

Effect of cholecystectomy on bowel function: a prospective, controlled study

S D Hearing, L A Thomas, K W Heaton, L Hunt

Abstract

Background—Published estimates of the prevalence of postcholecystectomy diarrhoea derive from retrospective or uncontrolled data. They ignore functional bowel syndromes and possible changes in diet and drug use.

Aims—To determine prospectively whether and how often cholecystectomy leads to changes in bowel function and bowel symptoms, especially to liquid stools, over and above any non-specific effect of laparoscopic surgery.

Subjects—Patients: 106 adults undergoing laparoscopic cholecystectomy (85 women, 21 men). Controls: 37 women undergoing laparoscopic sterilisation.

Methods—Before and 2–6 months after surgery patients were administered questionnaires about bowel frequency, bowel symptoms, diet, and drugs, and kept records of five consecutive defecations with assessment of stool form or appearance on a seven point scale.

Results—In cholecystectomised women, stated bowel frequency increased, on average by one movement a week, and fewer subjects felt that they became constipated. However, records showed no consistent change in bowel frequency, stool form, or defecatory symptoms. Six women reported diarrhoea after the operation but in only one was it clearly new and in her it was mild. Change in dietary fibre intake did not associate with change in bowel function but stopping constipating drugs did in a minority. In women being sterilised there was no consistent change in bowel function. In men having cholecystectomy no consistent changes were observed.

Conclusions—In women, cholecystectomy leads to the perception of less constipation and slightly more frequent defecations but short term recordings show no consistent change in bowel function. Clinical diarrhoea develops rarely and is not severe. (Gut 1999;45:889–894)

Keywords: cholecystectomy; bowel habit; stools; diarrhoea; constipation; irritable bowel syndrome

The effect of cholecystectomy on bowel function is controversial. In three series of operated patients, 5%, 9%, and 12%, respectively, reported having problems with diarrhoea.^{1–3} These figures are of uncertain significance because the term diarrhoea means different things to different people^{4–6} and

reported bowel habit is often not confirmed by objective records.^{7,8} In a study of recorded defecations, there was no difference in bowel frequency or stool characteristics between cholecystectomised women and women with unoperated (indeed undiagnosed) gallstones, except that the former perceived defecation as more urgent.⁹

All these studies are difficult to evaluate because in none was bowel function assessed before the operation as well as after it. Only one such study has been reported.³ Of 24 patients, eight reported more frequent or “looser” stools after the operation (but not, apparently, frank diarrhoea). Overall, colonic transit time fell from 51 to 38 hours. This study strongly suggests that there is a real effect of cholecystectomy. However, the specificity of the effect can be questioned because there were no controls undergoing a similar operation and no account was taken of possible changes in dietary intake and drug usage as a result of the operation. Also, a possible role for irritable bowel syndrome was not considered.

Until recently there has been no standard definition of diarrhoea but in 1992 an international, consensus working group proposed fluidity of the stools as the key feature.¹⁰ In 1999, this was endorsed and it is now recommended that a validated stool form scale be used to assess faecal characteristics.¹¹

We have undertaken a prospective study of bowel habit including stool form, and of bowel symptoms in patients undergoing laparoscopic cholecystectomy. In order to detect and, if necessary, correct for non-specific effects of surgery, we also studied women undergoing laparoscopic sterilisation. In addition to looking for the true prevalence of post-cholecystectomy diarrhoea, we also aimed to find out whether some patients experience relief of constipation (as already suggested³), and whether the bowel changes might be explained by increased dietary fibre intake or reduced use of constipating drugs.

Subjects and methods

Between April 1993 and June 1996 we wrote to all patients with ultrasonographically diagnosed gallstones who were scheduled for non-urgent laparoscopic cholecystectomy at the Bristol Royal Infirmary. Patients who were accessible on the telephone and gave informed consent were administered a questionnaire (see Appendix) about how often they defecated (per day and per week), how often they experienced

Abbreviations used in this paper: IBS, irritable bowel syndrome.

