and the controls, which was unlikely to have been artificially created by either an exaggeration in the fibre intake of the control group or a reduction in the intake of those with diverticular disease. Eating patterns in this age range appear to be stable over many years.

ASSOCIATION WITH OTHER CONDITIONS

The questionnaire elicited a significantly increased incidence of haemorrhoids, varicose veins, abdominal hernias, hiatus hernia, and gall stones in the patients with diverticular disease. This type of assessment may not be very reliable in the case of haemorrhoids, as patients are sometimes told that they have piles without proctoscopy being carried out, and it was not feasible to examine the controls.

The method of selecting the controls was unlikely to have caused significant bias in the incidence of associated disorders, despite the rejection of a few subjects. The patients with diverticular disease had been attending their doctor and had been more thoroughly investigated than the controls, which may have increased the number of disorders diagnosed. The results must be interpreted in the light of these factors, but it is unlikely that they could have accounted for such large differences in the incidence of some conditions and the negligible difference in the incidence of others, such as hypertension and arterial disease.

The reported incidence of hiatus hernia in patients with diverticular disease has varied from 11% to 16%.[14-16] Similarly, the incidence of gall stones has varied from 11% to 31%.[14-16] These differences are probably due to different methods of selecting patients and obtaining information and to geographical differences. A relation between diverticular disease and varicose veins has been reported by Latto *et al*:[17] 73% of 110 patients with diverticular disease had some evidence of varicose veins on examination compared with 33% of age- and sex-matched controls. A relation to peptic ulceration has been reported by Boles and Jordan,[15] who found ulcers in 18% of patients with diverticular disease and Painter,[14] who found ulcers in 13% of patients. We know of no similar reports of an association with abdominal hernias.

Cleave *et al*[3] suggested that diverticular disease and many other disorders common in Western civilization were different manifestations of a common causal factor related to the intake and refinement of dietary carbohydrate. Burkitt has produced epidemiological evidence to support this and has suggested that hiatus hernia, abdominal hernias, haemorrhoids, and varicose veins may be caused by intermittent high intra-abdominal pressure due to straining at stool secondary to a low-fibre diet.[19] Our findings support the concept that a fibre-depleted diet is a causative factor in diverticular disease and is also associated with several other conditions.

Acknowledgments are given at the end of Part III.

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Part II—Treatment with bran

Summary

Forty patients with diverticular disease were treated with wheat bran 24 g/day for at least six months. Thirty-three patients showed a very satisfactory clinical response. Sixty per cent of all symptoms were abolished, and a further 28% were relieved. After treatment the transit times accelerated in patients whose initial times were slower than 60 hours and slowed down in those whose initial transit times were faster than 36 hours. Stool weight increased significantly. The number of intracolonic high pressure waves decreased, especially during and after eating. Barium enema studies showed less spasm in eight patients and no diverticula in three patients after taking bran. As well as relieving the symptoms of diverticular disease a high-fibre diet may also prevent the condition from developing.

Introduction

In the past a low-residue diet was generally prescribed for patients with diverticular disease of the colon. This was accepted without any real proof of its therapeutic value.[1] Medical opinion has now swung in favour of a high-fibre regimen, which has been reported to produce clinical improvement[2 3] and reduce the

abnormally high intraluminal pressure within the colon.[4 5] It has been suggested that a deficiency of fibre may be responsible for the development of the condition.[6]

There is still some doubt about the clinical efficacy of a high-fibre diet[7] and relatively few clinical studies have been published.[8] Our study was designed to assess the effect on both symptomatic relief and colonic physiology of giving a standard quantity of bran to 40 patients with diverticular disease.

Patients and methods

Forty patients presenting at the Royal Berkshire Hospital over 12 months with symptoms and barium enema findings of diverticular disease were studied. Most of the patients had had persistent symptoms for some time before seeking medical advice (mean 18 months). None of the patients had been treated for diverticular disease and none showed evidence of inflammatory or obstructive complications. They had no other serious colonic disease, were not disabled or senile, and were willing to enter a therapeutic trial.

INITIAL ASSESSMENT

Patients were initially admitted for four days' assessment, during which they completed a detailed symptomatic questionnaire on dyspeptic symptoms, abdominal pain, and symptoms relating to defecation (see table I). Each symptom was scored according to its severity and frequency. One of us (DMH) independently assessed the symptoms while the other (AJMB) acted as therapist.

