Diet and health of people with an ileostomy

2. Ileostomy function and nutritional state

BY N. I. McNEIL*, SHEILA BINGHAM, T. J. COLE, A. M. GRANT AND J. H. CUMMINGS

Dunn Clinical Nutrition Centre, Old Addenbrooke's Hospital, Trumpington Street, Cambridge, CB2 1QE and Department of Clinical Biochemistry, New Addenbrooke's Hospital, Cambridge, CB2 2QQ

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1. Most subjects who have their large intestine removed and an ileostomy formed lead a healthy life after operation, although they are prone to a variety of metabolic problems. In order to determine the factors likely to lead to these metabolic disturbances a detailed assessment of ileostomy output and composition and of dietary intake in relation to nutritional and metabolic status has been made in a group of ileostomy patients living at home.

2. Thirty-six volunteers with established ileostomies (twenty-six ulcerative colitis (UC) patients and ten Crohn's colitis (CC) patients) made a 24 h collection of urine and ileostomy effluent and kept a 7 d record of dietary intake and the frequency with which they emptied their ileostomy bag. Blood was collected for haematological and biochemical indices of nutritional status and height, weight and skinfold thickness were measured.

3. Effluent output for the whole group was 760 ± 322 g/day (range 273–1612) and was very closely related to effluent sodium output (*R* 0·98). Stepwise multiple regression analysis of dietary and other variables identified the amount of ileum resected as the main determinant of both effluent output and effluent sodium. The CC group had significantly greater effluent output (1084 ± 340 g/d) compared with the UC patients (635 ± 215 g/d) ($P < 0.001$); and excreted significantly more nitrogen, carbohydrate and sodium than the UC group.

4. The CC patients particularly showed evidence of salt depletion. The mean ($\pm$SD) 24 h urine Na loss for CC patients was 31 ± 30 mmol and for UC patients 67 ± 34 mmol ($P < 0.01$) with five of the ten CC patients *v.* four of the twenty-six patients with UC having raised urinary or plasma aldosterone levels.

5. All subjects had normal haematological and biochemical indices of nutritional status in the blood. Height and percentage body fat were also within the normal range when compared with a control population matched for age, sex and occupation, but patients with an ileostomy weighed on average 4·1 kg less than the controls.

6. These studies show that patients with an ileostomy come within the range of the normal population for most nutritional indices although are at increased risk of salt depletion. Effluent volume, which is probably the determining factor in most metabolic complications of ileostomy, is related more to the extent of the small bowel resection than to diet.

Despite having had their large intestine removed the majority of patients with an ileostomy lead a normal life, have regular employment and an active social life (Beahrs, 1971; Ritchie, 1971). They are, however, prone to episodes of salt and water depletion, bowel dysfunction (Gallagher *et al.* 1962; Clarke *et al.* 1967), have increased urinary calcium, uric acid and oxalate concentrations (Bambach *et al.* 1981) and get more renal and biliary stones than the general population (Deren *et al.* 1962; Maratka & Nedbal, 1964; Hill & Goligher, 1975; Jones *et al.* 1976).

These disorders probably arise as a result of loss of colonic fuction with the resulting failure to re-absorb fluid and electrolytes which normally pass from the ileum. Ileostomy output has been determined quantitatively on several occasions (see Table 1 and Hill, 1976) in an attempt to explain these disturbances in metabolism, but such studies have usually been undertaken on small numbers of hospitalized patients soon after operation. Few investigators have looked at ileostomy patients at home where a different diet (Kramer *et al.* 1962; Thomson *et al.* 1970), stress (Cummins, 1954) and exercise may alter ileostomy

* Present address: Department of Medicine, University College London Medical School, The Rayne Institute, London, WC1E 6JJ.

Table 1. *Ileostomy output (g/d) in patients with established ileostomies*

Source	Reason for ileostomy	No. of subjects	Output (g/d) Mean	SD	Range
Crawford & Brooke (1957)*	Ulcerative colitis	7			200–500
Smiddy *et al.* (1960)*	Ulcerative colitis	2			300–500
Nuguid *et al.* (1961)*	Ulcerative colitis	6	600 (ml)		280–1130
Kramer *et al.* (1962)	Ulcerative colitis	7	507		252–838
Kanaghinis *et al.* (1963)*	Ulcerative colitis and polyposis coli	8	465	219	53–1162
Hill *et al.* (1974)*	Ulcerative colitis and Crohn's disease	10	743	477	260–1590
Hill, Mair, Edwards *et al.* (1975)	Ulcerative colitis and Crohn's disease	10	570	275	312–1264
Tytgat *et al.* (1977)	Ulcerative colitis and Crohn's disease	7	716		409–1158

* Study undertaken in hospital.

output. In addition, many patients have an ileostomy made because of Crohn's colitis (CC), a proportion of whom will have had an ileal resection also, and many have residual or recurrent small bowel disease (Lockhart-Mummery & Morson, 1960). Little is known about how they fare, in regard to ileostomy function, when compared with those who have their colectomy and ileostomy for ulcerative colitis (UC).