University
Department of
Medicine, Bristol
Royal Infirmary,
Bristol, UK
S D Hearing
L A Thomas
K W Heaton

University Division of
Child Health, Royal
Hospital for Sick
Children, Bristol, UK
L Hunt

Correspondence to:
Dr K W Heaton, Claverham
House, Claverham,
N Somerset BS49 4QD, UK.

Accepted for publication
23 June 1999

“diarrhoea” and “constipation”, and how often they experienced individual symptoms of constipation, diarrhoea, and irritable bowel syndrome (IBS)—that is, lumpy stools, runny/mushy stools, urgency of defecation, feelings of incomplete evacuation, abdominal pain which lessened with defecation, abdominal bloating or distension, and rectal passage of mucus.

During the interview, all medications were recorded and particular note made of those known for their constipating properties, for example, analgesics and antidepressants.

Subjects were then mailed a printed bowel record form on which to record each of five consecutive defecations including the date and time of each stool and also its form or appearance on the seven point Bristol stool form scale, which is sensitive to intestinal transit time, and the type of faeces, ranging from lumpy stools or scybala to watery diarrhoea.^{12, 13} On the record form the subject also rated the strength of each call to stool on the following scale: weak and vague; definite but not strong; strong, hard to resist; or violent, had to rush (scored 1, 2, 3, and 4 respectively). The sum of the five scores was the urge score for that subject (maximum 20). With each defecation the subject also stated whether or not they had a sense of incomplete evacuation or rectal dissatisfaction (scored 1), yielding a dissatisfaction score (maximum 5).

Between two and six months after the operation the interviews and recordings were repeated. While the study was in progress it occurred to us that surgery might induce a change in eating habits and so in bowel function. Accordingly, the last 44 cholecystectomy subjects to be recruited were asked in the postoperative interview whether they had altered the frequency of eating the four major classes of fibre rich foods: bran containing products, brown bread, fruit, and vegetables.

Patients were classified preoperatively by their gall bladder function, in most cases by oral cholecystography, function being equated with opacification of the gall bladder 12 hours after administration of 3 g Biloptin orally. In patients who could not or would not have cholecystography (24%), a thickened gall bladder wall on ultrasonography was taken to imply loss of function, as was a calculus in the neck of the gall bladder.

Women scheduled for laparoscopic sterilisation were recruited and studied contemporaneously but over a slightly shorter time period. The only exclusion criteria were known gastrointestinal disease and prior cholecystectomy; these were never met. The data collected before and two to three months after the operation, were the same as in the cholecystectomy subjects.

The study was approved by the local Research Ethics Committee.

CALCULATIONS

Men and women were considered separately because they are known to differ in most aspects of bowel function.^{8, 14-16} For the questionnaire data, proportions of responders were compared using McNemar's test for change

(preoperative versus postoperative), and the χ^2 test and Fisher's exact test for group comparisons. The number of defecations per week was compared using non-parametric methods: the Wilcoxon matched pairs signed rank test for preoperative versus postoperative data, and Mann-Whitney U tests for group comparisons. From the bowel record forms we computed for each subject a mean value for stool form as a semiquantitative index of intestinal transit time¹² and mean interdefecatory interval as an index of bowel frequency. These were compared, preoperatively versus postoperatively and between groups, using paired or unpaired Student's *t* tests. Within subject standard deviations of these parameters were calculated as measures of bowel irregularity, which is a feature of IBS.¹⁷ Urge scores and dissatisfaction scores were compared using non-parametric methods as above.

Results

LAPAROSCOPIC CHOLECYSTECTOMY

During the recruitment period 213 patients were scheduled for non-urgent surgery, of whom 200 (94%) could be traced and were invited to take part. Of these, 140 were willing and able to do so (66% of all those available). Reasons for not taking part were: unwilling (22), not on the telephone (19), changed mind about operation (5), already had operation (5), comprehension problems (4), and miscellaneous (5). Of the 140 who entered the study, 34 failed to provide postoperative data because their operations were delayed or they moved house. Thus 106 subjects form the basis of this report, consisting of 85 women (aged 22–80 years, median 56), and 21 men (aged 35–82 years, median 66). All 106 subjects provided questionnaire data. Completed bowel record forms were received preoperatively and postoperatively from 97 subjects (92%) (79 women and 18 men).

