Body composition in ileostomy patients with and without ileal resection

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SUMMARY Body composition was measured in 24 patients who had previously undergone proctocolectomy and ileostomy. One group (control group) had undergone resection of only small amounts of terminal ileum (median 4 cm), the other group of patients (resected group) had undergone resection of greater lengths of small bowel (median 54 cm). These values of body composition were then compared with predicted values in normal subjects. Proctocolectomy and ileostomy without ileal resection did not significantly affect body weight, or the body contents of fat or water, but led to a reduction in total body nitrogen and total body potassium, suggesting a reduction in fat free mass. A modest resection of the terminal ileum undertaken during the course of proctocolectomy decreased body weight largely because of a reduction in body fat. None of the ileostomy patients was found to be dehydrated.

Proctocolectomy and the establishment of an ileostomy leads to increased fluid and electrolyte losses even when adaptation is complete, and such patients are susceptible to salt and water depletion.¹ Should a resection of the terminal ileum accompany proctocolectomy impairment of the adaption process can occur resulting in even greater ileostomy outputs.² Even after a modest resection of the terminal ileum (50-60 cm) patients can suffer disproportionately high outputs of water and electrolytes.²⁻⁵ Recent evidence has also shown that such patients excrete increased amounts of fat and nitrogen⁶ compared with ileostomy patients who have not undergone a resection. Important clinical implications are thus apparent as continual loss of nutrients and electrolytes could lead to serious nutritional deficits. Surprisingly, however, there is little information regarding their nutritional state and in particular their body composition. Most studies of ileostomy patients have concentrated on the estimation of total body water and electrolytes⁷⁻⁹ using isotope dilution techniques, and have not measured the body contents of fat, nitrogen, and minerals. Furthermore, although one study measured body composition in ileostomy patients with the short bowel syndrome¹⁰ no studies are available

which have measured body composition after a modest resection of the terminal ileum. Because the latter is a frequent adjunct to the operation of proctocolectomy its effect upon the nutritional state of these patients has important clinical relevance.

The aims of the present study were, therefore, to measure the body composition of one group of ileostomy patients without ileal resection, and a second group who had undergone a modest ileal resection and then compare these values with predicted values in normal subjects.

Methods

PATIENTS

Twenty four patients with well established ileostomies agreed to take part in the study, the protocol having been approved by the Leeds Western District Ethics Committee. All the subjects had undergone proctocolectomy for ulcerative colitis apart from one patient who had suffered from Crohn's colitis. This patient's small bowel was radiologically normal at the time of the study.

Twelve patients had undergone only minimal resection of the ileum (control group: median 4 cm [range 2-10 cm]) and 12 patients had undergone resection of a greater length of ileum mainly for a failed ileal reservoir (resected group: 54 cm [50-120 cm]; $p < 0.002$). Subjects in the resected group

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Table 1 Clinical details of the two study groups

	Control group n=12	Resected group n=12
Age (years) mean±SD	42.4±13.5	42.1±17.2
Sex M:F	6:6	6:6
Height (cm) mean±SD	171.0±9.5	172.0±12.0
Time interval between op & study (years) median (range)	5.8 (1.5–15)	2.5 (1.5–16)

were individually matched with control subjects for age, sex and height (Table 1). The median time interval between operation and the study in the control group (5.8 years [range 1.5–15 years]) was greater, but not significantly so, than that of the resected group (2.5 years [1.5–16 years]; *p*-NS). Six of the patients (five resected, one control) were taking antidiarrhoeal medication in an attempt to reduce ileostomy output. Two patients were taking non-steroidal anti-inflammatory drugs for arthritis, and a further two bronchodilators for asthma. All patients were fit, and many were in full-time employment.