We have therefore, as part of a study of the nutrition and metabolism of patients with an ileostomy, measured ileostomy output and composition, frequency of bag emptying, urine volume and composition and the nutritional status of thirty-six ileostomy subjects whilst they were living at home. The studies were carried out in conjunction with a detailed assessment of their dietary intake, the full results of which are reported elsewhere (Bingham *et al.* 1982).

EXPERIMENTAL

Subjects

Thirty-six patients with an ileostomy were recruited, by letter, through the Cambridge branch of the Ileostomy Association. There were seventeen men and nineteen women, with thirteen of each sex having had the ileostomy for UC and four men and six women for CC. Total colectomy had been performed in all subjects except one man with UC in whom the colon had been left in situ. The average age of the subjects was $49{\cdot}4 \pm 14{\cdot}8$ years (mean $\pm$ SD) but the CC subjects were younger than the patients with UC (mean age CC $36{\cdot}4 \pm 9{\cdot}1$ years, UC $55{\cdot}1 \pm 12{\cdot}6$ years, range (years) CC 21–52, UC 29–75). The interval between operation and the present study was CC $8{\cdot}7 \pm 6{\cdot}1$ years and UC $10{\cdot}6 \pm 8{\cdot}9$ years. Seven further operations on the ileostomy or residual intestine had been performed on five of the CC patients and nine on seven of the UC patients. The interval between the most recent operation and the study was CC $5{\cdot}8 \pm 5{\cdot}4$ years, UC $8{\cdot}9 \pm 7{\cdot}7$ years. The amount of ileum resected and state of the residual small intestine at surgery were obtained from a detailed study of the patient's operative, X-ray and pathological records. Eight of the CC subjects had small intestinal, usually terminal ileal, involvement at the time of colectomy or subsequent operation, but all disease was considered to have been surgically excised. One subject was thought to have had ileitis as seen by contrast radiography and one had not had evidence of small intestinal disease. At the time of the study no CC subject had symptoms suggestive of active disease in the small intestine. The extent of ileal resection was $40 \cdot 2 \pm 42 \cdot 8$ cm, range 1·0–150·0 cm in the CC group and $6 \cdot 4 \pm 7 \cdot 6$ cm, range 0–25·0 cm in the UC group. Eleven of the subjects were taking codeine phosphate (5 CC, 6 UC) and two Lomotil (both CC) in an attempt to reduce effluent volume.

Protocol

For 7 d each subject weighed and recorded all food and drink eaten and kept a record of the times when the ileostomy reservoir bag was emptied. On the seventh day, synchronous complete 24 h collections of urine and ileostomy effluent were made. The following day the subjects were visited to recover the collection, which ended that morning, and a blood sample was taken for nutritional, biochemical and haematological indices. Height and weight were recorded and skinfold thickness measured with a caliper, in triplicate, over the triceps and biceps of the left arm. A control population, matched for age, sex and occupation, was obtained from a local village for comparison of anthropometric indices (Bingham *et al.* 1982).

The 24 h collection of urine was made into a 2·5 l plastic bottle containing 1 g boric acid as preservative. Urine volume was measured and then the urine was thoroughly mixed before portions were taken and stored at $-20°$ before analysis. The 24 h ileostomy output was collected by the subjects who drained their ileostomy bags directly into a polyethylene bag which was tied and placed immediately in a container filled with dry ice. Subjects were asked not to use ileostomy deodorants during the collection.

Biochemical methods

Each 24 h ileostomy collection was weighed, thawed, homogenized and with the homogenizer running samples were taken for freeze-drying and for sodium, potassium, chloride and calcium analysis. Calcium measurements were made on a Pye SP90 atomic absorption Spectrometer and chloride with the Buchler-Cotlove Chloridometer, using a dilute nitric acid extract of the ileostomy effluent. Freeze-dried ileostomy output was analysed for nitrogen by the standard Technicon autoanalyser method, for free sugars and starch by the method of Hudson *et al.* (1976) and for fat using the Fosslet determination (Usher *et al.* 1973).