TABLE I—*Number of patients with diverticular disease with each symptom*

	Before bran	Worse*	No change	Relieved	Abolished
Dyspeptic symptoms					
Nausea	22	0	3	5	14
Flatulence	31	4	4	9	17
Distension	32	4	6	13	12
Wind	38	2	6	20	10
Vomiting	10	1	0	1	9
Pain					
Right iliac fossa	22	3	1	8	12
Left iliac fossa	20	1	0	10	10
Generalised	25	0	1	5	19
Colic	13	0	0	5	8
Bowel symptoms					
Straining	26	1	2	6	18
Pain on defecation	20	2	3	3	13
Incomplete emptying	30	3	5	11	14
Blood on defecation	12	2	1	3	8
Mucus	21	1	4	3	14
Hard or loose motion	33	0	1	3	29
Use of laxatives	12	1	0	1	10
Bowel habit	24	1	1	4	19
Total No (%) of symptoms	391	26 (7)	38 (10)	110 (28)	236 (60)

*Patients who developed a new symptom that they did not have before treatment were included in this category.

Daily stool weight was estimated as a mean of four days collections. Oral-anal transit times were measured by the method described by Hinton *et al.*[9] The patient swallowed 25 radio-opaque markers, and abdominal *x*-ray pictures were taken every 24 hours thereafter. All stool specimens were collected in polyethylene bags, labelled with the date and time passed, and subsequently examined by *x*-ray to count the markers in each specimen. By this method an accurate oral-anal transit time for 80% of markers was obtained.

Using twin open-ended, water-filled polyethylene catheters of 2 mm internal diameter, colonic pressures were measured for 30 minutes before eating, while eating a three-course meal, and again for 30 minutes after the meal. Recordings were taken at two different meals. Patients were sigmoidoscoped with a narrow-bore instrument and tubes placed with their tips about 15 cm and 30 cm from the anal margin. Little attempt was made to clear faeces as we considered that any extra mechanical stimulus to the bowel wall might affect the pressure recording. The tubes were connected to SE Laboratory pressure transducers, and pressures were recorded with a Bryans Southern Instruments 2800 twin pen recorder. This gave a stable recording unit with negligible drift or electrical interference.

TREATMENT AND REASSESSMENT

After this initial period of assessment patients were instructed to take three heaped tablespoons of Prewett's wheat bran (about 24 g) daily, which was thought to be the maximum that most people would tolerate. They were instructed to keep to their normal diet and were then discharged and seen regularly as outpatients. The patient's doctor was not prevented from using any additional treatment if required, and seven patients received a one to two week course of sulphasalazine in the first month of observation, but no further treatment was needed subsequently by any patient.

After at least six months (mean eight months) the patients were readmitted for four days' assessment and the initial investigations were repeated. A further barium enema examination was then carried out and the films were compared with those taken initially by the same consultant radiologist. We counted the number of diverticula seen before and after treatment.

Results

All the patients tolerated the bran well and said they were improved by it. Thirty-three (83%) were extremely satisfied, five patients (13%) still had some troublesome symptoms, and two patients (5%) showed only a slight improvement. One of these subsequently underwent laparotomy and was found to have numerous small bowel adhesions and a small chronic pericolic abscess .In the other patient, who had a severe anxiety neurosis, psychiatric help proved more valuable than bran. None of the patients deteriorated while on bran or required admission.

The effect of treatment on individual symptoms is summarised in table I. Most patients initially complained of many symptoms (a mean of nearly 10 per patient). After bran 60% of symptoms were abolished and a further 28% relieved. Some symptoms (7%) seemed to be worse, but this only signified a slightly increased symptom score or the emergence of a new symptom in mild form. No symptom got much worse. All types of abdominal pain were satisfactorily relieved, diffuse lower abdominal pain responding best and right iliac fossa discomfort least. Even when pain persisted it was minimal in all but four patients. Nausea, vomiting, and flatulence were much improved after treatment.

The only three symptoms abolished in fewer than half the cases by bran were the passage of wind per rectum, a sensation of abdominal distension, and a feeling of incomplete emptying of the rectum after defecation. This is compatible with the finding that normal volunteers taking bran often experience these complaints.