On the day of the study each patient had their weight and height recorded. A sample of venous blood was taken for estimation of haemoglobin concentration and plasma concentration of urea, electrolytes, calcium, phosphate, total protein and albumin. Total body water was calculated from the dilution in the body of 100 µCi of tritiated water given intravenously. A plasma sample was taken at three and five hours after injection and duplicate aliquots of the plasma samples and appropriate standards were added to a NE260 (Nuclear Enterprises (GB) Ltd) scintillator and measured on a liquid scintillation counter. Skin fold thicknesses were measured at the biceps, triceps, subscapular, and suprailiac sites using Holtain skin fold calipers from which body density was calculated using the regression equations of Durnin and Womersley.¹¹ From this estimate total body fat was then calculated using Siri's equation.¹²

Using neutron activation analysis^{13 14} measurements were made of the body contents of nitrogen, sodium, chlorine, phosphorus, and calcium, and the content of potassium by virtue of its natural radioactive constituent ⁴⁰K.¹⁵ Each patient, lying supine, was irradiated bilaterally with a horizontal beam of 14 Mev neutrons to a dose equivalent of 5 mSv. The patient was then transferred to a whole body radiation counter where the radioactivity induced in the body by the neutrons was measured for 30 minutes, and the resulting gamma ray spectrum was analysed to give the masses of the six elements. The procedure was approved by the Administration of

Radioactive Substances Advisory Committee of the Department of Health and Social Security.

In the week immediately after the study 24 hour ileostomy outputs were recorded on a normal diet, and the patients kept a seven day dietary diary, charting in detail everything they ate and drank during that period. This diary was then analysed by an experienced dietitian and with the aid of a computer the mean daily quantity of food eaten was calculated.

The values of body weight, total body fat, water, nitrogen, and potassium of the patients in the study were compared with predicted values for normal subjects matched for age, sex, and height. The predicted values were determined from regression equations based upon previous measurements of 91 normal volunteer subjects of similar ages (21–68 years) and height (150–188 cm), and both sexes (29 women:62 men) in our laboratory.¹⁶ The volunteers were measured as described above except that a lower dose of neutrons was administered and total body water was calculated by subtracting total body fat, total body protein (total body nitrogen × 6.25), and total body minerals from body weight (total body water diff). Hence in comparing the values for total body water in the patients with those predicted the values estimated by difference were used.

STATISTICAL ANALYSIS

The Mann-Whitney U test for non-parametric data¹⁷ was used to compare the differences between the groups with regard to the length of ileal resection, the time since surgery, and the 24 hour ileostomy output. All other data were compared using Student's *t* test for parametric data.¹⁷ Degrees of significance are all two-tailed values.

Results

ILEOSTOMY OUTPUT

The 24 hour ileostomy output was significantly greater in patients who had undergone ileal resection (median 900 g [range 609–5790 g]) compared with patients who had undergone no ileal resection (570 g [396–894 g]; *p*<0.002).

HAEMATOLOGICAL INDICES (Table 2)

Values of all the haematological indices measured were similar for patients in the resected group compared with patients in the control group, and all values were within the normal range of our laboratory.

DIETARY INTAKE (Table 3)

Mean daily intake of fluid, major foodstuffs and minerals were consistently 15–20% greater in the

Table 2 Haematological and biochemical indices

	Control group	Resected group	Normal for laboratory
Hb. (g/dl)	13.7±1.1	13.7±1.1	12-17
Plasma Na+ (mmol/l)	139±1.7	139±2.8	135-145
K+ (mmol/l)	3.9±0.3	3.9±0.3	3.6-5.0
Cl- (mmol/l)	101±1.2	100±3.2	98-107
Ca2+ (mmol/l)	2.4±0.1	2.3±0.1	2.25-2.60
Urea (mmol/l)	4.5±1.3	4.6±1.0	2.5-7.1
Serum albumin (g/l)	45±3	44±3	37-49
Serum protein (g/l)	76±6	73±6	67-82

Values mean±SD; all values p=NS

Table 3 Mean daily dietary intake

	Control group n=12	Resected group n=12
Fluid (ml)	1707±530	2298±1213
Total Kcal	2323±622	2958±1057
Nitrogen (g)	13.3±4.5	17.2±5.7
Fat (g)	108±31	125±47
CHo (g)	251±81*	346±134*
Na (mmol)	130±36	146±58
K (mmol)	80±25	107±33
Ca (mmol)	24±8	32±14

Values mean±SD; *p<0.05

resected group compared with the control group. Apart from the intake of carbohydrate, however, none of these differences were statistically significant.