Using the appropriate methods, Technicon SMA Autoanalyser equipment was used for the following measurements on plasma, ileostomy effluent and urine: Na and K (SD4-0007 PK 7, 1974), CO_2 (SD4-0008 PK 7, 1974), urea (SD4-0001 PK 7), 1974, creatinine (SD4-0011 PK 7), 1974, Ca (Gitelman, 1967), phosphate, alkaline phosphatase (*EC* 3.1.3.1) (AAII-06, 1970), protein (SE4-0014 FC4, 1974), bilirubin (Technicon Instrument Co., 1964), iron and Fe-binding capacity (AAII-25, 1972) and cholesterol (AAII-24, 1971). Values were compared with the normal ranges established in the laboratory for each measurement. For analysis the ileostomy effluent was carefully mixed, centrifuged and the supernatant fraction sampled. Where necessary the effluent was homogenized with additional distilled water.

Blood for aldosterone measurement was taken from ambulant, non-fasting subjects during the day. Plasma was immediately separated and stored at $-20°$. Both plasma and urine aldosterone were measured by radioimmunoassay, at the Leeds Supra-Regional Assay Service for Steroid Hormones. Dichloromethane extracts of plasma were purified by Sephadex LH-20 column chromatography and the aldosterone fraction estimated by radioimmunoassay using an antiserum raised in rabbits against aldosterone conjugated to bovine albumin via the 3-oxime. Urine samples were hydrolysed at pH 1 (which releases aldosterone from the conjugated form, the 18-glucuronide) and the free steroid was extracted into dichloromethane. Manipulative losses were assessed and corrected for by conventional tracer techniques. The normal range for 24 h urinary aldosterone output is

Table 2. *Output/24 h and composition of ileostomy effluent*

	Ulcerative colitis		Crohn's disease	
	Mean	SD	Mean	SD
Wet weight (g)	635	215	1084	340***
Dry weight (g)	54·5	12·0	81·3	21·9***
Free sugars (g)	5·5	1·8	9·1	2·9***
Starch (g)	0·6	0·4	1·6	1·3**
Fat (g)	4·7	2·5	6·8	6·3
Nitrogen (g)	2·3	0·7	3·0	1·0*
Sodium (mmol)	74	30	124	46***
Potassium (mmol)	5·1	2·2	10·3	6·3
Calcium (mmol)	24·6	8·1	23·8	4·8
Chloride (mmol)	37	22	81	47***
Na:K (molar ratio)	16·0	5·5	14·3	7·2

UC *v.* CC: *$P < 0·02$, **$P < 0·01$, ***$P < 0·001$.

10–70 nmol for ambulant subjects and in plasma is 100–900 pmol/l. Plasma vitamin C was measured by the method of Pelletier (1968) as modified by Bates (1977).

Statistical analysis was by Student's *t* test, χ^2 test and multiple stepwise regression analysis. Results are expressed as means with one standard deviation.

RESULTS

Mean 24 h ileostomy output for the whole group was 760 ± 322 g, with the subjects emptying their bags on average 5·2 times/d. Table 2 shows that the ten CC subjects had a significantly higher output than those with UC and correspondingly higher excretion of total solids, including electrolytes, sugar, starch and N. Fat excretion, although higher in the CC patients was not significantly so. However, most subjects who had had more than 25 cm ileum removed showed fat excretions above the normal range. Na concentration in ileostomy fluid was remarkably constant at approximately 118 mmol/kg for all subjects. As a result of this there was a close linear correlation between ileostomy output and ileal sodium losses (R 0·98, $P < 0·001$) (see Fig. 1).