Preoperatively the gall bladder was assessed as “functioning” in 53 of the women and nine of the men. There was no consistent difference in the results between subjects with and without functioning gall bladders; the data were therefore pooled.

LAPAROSCOPIC STERILISATION

Of 65 patients scheduled for operation, 52 were invited to take part in the study and 37 agreed to do so. All 37 women responded to both questionnaires (median age 37 years, range 30–43) and 28 provided both bowel record forms.

QUESTIONNAIRE DATA IN WOMEN

After laparoscopic cholecystectomy the stated frequency of defecation rose by a median of one bowel movement per week (95% confidence interval 0.5 to 2.0; $p < 0.001$). A substantial increase in stated defecation frequency, defined as one of three movements per week or more, occurred in 24 of the 85 women having this operation (28%) but in only four of the 37 women having laparoscopic sterilisation (11%; $p = 0.062$).

Table 1 Preoperative and postoperative findings from the questionnaires in subjects undergoing laparoscopic sterilisation (controls) or cholecystectomy (gallstones)

	Controls (n=37)		Gallstones		Men (n=21)	
	Before surgery	After surgery	Women (n=85)		Before surgery	After surgery
			Before surgery	After surgery		
Defecations/week	7 (3–21)	7 (1–21)	7 (1–28)	8 (2–28)*	8 (3–24)	8 (3–25)
Constipated more than occasionally	11 (30)	9 (24)	32 (38)	16* (19)	2 (10)	2 (10)
Straining to start‡	3 (8)	3 (8)	24 (28)	17† (20)	1 (5)	2 (10)
Lumpy stools‡§	0/22 (0)	1/17 (6)	12/59 (20)	9/51 (18)	1/15 (7)	4/18 (22)
Runny stools‡§	3/22 (14)	3/17 (18)	9/59 (15)	13/51 (25)	4/15 (27)	4/18 (22)
Urgency‡	14 (38)	11 (30)	31 (36)	35 (41)	4 (19)	6 (29)
Diarrhoea occasionally	8 (22)	10 (27)	19 (22)	26 (31)	7 (33)	3 (14)
Diarrhoea usually or always	1 (3)	1 (3)	3 (4)	6 (7)	0	0

Data presented are actual numbers of subjects with percentages in brackets, except for defecations/week, where data are median (range).

* $p < 0.001$, † $p = 0.065$ *v* before surgery.

‡Often or more (more than 25% of defecations).

§In subjects who admitted examining their stools.

The number of women with perceived constipation at least occasionally fell by half after cholecystectomy ($p < 0.001$) and did not change significantly after sterilisation.

Frequent straining to start defecating was reported preoperatively by more gallstone women than controls ($p = 0.026$) but the difference became non-significant postoperatively, owing to seven fewer of the gallstone women reporting it. Similarly, lumpy stools were more prevalent in the women with gallstones than in the controls preoperatively ($p = 0.032$), but not significantly so postoperatively.

Perceived diarrhoea tended to be more prevalent after cholecystectomy but not significantly so (table 1). Postoperatively, diarrhoea “usually or always” was reported by one of the 37 sterilised women and by six of the 85 cholecystectomised women ($p = 0.444$). These six were examined in detail, case by case (table 2). Among them, three had denied diarrhoea preoperatively, one had said she had it occasionally, one often, and one usually or always. Therefore, by self report, three or perhaps four patients can be said to have had postcholecystectomy diarrhoea. However, one of them (patient 2) had wrongly denied diarrhoea preoperatively as at that time she admitted to 28 stools a week, usually runny. Another (patient 6) is hard to evaluate because she clearly had irritable bowel syndrome, with frequent abdominal pain relieved by defecation and frequent bloating, both before and after the operation (furthermore, she failed to answer the question about runny stools).

In neither group was there any significant change in the prevalence of abdominal pain

(whether or not relieved by defecation), abdominal bloating, feelings of incomplete evacuation, or passage of mucus—that is, the Manning criteria for irritable bowel syndrome.¹⁸

BOWEL RECORD FORM DATA

The mean interdefecatory interval and the mean stool form score did not change significantly with either operation (table 3). There was also no change in within subject standard deviations. Urge scores and rectal dissatisfaction scores did not change significantly with either operation.