BODY COMPOSITION

Control group versus resected group (Table 4)

Mean body weight was greater in the control group (68.4±14.3 kg) compared with patients who had undergone resection of the ileum (61.5±10.8 kg). This difference though not statistically significant was largely because of a reduction in total body fat in patients who had undergone a resection of the ileum (13.1±4.9 kg) compared with the control group (18.0±7.6 kg p=0.06). Remarkably similar values for all other measurements of body composition were found for the two groups.

Control group: observed versus predicted values (Table 5)

There was a significant reduction of mean total body nitrogen and total body potassium in the control

Table 4 Body composition results

	Control group n=12	Resected group n=12
Body wt (kg)	68.4±14.3	61.5±10.8
Total body fat (kg)	18.0±7.6*	13.1±4.9*
Total body nitrogen (g)	1511±385	1481±416
Total body water (l)	39.7±8.3	40.0±8.7
Total body water diff (l)	39.3±7.7	37.5±7.9
Total body potassium (g)	108±27	106±32
Total body sodium (g)	73±12	74±14
Total body chlorine (g)	65±9	65±12
Total body calcium (g)	913±199	901±146
Total body phosphorous (g)	489±103	476±115

Values mean ±SD; *p=0.06

Table 5 Body composition: control group: observed versus predicted values

	Observed	Predicted
Body wt (kg)	68.4±14.3	68.5±8.0
Total body fat (kg)	18.0±7.6	17.0±4.9
Total body nitrogen (g)	1511±385*	1671±377*
Total body potassium (g)	108±27†	118±29†
Total body water diff (l)	39.3±7.7	37.6±7.7

*p<0.01 †p<0.02

group (1511±385 g, and 108±27 g respectively) compared with predicted normal values (1671±377 g; (p<0.01), and 118±29 g (p<0.02) respectively). The predicted values of weight, total body fat and total body water diff were similar to those of controls.

Resected group: observed versus predicted values (Table 6)

The values for body weight and total body fat were significantly reduced in the patients who had undergone ileal resection (61.5±10.8 kg and 13.1±4.9 kg respectively) compared with predicted normal values (69.2±8.7 kg (p<0.01) and 17.0±5.6 kg (p<0.02) respectively). As with the control group,

Table 6 Body composition: resected group: observed versus predicted values

	Resected	Predicted
Body wt (kg)	61.5±10.8*	69.2±8.7*
Total body fat (kg)	13.1±4.9†	17.0±5.6†
Total body nitrogen (g)	1481±416*	1690±432*
Total body potassium (g)	106±32†	120±33†
Total body water diff (l)	37.5±7.9	38.2±9.0

*p<0.01; †p<0.02

patients who had undergone a resection of the ileum showed similar statistically significant reductions in total body nitrogen and total body potassium compared with predicted values. The value of total body water diff in the resected group however was similar to that predicted.

Discussion

This study has shown that proctocolectomy and ileostomy alone without ileal resection does not significantly affect body weight or the body contents of fat or water, but does lead to a reduction in total body nitrogen and total body potassium. It has also shown that a modest resection of the terminal ileum done during the course of proctocolectomy, reduces body weight largely because of a reduction in body fat. Despite quite large ileostomy outputs in this group of patients, however, other measurements of body composition remain unaltered.

While the long term nutritional effects of extensive small bowel resection have been documented,¹⁰ detailed investigation of body composition has not previously been carried out in groups of ileostomy patients similar to those we studied. It is not possible therefore to compare the results of many of the indices that we measured with those of other investigators. Determinations of body water and electrolytes have, however, been previously documented. Clarke *et al*⁷ reported an 11% reduction in total body water and a 7% reduction in total exchangeable sodium in ileostomy patients compared with healthy controls, and these findings were later confirmed by Hill *et al*.⁸ In our study dehydration was not present in the ileostomy patients even when the terminal ileum had been excised, findings which are in agreement with Turnberg *et al*.⁹ There are several possible explanations for these differences. Firstly Clarke *et al* and Hill and his colleagues measured total body water using an oral dose of radioactive water, which is less accurate than an intravenous injection used by ourselves and Turnberg *et al*.⁹ Secondly, in the study by Hill *et al* the predicted values of total body water were obtained from a control group consisting of only 22 male subjects, who had been measured as part of a previous study.¹⁸ Another criticism of this study is that nearly half the ileostomy patients had suffered from Crohn's disease, whereas in our study there was only one such patient. As it is now generally accepted that patients with this disease may have impaired intestinal function with abnormalities throughout their gastrointestinal tract^{19 20} the presence of disease in the residual small bowel alone may explain the differences observed. Even if the results of the single patient with Crohn's disease are

excluded from our study, the findings remain unchanged.