This excessive loss of Na in the ileostomy effluent led to evidence of Na deficiency in some patients (Table 3). Urine Na losses during 24 h were significantly lower in the CC patients than the UC patients, with two of the ten CC patients having no detectable Na in their urine and four more with 20 mmol or less/d. Na:K values in the ileostomy effluent were not different between the two groups, but in the urine Na:K value was significantly lower in the CC subjects. Nine of the thirty-six patients had either a raised plasma aldosterone or raised 24 h urinary aldosterone output or both; five of them had CC. When these subjects with high plasma or urinary aldosterone were compared with the remaining twenty-seven it was noted that ileostomy K concentration was higher in the high-aldosterone group ($12·7 \pm 8·1$ mmol/kg) in contrast to the remaining subjects ($7·7 \pm 3·1$ mmol/kg) (t 2·69, $P < 0·02$). Effluent output was also significantly greater in the high aldosterone group, 959 ± 446 g/d, than in the others, 693 ± 246 g/d (t 2·26, $P < 0·05$). Since urinary K losses were similar in the groups, over-all daily K output was much greater in the subjects with high aldosterone levels. Urinary Na loss during 24 h also differed significantly at 31 ± 36 mmol in the high-aldosterone group and 66 ± 33 mmol in the remaining patients (t 2·66, $P < 0·02$).

The main determinant of sodium losses in these subjects was the volume of ileostomy

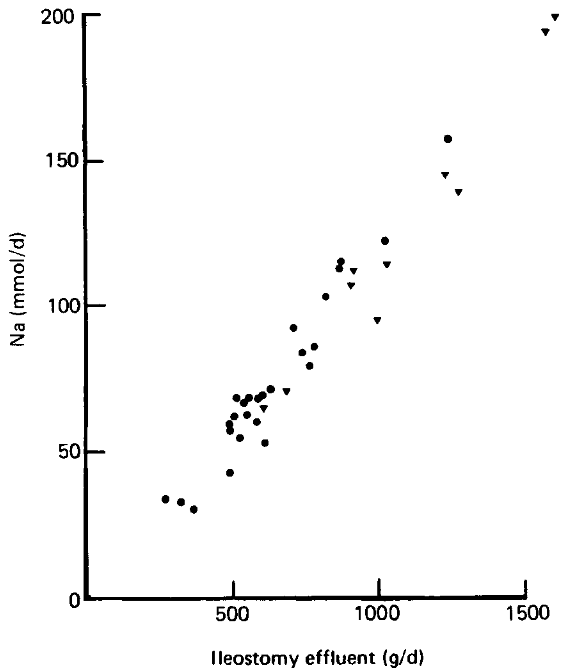

Fig. 1. Relationship between daily ileostomy sodium loss (mmol/d) and daily ileostomy effluent loss (g/d) in patients with an established ileostomy after colectomy for either ulcerative colitis (●) or Crohn's colitis (▼). *R* 0·98.

effluent. In order to learn what dietary or other factors might, in turn, control effluent volume stepwise multiple regression analysis was used to identify significant associations between on the one hand ileostomy output, and ileal Na output, and on the other anthropometry, diagnosis, current treatment and nineteen variables related to dietary intake (see Bingham *et al.* 1982). Initially all patients were included. For the whole group the length of ileum resected had the main effect on output, the greater the amount of ileum resected, the greater effluent output ($5 \cdot 0 \pm 1 \cdot 9$ g effluent/cm ileum resected). Male sex resulted in significantly greater output than female sex (305 ± 130 g, $P < 0 \cdot 05$) and greater sodium losses, although this effect was counteracted by a negative contribution of height to ileal output. The predominant nutritional factor relating to output was sugar. Subjects obtaining more of their dietary energy from sugar tended to have reduced effluent and ileal Na outputs. Other nutrients affecting output, although weakly, were energy, total fibre and the pentose component of fibre, all of which were associated with increased output. The CC subjects were distinguished from the UC by length of ileum resected and age at operation. To remove these sources of variation the analysis was repeated omitting the CC patients. For the UC patients alone both ileostomy output and ileal Na were found to be significantly greater with male sex and less with years since the operation and taking codeine.

Results from the blood analysis show that the plasma creatinine value exceeded the normal range in seventeen people (47%) and alkaline phosphatase in twelve subjects (33%). All other measurements including serum phosphate, total protein, albumin, calcium, bilirubin and plasma electrolytes and urea were normal as were vitamin B_{12}, plasma and erythrocyte folate levels. Plasma vitamin C levels were normal for all the subjects except three. One female subject had a low haemoglobin (11·8 g/l) and serum Fe (9·6 μmol/l). A comparison between the subjects and the controls is shown in Table 4. One female subject