Of the two cholecystectomised women who, by self report, may have developed diarrhoea (patients 1 and 4), one (patient 1) must be discounted because her bowel record form revealed that she was passing liquid stools preoperatively (mean stool form 6.6, see table 4). Therefore, only one patient can be stated with any confidence to have diarrhoea as a sequel to cholecystectomy. Of note, she had admitted to occasional diarrhoea before the operation, and had also recorded frequent urgency and had admitted frequent bloating, suggesting a tendency to irritable bowel syndrome. Her postoperative diarrhoea was mild and possibly intermittent; she reported 17 stools a week but her mean interdefecatory interval was 17.7 hours.

LAPAROSCOPIC CHOLECYSTECTOMY IN MEN

No change was noted in stated or recorded bowel frequency, nor in stool form. Self assessed constipation was rare before and after surgery. Diarrhoea usually or always was

Table 2 Findings from the questionnaires preoperatively and postoperatively in the six women who, after cholecystectomy, claimed to have diarrhoea usually or always

Patient no	Diarrhoea before surgery	Bowel movements per week		When stools runny		Colon pain* (days) †		Bloating (days) †		When defecation urgent	
		Before surgery	After surgery	Before surgery	After surgery	Before surgery	After surgery	Before surgery	After surgery	Before surgery	After surgery
1	Never	14	10	QNA	Usually	0	11+	0	0	Always	Always
2	Never	28	28	Usually	Usually	11+	0	0	0	Never	Never
3	Usually	12	24	QNA	QNA	11+	0	3–5	0	Occasionally	Never
4	Occasionally	9	17	Occasionally	Usually	1–2	3–5	11+	11+	Often	Always
5	Often	9	18	Always	Always	11+	11+	11+	11+	Always	Always
6	Never	9	17	QNA	QNA	11+	11+	11+	11+	Never	Often

*Abdominal pain relieved by defecation.

†Number of days in past three months.

QNA, question not answered.

Table 3 Preoperative and postoperative findings from the bowel record forms in subjects undergoing laparoscopic sterilisation (controls) or cholecystectomy (gallstones)

	Controls (n=28)		Gallstones			
			Women (n=79)		Men (n=18)	
	Before surgery	After surgery	Before surgery	After surgery	Before surgery	After surgery
Interdefecatory interval (h)	23.9 (9.9)	23.8 (9.6)	22.9 (10.2)	23.3 (11.4) (n=77)	23.6 (13.1)	21.5 (6.7)
WSSD of interdefecatory interval	12.3	13.3	14.3	13.5 (n=77)	6.8	9.4
Stool form on point scale	3.5 (1.1)	3.8 (1.1)	3.5 (1.2)	3.8 (1.2) (n=77)	4.1 (1.7)	3.8 (1.1)
WSSD of stool form	1.0	0.8	1.2	1.1 (n=77)	0.8	1.2
Urge score	11 (8–16)	11 (8–14)	10 (8–18) (n=78)	10 (5–20) (n=76)	10 (10–17)	10 (7–13)
Rectal dissatisfaction score	4 (0–5)	4 (0–5) (n=26)	3 (0–5) (n=78)	3 (0–5) (n=76)	3 (0–5)	0.5 (0–5)*

Data are presented as mean (SD) except for last two rows which are median (range).

WSSD (within subject standard deviation) is a measure of variability and is given because variability of bowel function is a feature of irritable bowel syndrome.¹⁷

*p=0.021 v before surgery.

Table 4 Data from the bowel record forms preoperatively and postoperatively in the six women who, after cholecystectomy, claimed to have diarrhoea usually or always

Patient no	Diarrhoea before surgery	Interdefecatory interval (h)		Stool form		Urge score		Rectal dissatisfaction score	
		Before surgery	After surgery	Before surgery	After surgery	Before surgery	After surgery	Before surgery	After surgery
1	Never	11.9	12.5	6.6	5.0	14	15	4	5
2	Never	8.3	6.0	5.7	6.0	12	11	4	5
3	Usually	24.3	12	4.0	5.2	10	11	0	3
4	Occasionally	17.9	17.7	2.0	5.0	12	11	2	2
5	Often	12.7	DNP	4.6	DNP	11	DNP	DNP	DNP
6	Never	17.6	26.9	4.6	3.3	10	8	1	3

Results for interdefecatory interval and stool form expressed as mean values. Results for urge score and rectal dissatisfaction score are sum of scores from five defecations.