Straining on defecation was reduced by bran, and there was a considerable change in both the consistency of the motion and the frequency of bowel habit (tables II and III). Many patients initially passed either liquid motions or very hard motions. Some alternated between the two. Bran effectively thickened liquid motions and softened hard motions. Similarly, patients with very frequent motions defecated less often after bran, and constipation was successfully relieved. Only two out of 12 patients who initially took laxatives continued to do so after bran.

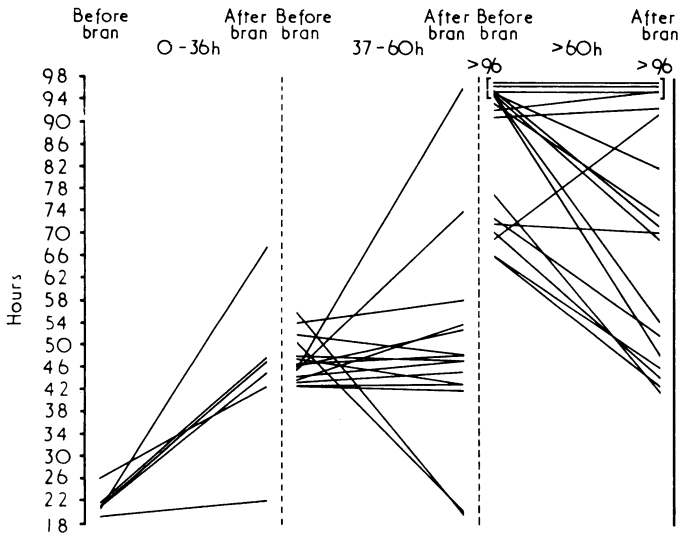
The oral-anal transit times for 39 patients were divided into three arbitrary groups, as shown in the figure. Six patients had rapid transit times of less than 36 hours; 15 had medium transit times of 36 to 60 hours; and 18 had transit times slower than 60 hours. Each group responded differently after bran. All those with rapid times slowed down towards 48 hours (mean 21 hours to mean 45 hours); those with medium length transits showed no change (mean 47 hours to

TABLE II—*Reported consistency of motions before and after bran in 40 patients. Results are numbers of patients*

Consistency:	Liquid	Semi-formed	Formed	Hard	Very hard	Alternating liquid/hard
Before bran	7	3	5	5	5	15
After bran	1	7	30	0	0	2

TABLE III—*Reported frequency of defecation before and after bran in 40 patients. Results are numbers of patients*

No of stools:	>3/d	3/d	1-2/d	1 in 2 days	1 in 3 days	1 in 4-6 days	1 in >6 days
Before bran	10	8	15	2	0	2	3
After bran	2	4	34	0	0	0	0



Oral-anal transit times in 39 patients before and after bran. Patients were divided into three groups according to initial transit times: 0-36 hours, 37-60 hours, and >60 hours.

mean 49 hours); and those with slow transit times tended to speed up towards 48 hours ($P<0.006$). Thus bran tended to modify both slow and fast initial transit times towards a 48-hour mean.

Daily wet stool weight increased by 23 g, from a mean of 66 g to 89 g ($z = 3.50$; $P<0.0002$). This increase was similar whatever the initial transit time.

The colonic pressure studies in 39 patients were analysed in terms of the number and height of high-pressure waves rather than as a motility index. The results are summarised in table IV. Pressure wave activity in the sigmoid colon was reduced in 32 out of 39 patients after bran. The greatest reduction was in the number of pressure waves over 30 mm Hg, and this was most noticeable during and after eating ($P<0.003$ and $P<0.0001$ respectively).

TABLE IV—*Effect of treatment with bran on sigmoid colon pressure waves in 39 patients before, during, and after a meal. Results are numbers of waves per hour*

Pressure waves (mm Hg):	15–20	–30	–40	–50	–60	–70	–80	>80
Preprandial								
Before bran	4·93	3·53	1·64	0·86	0·26	0·13		
After bran	3·43	2·62	1·17	0·21	0·03	0·10		
Prandial								
Before bran	17·09	14·98	6·27	2·58	1·63	1·05	0·29	0·05
After bran	8·24	6·80	2·28	0·99	0·45	0·20		
Postprandial								
Before bran	12·23	10·65	5·04	3·30	1·74	0·96	0·62	0·31
After bran	6·29	4·99	2·05	1·17	0·39	0·16	0·08	

The initial barium enema examination showed diverticular disease involving the sigmoid colon in 20 patients. Four of these showed spasm and transient diverticular formation and were described as having "early diverticular disease." A further 10 patients showed diverticula throughout the left side of the colon, and in the rest diverticula were more extensive, except in one patient who had diverticula on the right side only. In 33 patients the barium enema examination was repeated after bran, the remainder being either elderly or particularly anxious not to have the investigation repeated. There was no significant change in the number of diverticula seen. Eight patients showed a reduction in spasm and contraction, while two showed increased spasm. The three patients with "early diverticular disease" who had repeat barium enema examinations showed no diverticula after bran. One showed some spasm and the other two were described as having normal colons.