Table 3. *Electrolytes and aldosterone content of 24 h urine and blood*

	Ulcerative colitis		Crohn's disease	
	Mean	SD	Mean	SD
Urine volume (ml)	1287	590	926	446
Urine sodium (mmol)	67	34	31	30*
Urine potassium (mmol)	57	11	58	27
Na:K (molar ratio)	1·20	0·59	0·48	0·48*
Urine aldosterone (nmol/d)	33·4	21·6	172·4	262·8
	(1 elevated)		(4 elevated)	
Plasma aldosterone (pmol/l)	487	388	990	1140
	(4 elevated)		(2 elevated)	
Plasma sodium (mmol/l)	140	2	139	2
Plasma potassium (mmol/l)	4·0	0·7	4·1	0·4
Plasma bicarbonate (mmol/l)	25·5	2·6	26	2·2
Plasma creatinine (μmol/l)	87·2	25·3	92·3	19·7
Plasma urea (mmol/l)	5·4	1·3	4·2	1·2

Values for the two groups were statistically significantly different. *$P < 0·01$.

Table 4. *Comparison of subjects with ileostomies and age-matched controls*

	Ileostomy		Control	
	Mean	SD	Mean	SD
Age (yrs)	49·4	14·8	50·3	14·6
Height (cm)	165·0	10·1	166·5	8·6
Weight (kg)	54·3	10·6	58·4	10·7*
Body fat (%)	28·2	7·6	29·4	6·4

Values for the two groups were statistically significantly different. *$P < 0·01$.

had only 16·2% body fat (Durnin & Womersley, 1974) which is below the normal range (Department of Health and Social Security, 1976).

DISCUSSION

This study has shown that most patients with an ileostomy are in good health with little evidence of any nutritional deficiency. Absence of the large intestine does however mean that they lose large amounts of Na in their ileostomy effluent rendering them vulnerable to salt depletion, especially if there is associated ileal resection.

Over all, the subjects in the present study had higher effluent outputs (760 g daily) than those recorded by other investigators (Table 1). Output in the UC patients was similar to previous studies at 635 g/d but the CC patients produced 1084 g/d with eight of the ten subjects over 900 g/d. The only report of ileostomy output in CC (Hulton *et al.* 1971) compared ileostomy losses in the first twelve post-operative days for CC and UC subjects and found no difference between the two groups.

The statistical association of increased ileostomy output with increasing amounts of ileum resected explains why the CC patients had greater outputs than the UC patients, and confirms that the terminal ileum is an important organ for normal conservation of salt and water. Hill *et al.* (1974), Hill, Mair *et al.* (1975) noted that longer ileal resections were associated with increased ileostomy output and ileal resection is known to increase the severity of diarrhoea in subjects who have an associated colonic resection (Cummings *et al.* 1973). In addition, residual small bowel Crohn's disease may add to the malabsorptive picture (Allan *et al.* 1975).

In the UC patients, who were mostly without significant ileal resection, effluent volume was related to male sex, time since operation and taking codeine. There was a weak association with obesity index but no relation with body-weight as noted by Hill *et al.* (1979). These associations however were not as significant as that of resected ileum in the whole group. The contribution of dietary variables to ileostomy output and Na output was weak and inconsistent statistically. This is important to note in the medical management of these subjects since the major determinant of output, ileal resection, is decided at operation.

These subjects were all losing considerable amounts of Na in their ileostomy effluent (mean for group 145 ± 40 mmol/d). These Na losses are obligatory, unlike those in urine, and, as may be seen from Fig. 1, are directly related to total effluent volume so subjects with the highest daily output, mainly those with CC, have higher salt losses (the highest was 224 mmols in a day) and are at increased risk of salt and water depletion with nausea, loss of appetite and hypotension. Depletion of total body Na in patients with ileostomies has been reported by Clarke *et al.* (1967) and Turnberg *et al.* (1978). Aldosterone measurements showed that 25% of subjects had a high value in either plasma or urine. High aldosterone levels were associated with high ileostomy K concentrations which may reflect physiological changes in the ileum comparable to the effect of aldosterone on the kidney and colon. Increased transmucosal potential difference in aldosterone-treated patients has been observed by Edmonds & Godfrey (1970). Isaacs *et al.* (1976) showed that patients with ileostomies had increased potential differences across their ileal mucosa, although plasma aldosterone values were normal. Administration of fludrocortisone to ileostomists increases K losses (Kramer & Levitan, 1972). By increasing transmucosal potential difference aldosterone may favour the accumulation of higher levels of intraluminal potassium, or alternatively may directly affect active K transport in the mucosa such as occurs in the large intestine (Edmonds, 1981). The study of Turnberg *et al.* (1978) which showed some patients with an ileostomy to have normal plasma aldosterone levels despite intracellular sodium depletion suggests that they may have adapted to a stable but depleted Na state.