DNP, data not provided.

denied by all. Symptoms of IBS did not appear; the rectal dissatisfaction score even fell.

CHANGE IN FIBRE INTAKE AND DRUG USAGE IN RELATION TO CHANGE IN CONSTIPATION

Among the 44 gallstone women with dietary information were 12 who reported a lower frequency of being constipated after cholecystectomy and 32 who reported either no change (n=30) or more frequent constipation (n=2). These two groups did not differ significantly with respect to the proportion who increased their intake of fibre rich foods (50% and 44%). Similar dietary change was reported by 35% of the sterilised women with dietary information (n=23), none of whom experienced less constipation.

Full drug information was provided by 63 gallstone women (74%) of whom 18 reported a lower frequency of constipation postoperatively. Among these were five (28%) who were taking a drug likely to cause constipation before but not after cholecystectomy (analgesics or antidepressants).

Discussion

The main positive finding of this study is that—in women but not men—cholecystectomy was followed by a subjective change in bowel function, consisting of a slight increase in defecation frequency and a perceived reduction in the incidence of constipation. The data agree with and greatly extend those of an earlier study.³ The changes seem to be specific to this operation as they were not seen after another laparoscopic procedure. They seem to be independent of dietary change and in only a small minority were they associated with—and, therefore, conceivably due to—the stopping of constipating drugs.

The orthodox explanation for the change in bowel function is that loss of the gall bladder's reservoir function alters bile acid metabolism. In particular, it raises the faecal concentration of deoxycholic acid,¹⁹ this bile acid being an agent that sensitises the rectum and can cause an urge to defecate.²⁰ However, we found no difference between patients with functioning and non-functioning gall bladders, so other mechanisms—so far unknown—may be operating.

There was no clear increase in perceived diarrhoea after laparoscopic cholecystectomy and, on close examination of the women who claimed to have postoperative diarrhoea, this had already been present in most of them before the operation. Moreover, some had irritable bowel syndrome. Only one patient had clear evidence of newly developed diarrhoea and she too had features of IBS before the operation. Moreover, her diarrhoea was very mild. The findings of this study suggest, therefore, that diarrhoea is a rare sequel to cholecystectomy whereas relief of constipation is common. This may relate to the fact that the bile acid malabsorption caused by cholecystectomy is relatively mild.²¹

The bowel record forms disagreed with the questionnaires in that they revealed no consistent change in bowel function, which mirrors the findings of our cross sectional population study.⁹ Discrepancy between recorded and reported bowel information is not unusual.^{7,8} Here, a possible explanation is that the change in bowel function which follows cholecystectomy is intermittent, in which case it might be missed by a five stool "snapshot".

There was no evidence of increased urgency of defecation after cholecystectomy, in contrast to what we found in the population study,⁹ but in that study, the strength of the urge had been

assessed crudely. There was also no indication that cholecystectomy precipitates the symptoms of IBS or irregularity of bowel habit.

As stool form reflects colonic transit time,^{12 22} the lack of change in the bowel record form data contrasts with the findings of the only other prospective study, in which mean colonic transit time fell from 51 to 38 hours.³ However, the latter value is still within normal limits so the discrepancy may be more apparent than real.

In published series, the vast majority of patients reporting postcholecystectomy diarrhoea are women³ and—consistent with this—the men in this study registered no change in bowel function. However, the number of men was small and a larger study is necessary to be sure that there is a real gender difference in this respect.