It is of interest that the present study has shown a significant reduction in total body potassium in ileostomy patients similar to that reported by Turnberg *et al*.⁹ As the reduction is of the same magnitude for both our groups of ileostomists, this suggests that it is attributable to proctocolectomy alone rather than to ileal resection. Furthermore, accompanying the fall in total body potassium there were comparable reductions in total body nitrogen in both groups of patients, and together these findings indicate a reduction of fat free mass. Exactly why proctocolectomy alone should be associated with this change is unclear. As the colon itself is part of the fat free mass its removal might be expected to reduce total body nitrogen and total body potassium. We have, however, analysed the amounts of nitrogen in the colon, and estimate that the total content in the wall of the colon and rectum accounts for only 15–20% of the overall change in total body nitrogen that we observed. The reduction in fat free mass suggests therefore that these patients are either malnourished or alternatively have a small but normally constituted fat free mass. This latter explanation could possibly result from either a failure of the fat free mass to develop, if the colitis affected patients at a young age when normal growth and development of lean tissue was occurring. Alternatively it could be because of an irrecoverable erosion of cells constituting the fat free mass if the colitis occurred in later life. Either way even though surgery produces an 'apparent cure' and returns these patients back to health, the fat free mass remains small because of the reduced number of cells and, consequently, it can never attain its predicted size.

If a modest ileal resection is done during the course of proctocolectomy and ileostomy. It is now known that an impairment of ileostomy adaption can occur resulting in increased excretion of water and electrolytes²⁻⁵ and also fat and nitrogen.⁶ The explanation for these findings is not fully understood, but a combination of factors probably contribute. These include a reduction in absorptive surface,²¹ rapid small bowel transit consequent upon resection of the 'ileal brake' mechanism^{22 23} and malabsorption of fat.²⁴ In this study we have confirmed the observation of others that ileostomy output is significantly greater in patients who have undergone a resection of the terminal ileum compared with patients who do not undergo a resection. Also, patients in the resected group showed a reduction in weight largely because of the alterations in their total body fat. Although both these reductions failed to reach statistical significance

when compared with the control group, we feel these are genuine reductions as the differences were highly significant when compared with the predicted values, where age, sex, and height are matched accurately with those of the resected patients. What seems remarkable, however, is that other indices of body composition in patients who had undergone ileal resection compared with their controls, remained unaltered despite the continual malabsorption of nutrients and electrolytes. The explanation for this probably lies in the fact that the patients in the resected group increased their dietary intake of all the major foodstuffs, minerals and fluid. Bingham *et al*²⁵ similarly found that the energy and water intake of ileostomy patients was proportional to the length of ileal resection. We believe that it is in this way ileostomy patients who have undergone ileal resection minimise the effect of nutrient malabsorption, and so maintain their nutrition. The reduction in body fat is almost certainly caused by impaired absorption of bile salts and a reduction in the bile salt pool consequent upon a terminal ileal resection.²⁶ Thus no matter how much dietary fat is increased, the loss of fat from the stoma is obligatory and cannot be compensated for. The exact length of terminal ileum that needs to be resected in order to deplete the bile salt pool was previously thought to be about 100 cm, but recent work suggests that it may be much shorter²⁷ and our results would indirectly support this contention as the median length of terminal ileum resected in patients in the resected group was 54 cm.

In conclusion we have shown that the fat free mass of ileostomy patients with or without terminal ileal resection is reduced compared with that predicted in normal subjects and this could indicate a subclinical state of malnutrition. In neither group, however, have we been able to show any degree of dehydration. Patients who undergo relatively short terminal ileal resections have been shown to lose weight and have reduced fat stores. In view of these findings it would therefore be prudent that close attention is paid to fluid and nutritional therapy in any ileostomy patient who suffers intercurrent illness or requires further surgery. This would be of particular importance for those ileostomy patients who have suffered an ileal resection, no matter how modest.

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