Excretion of solids, at 50–80 g/d, is two to three times greater than normal faecal losses. The main reason for this is probably the presence of undigested dietary fibre. Fat, K and Ca losses in ileostomy approximate to faecal losses (Sammons, 1961; Cummings *et al.* 1976) except where there is substantial ileal resection (more than 25 cm). Na, chloride, N and carbohydrate losses are greater than in faeces. The presence of free sugars in significant quantities in ileostomy effluent is perhaps surprising since these should be completely absorbed in the normal upper small bowel. The methods used in this study did not allow us to determine whether the sugars were disaccharides such as lactose or free glucose, possibly derived from starch. Malabsorption of sugars in these patients may be due to abnormalities of small bowel morphology and function known to occur in ulcerative colitis (Salem & Truelove, 1965; Frazer *et al.* 1966), and which might be present in Crohn's disease, or may reflect the recently observed partial failure to digest and completely absorb certain sources of carbohydrate (Anderson *et al.* 1981), in normal people.

When the diet of these subjects was assessed (Bingham *et al.* 1982) it was found that daily dietary fibre consumption was $17 \cdot 6 \pm 2 \cdot 4$ g for UC patients and $19 \cdot 9 \pm 8 \cdot 8$ g for CC patients. It is unlikely that much of this fibre is metabolized in the small intestine, especially as there were still free sugars and starch present in the effluent. Fibre therefore accounts for 25–33% of the excreted solids. Two CC subjects were taking 12 g/d Isogel (Ispaghula) which will also appear unchanged in the ileostomy effluent adding a further 2·5 g to the over-all mean dry weight of the whole group. In faeces, bacteria account for 55% of dry weight (Stephen

& Cummings, 1980) but with bacterial counts twenty – thirty times lower in ileostomy fluid than faeces (Gorbach *et al.* 1967; Levine *et al.* 1970) bacteria are unlikely to account for more than 1–2% of total ileostomy solids. Assuming dietary fibre is excreted unchanged in the ileostomy it is possible to account for 95% of the solids in UC patients and 90% in CC patients.

Nutritional assessment of the subjects indicates that almost all were in good health. Nearly all the biochemical and haematological analyses in these patients fell within the range of the population at large. Plasma creatinines were higher than normal though electrolytes and urea measured on the same sample were usually normal. This may be because patients with an ileostomy have reduced total body water and total exchangeable Na (Clarke *et al.* 1967; Hill, Goligher *et al.* 1975; Turnberg *et al.* 1978). One third of the subjects showed an elevated alkaline phosphatase, however abnormalities of calcium metabolism are rare in these patients and they are not known to suffer from bone disease in later life (Ritchie, 1971; Cooke *et al.* 1980). Similarly vitamin B_{12} deficiency is rare in these patients unless there is substantial associated ileal resection. In fact increased B_{12} absorption has been reported for ulcerative colitis patients with an ileostomy (Kennedy *et al.* 1981).

One metabolic problem which does affect these patients is an increased risk of renal calculi. Because of the large losses of water from the ileostomy these subjects have small urine volumes compared to controls and therefore higher pH and concentrations of calcium oxalate and uric acid (Bambach *et al.* 1981). Small bowel resection increases these problems and the risk of stone formation further.

Ileostomy subjects weigh 4 kg less than their controls. This is likely to be for several reasons. Patients with an ileostomy have an organ missing which probably weighs $\frac{1}{2}$–1 kg. They show chronic water and salt deficiency (Clarke *et al.* 1967; Turnberg *et al.* 1978). They also lack the energy salvaging system present in the normal large intestine where sugars, starch and dietary fibre are fermented, wholly or in part, by the microflora to short chain fatty acids which are subsequently absorbed, and can act as an energy source (McNeil *et al.* 1978; Bond *et al.* 1980).

Over all therefore, removal of the large intestine, unless accompanied by ileal disease or resection, has few ill-effects for these subjects beyond the inconvenience of an ileostomy, increased risk of urinary and gall bladder stones and of salt depletion. These findings however should be judged against a background of the diet and habits prevalent in the United Kingdom at present. In countries where the diet contains more complex polysaccharide and the climate is hotter loss of the large intestine may be more detrimental to health.

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