An incidental finding of this study is that the women awaiting cholecystectomy were reportedly more prone to lumpy stools and straining than those awaiting sterilisation, few of whom, at their age, will have had gallstones.²³ This is not explained by the age difference between the two groups because, although older women are somewhat more prone to strain than younger ones,²⁴ they do not pass lumpy stools more often.⁸ Therefore, the finding may be seen as supporting the hypothesis that cholesterol gallstone formation is favoured by slow colonic transit.^{25 26}

This study has limitations: lack of truly objective measures, relatively small number of controls and their low response rate, and a bowel recording period too short to detect

occasional diarrhoea. Ideally, we would have started with a rigorous definition of postcholecystectomy diarrhoea and designed the study to look for it. However, such a definition has yet to be made and our approach was in line with international endorsements of stool form scales for the characterisation of diarrhoea and constipation.^{11 27} The data support the conclusion that, while cholecystectomy causes a perceptible change in bowel function in some women (perhaps 20–25%), this is much more often the relief of constipation than the development of diarrhoea. Indeed, as there was only one clear case of de novo diarrhoea among 106 subjects (0.9%) and the annual incidence of chronic or recurrent diarrhoea in the population is 0.7%,²⁸ the question arises whether cholecystectomised patients experience diarrhoea any more than the general population. In the latter, chronic or recurrent diarrhoea affects 4–18%,^{15 16 29} while in cholecystectomised subjects its prevalence is reported as 5–12%.^{1–3} Conversely, among patients with obscure chronic diarrhoea only 5–8% have undergone cholecystectomy,^{21 30} a figure probably no more than expected.²³ We suggest, therefore, that postcholecystectomy diarrhoea is an unproved entity and will remain so until a prospective study shows that diarrhoea develops more frequently in patients having this operation than in appropriate controls.

This work was supported by a grant from the Special Trustees of the United Bristol Hospitals NHS Trust. We thank the surgeons who allowed us access to their patients.

Appendix

SAMPLE QUESTIONS AND ANSWER OPTIONS

Do you ever have diarrhoea?	Never Rarely (less than six times per year) Occasionally (less than 25% of the time) Often (25–50% of the time) Usually (more than 50% of the time) Always
Are you ever constipated?	Never Rarely (less than six times per year) Occasionally (less than 25% of the time) Often (25–50% of the time) Usually (more than 50% of the time) Always
Are your stools ever runny, like porridge or a cow-pat?	Never Rarely (less than six times per year) Occasionally (less than 25% of the time) Often (25–50% of the time) Usually (more than 50% of the time) Always
Do you ever leave the toilet with the feeling in your back passage that you have not emptied your bowel completely?	Never Occasional bowel movements Often (25–50% bowel movements) Most bowel movements All bowel movements
In the past three months have there been any days when you have had pain in the tummy or abdomen which went away or lessened when you had your bowels open?	None 1–2 days 3–5 days 6–10 days 11 days or more
In the past three months have there been any days when your tummy or abdomen has felt bloated or distended, except after large meals or before a period?	None 1–2 days 3–5 days 6–10 days 11 days or more