Discussion

In this study treatment with cereal fibre not only provided good symptomatic relief in patients with uncomplicated diverticular disease but also improved colonic function by increasing stool weight, altering transit time, and reducing the abnormally high intraluminal pressure within the bowel.

It was not feasible to carry out a double-blind controlled trial. A positive placebo effect may have resulted from hospital investigation and follow-up, though most patients were initially sceptical at the idea of being treated with only bran. Despite the long period of persistent symptoms before treatment and the substantial and sustained improvement while on bran, symptomatic relief must be interpreted with some reservation compared with the objective changes in colonic physiology.

So far as we could ascertain from direct and indirect questioning at regular outpatient appointments, all the patients continued to take their bran successfully throughout the trial. A few patients failed to take the bran on the occasional weekend when they were away from home and noticed that their original symptoms started to return within three days. At the end of the trial most patients were determined to continue to take bran indefinitely. The patients tolerated bran well because time was taken to explain to them how it could be made palatable with other food, that they might initially feel distended but that this was normal, that maximum relief of symptoms could take up to four to six weeks of treatment, and that the bran must be taken regularly every day.

Plumley and Francis[3] found that six slices of a bran crispbread gave good symptomatic improvement and several patients deteriorated when this was replaced by a low-fibre crispbread. Painter *et al*[2] advised their patients to take bran in the quantity required to achieve a normal bowel habit without straining and also advised them to alter their diet to increase its fibre content and decrease its sugar content. Their patients had fewer initial symptoms than ours, but they were presenting symptoms while those of our patients were collected as replies to a fixed questionnaire. The value of a symptom score for each symptom is that it enables subsequent improvement in symptoms to be more accurately assessed. We considered it important that this assessment should not be carried out by the therapist. Our results are, however, broadly similar to those of Painter *et al*, supporting their conclusion that the increased fibre intake was responsible for the relief of symptoms.

The effect of bran on transit times is comparable with findings in other studies performed for shorter periods of time and with fewer patients[4 10] and with those in studies of normal subjects.[11 12] Bran seems to "normalise" transit times towards a mean of about 48 hours.[11 13] While this phenomenon could merely be a regression towards the mean, we conclude that increasing the fibre intake does have a genuine physiological action in slowing fast transit times and accelerating slow transit times in patients with diverticular disease.

The increase in faecal weight in patients with diverticular disease after increasing their fibre intake was less than in normal subjects after a similar increase.[4] After bran the faeces became soft but solid, less malodorous, and less sticky. When sigmoidoscoping the patients the rectum was emptier and cleaner after bran—an observation recorded after methyl cellulose.[14]

Colonic pressure studies have shown that patients with diverticular disease have abnormally high-pressure waves.[15 16] When analysing the pressure traces we considered it more informative to find the number and magnitude of high-pressure waves than to obtain an overall motility index.

Prostigmine, morphine, and other pharmacologically active agents were not used as we considered that they would interfere with the results of other studies (such as transit time measurements), might produce excessively high intracolonic pressures, and were not a normal physiological stimulus to the bowel and, therefore, of uncertain clinical significance.

Hodgson[14] found that six months' treatment with methyl cellulose reduced basal and postprandial sigmoid pressure waves in six patients with diverticular disease, and Findlay *et al*[4] found a reduction in postprandial and post-prostigmine pressure activity in such patients who had taken bran for five weeks. Similar studies suggested that Prewett's bran, which is a coarse

preparation, was most effective.[17] Prolonged treatment with bran after surgery reduced colonic pressure after sigmoid resection and prevented pressure increases after myotomy.[4] We compared 77 analyses before bran on 39 patients with 77 analyses after bran. The most striking change was the reduction in the number of colonic pressure waves while eating and for 30 minutes after a meal. High pressure waves still occasionally occurred after bran but were infrequent.

Changes in barium enema appearances after treatment with bran probably have limited clinical significance. Small diverticula may be transient,[18 19] though the mucosal herniations become irreducible. In view of the latter it is not surprising that there was no reduction in the number of diverticula seen at the second *x*-ray examination, but it is noteworthy that the number had not increased. The fact that two patients who initially showed early diverticular disease were reported as having normal colons after bran does not necessarily mean that the condition is fully reversible at this stage.

The patients in this study had abnormally low crude-fibre intakes before treatment (mean 2·6 g; see Part I) and the quantity of cereal fibre given (about 3 g crude fibre) brought their fibre intake up to the level of the control group (mean 5·2 g crude fibre). Treatment therefore made good a deficiency of fibre in the diet. While three heaped tablespoons of bran gave a satisfactory therapeutic response in most patients, persistent bowel symptoms or slow transit times did not correlate closely with the total crude-fibre intake. Bran is probably best given in gradually increasing quantities until maximum relief is obtained. A high-fibre diet might protect against the development of the condition, as well as relieving symptoms. Such a diet need not necessarily be supplemented with bran provided that an equivalent amount of cereal fibre, such as wholemeal bread, breakfast foods, bran crispbread, etc, is present.

Acknowledgments are given at the end of Part III.

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Part III—Metabolic effect of bran in patients with diverticular disease

Summary

Patients with diverticular disease were given about 24 g bran daily for at least six months. After treatment the oral glucose tolerance curve fell, faecal fat excretion increased, the serum lipoprotein pattern was altered, urinary calcium excretion was reduced, and the serum folate level fell. These changes were not considered to contraindicate the use of bran in the treatment of diverticular disease.

Introduction

The use of wheat bran or other forms of dietary fibre supplements has become widespread in treating diverticular disease. Because this form of treatment does not use a new chemical compound it has not undergone the detailed assessment that drugs now legally require. It may be argued that bran is a component part of Western man's traditional diet and that therefore its effect on his metabolism is unlikely to be harmful. Most doctors would, however, like to know the metabolic effect of any treatment they prescribe for their patients.

Various consequences of increasing the fibre content of the diet have been described. There is an increasing loss of energy and faecal nitrogen and fat as the fibre content of the diet is increased,[1] but the nutritional significance of this remains debatable.[2] Glucose tolerance may be affected by the fibre content of the diet.[3 4] There have been conflicting reports of the effect on serum lipids[5 6] and concern that the phytate content of bran may be detrimental to calcium absorption.[7] While carrying out a therapeutic trial on patients with diverticular disease, we studied the effect of wheat-bran supplements on various simple metabolic indices.

Patients and methods

Forty new patients presenting with symptomatic, uncomplicated, and untreated diverticular disease of the colon entered a trial to assess the therapeutic role of dietary fibre supplements (see part II) given for at least six months (mean eight months). The age and sex distribution of the patients is shown in part I. Eight patients had gall stones or had had surgery for gall stones.

Before beginning the bran the patients were weighed and their fasting blood was taken on three consecutive days for analysing total serum protein, albumin, urea, creatinine, urate, calcium, phosphate, alkaline phosphatase, bilirubin, aspartate aminotransferase (SGOT), lactate dehydrogenase (LDH), and cholesterol, haemoglobin, and white cell count. A mean of the three results was subsequently calculated to minimise experimental error on one reading alone. Single serum samples were also taken for estimating iron, total iron binding capacity, vitamin B_{12}, and folate levels and for fasting triglyceride and lipoprotein analysis (assessed by nephelometry).

Twenty-four-hour urine collections were made on two occasions for measuring calcium, phosphate, and urate excretion, and two random urine samples were checked for the presence of indican. A standard oral 50-g glucose tolerance test was done on each patient, and a four-day faecal fat collection was made.

This sequence of tests was repeated in 39 patients on readmission to the assessment unit after taking three heaped tablespoons daily of Prewett's bran for at least six months. All tests on both admissions were carried out while the patient was on a normal diet, and during the rital no dietary adjustments were made apart from the addition of about 24 g bran daily.

Possible laboratory and seasonal variation in pre- and post-bran samples was minimised by rigid quality control and extensive overlapping between analysis of pre- and post-bran samples over two years. Except when otherwise indicated, the significance of differences was assessed by non-parametric statistical methods.[8]

Results

There was no significant change in body weight; the mean body weight before bran was 69·4 kg and after bran 68 kg. There was no