- 1 Luman W, Adams WH, Nixon SN, et al. Incidence of persistent symptoms after laparoscopic cholecystectomy: a prospective study. *Gut* 1996;**39**:863–6.
- 2 Ros E, Zambon D. Postcholecystectomy symptoms. A prospective study of gallstone patients before and two years after surgery. *Gut* 1987;**28**:1500–4.
- 3 Fort JM, Azpiroz F, Casellas F, et al. Bowel habit after cholecystectomy: physiological changes and clinical implications. *Gastroenterology* 1996;**111**:617–22.
- 4 Sandler RS, Drossman DA. Bowel habits in young adults not seeking health care. *Dig Dis Sci* 1987;**32**:841–5.
- 5 Philipp R, Wood N, Heaton KW, et al. Perceptions and reactions of the public to diarrhoea. *J R Soc Health* 1993;**113**:128–31.
- 6 Talley NJ, Weaver AL, Zinsmeister AR, et al. Self-reported diarrhea; what does it mean? *Am J Gastroenterol* 1993;**89**:1160–4.
- 7 Manning AP, Wyman JB, Heaton KW. How trustworthy are bowel histories? Comparison of recalled and recorded information. *BMJ* 1976;**3**:213–14.
- 8 Heaton KW, Radvan J, Cripps H, et al. Defecation frequency and timing, and stool form in the general population: a prospective study. *Gut* 1992;**33**:818–24.
- 9 Heaton KW, Parker D, Cripps H. Bowel function and irritable bowel symptoms after hysterectomy and cholecystectomy—a population-based study. *Gut* 1993;**34**:1108–11.
- 10 Thompson WG, Creed F, Drossman DA, et al. Functional bowel disease and functional abdominal pain. *Gastroenterol Int* 1992;**5**:75–91.
- 11 Thompson WG, Longstreth GF, Drossman DA, et al. Functional bowel disorders and functional abdominal pain. *Gut* 1999;**45**(suppl II):II43–7.
- 12 O'Donnell LJD, Virjee J, Heaton KW. Detection of pseudo-diarrhoea by simple clinical assessment of intestinal transit rate. *BMJ* 1990;**300**:439–40.
- 13 Lewis SJ, Heaton KW. Stool form scale as a useful guide to intestinal transit time. *Scand J Gastroenterol* 1997;**32**:920–4.
- 14 Lampe JW, Fredstrom SB, Slavin JL, et al. Sex differences in colonic function: a randomised trial. *Gut* 1993;**34**:531–6.
- 15 Heaton KW, O'Donnell LJD, Braddon FEM, et al. Symptoms of irritable bowel syndrome in a British urban community: consultants and nonconsulters. *Gastroenterology* 1992;**102**:1962–7.
- 16 Drossman DA, Li Z, Andruzzi E, et al. US householder survey of functional gastrointestinal disorders. *Dig Dis Sci* 1993;**38**:1569–80.
- 17 Heaton KW, Ghosh S, Braddon FEM. How bad are the symptoms and bowel dysfunction of patients with the irritable bowel syndrome? A prospective, controlled study with emphasis on stool form. *Gut* 1991;**32**:73–9.
- 18 Manning AP, Thompson WG, Heaton KW, et al. Towards positive diagnosis of the irritable bowel. *BMJ* 1978;**2**:653–4.
- 19 Breuer NF, Jaekel S, Dommers P, et al. Faecal bile acid excretion pattern in cholecystectomised patients. *Dig Dis Sci* 1986;**21**:953–60.
- 20 Edwards CA, Brown S, Baxter AJ, et al. Effect of bile acid on anorectal function in man. *Gut* 1989;**30**:383–6.
- 21 Suhr O, Danielsson A, Nyhlin H, et al. Bile acid malabsorption demonstrated by SeHCAT in chronic diarrhoea, with special reference to the impact of cholecystectomy. *Scand J Gastroenterol* 1988;**23**:1187–94.
- 22 Degen LP, Phillips SF. How well does stool form reflect colonic transit? *Gut* 1996;**39**:109–13.
- 23 Heaton KW, Braddon FEM, Mountford RA, et al. Symptomatic and silent gallstones in the community. *Gut* 1991;**32**:316–20.
- 24 Heaton KW, Cripps HA. Straining at stool and laxative taking in an English population. *Dig Dis Sci* 1993;**38**:1004–8.
- 25 Heaton KW, Emmett PM, Symes CL, et al. An explanation for gallstones in normal-weight women: slow intestinal transit. *Lancet* 1993;**341**:8–10.
- 26 Dowling RH, Veysey MJ, Pereira SP, et al. Role of intestinal transit in the pathogenesis of gallbladder stones. *Can J Gastroenterol* 1997;**11**:57–64.
- 27 Talley NJ, Nyren O, Drossman DA, et al. The irritable bowel syndrome: toward optimal design of controlled treatment trials. *Gastroenterol Int* 1993;**6**:189–211.
- 28 Talley NJ, Weaver AL, Zinsmeister AR, et al. Onset and disappearance of gastrointestinal symptoms and functional gastrointestinal disorders. *Am J Epidemiol* 1992;**136**:165–77.
- 29 Talley NJ, Zinsmeister AR, Van Dyke C, et al. Epidemiology of colonic symptoms and the irritable bowel syndrome. *Gastroenterology* 1991;**101**:927–34.
- 30 van Tilburg AJP, de Rooij FWM, van den Berg JWO, et al. Primary bile acid malabsorption: a pathophysiologic and clinical entity? *Scand J Gastroenterol* 1992;**27**(suppl 194):66–70.