Radiodiagnostic problems in malabsorption

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In previous communications we have shown that in 95 per cent of cases of tropical idiopathic malabsorption there are radiological changes (Paterson and Baker, 1958; Paterson, Ignatius and Baker 1962). Over 200 cases of this disease have now been investigated in the Wellcome Unit at Vellore. The objects of this paper are to point to the lack of correlation between the varied degrees of radiological and clinical laboratory findings in a sample group of 32 of these cases, and also to the difficulty of radiological investigation of the ileum which is necessary for the exclusion of stenotic and other organic lesions in the diagnosis of sprue (Baker, 1957; Laws and Pitman, 1960).

MATERIAL

The patients were adults of Indian nationality and of varied nutritional and social status. They all suffered from the condition that has been variously labelled "tropical sprue", "idiopathic malabsorption", or "primary malabsorption". This is a syndrome of unknown aetiology, occurring among people resident in the tropics, associated with varying degrees of malabsorption of fat, carbohydrates, vitamins and other nutrients. In some parts of the tropics the syndrome may be due to sensitivity to wheat gluten (coeliac disease), but in South India most people do not eat wheat, and in the cases described in this report coeliac disease has been excluded. The series of patients described in 1958 (Paterson and Baker) were cases of endemic sprue. The cases in the present series include both endemic and epidemic forms. The latter were patients from an epidemic that involved some 150,000 people with a mortality in some areas of 30 per cent (Baker, Mathan and Joseph, 1963). There was no relation between the incidence of this disease and wealth, diet or intestinal parasites. The epidemic suggests an infective agent, but since cultures failed to reveal any bacterial pathogens, it may perhaps be viral in origin.

For the purpose of accurate comparison of radiological findings with a group of clinical and laboratory tests, 32 recent patients of mixed epidemic and endemic types have been selected. A suitable control group of 27 subjects of similar socio-economic status and similar dietary habits who had no clinical or laboratory evidence of malabsorption were submitted to radiological examination and a similar series of biochemical tests.

METHODS

All the patients studied were admitted to a metabolic ward where they were put on a standard diet containing approximately 50 g of fat per day. The excretion of fat in the faeces was measured daily by the method of Kemer, Hulinike and Weyers (1949) and the results expressed as a three-day running mean. Xylose absorption was studied by measuring the urinary excretion of xylose for five hours after an oral dose of 5 g of d-xylose. Vitamin B_{12} absorption was measured by feeding an oral dose of 1 μg of ^{60}Co labelled vitamin B_{12} and measuring the amount excreted in the stools. Folic acid absorption was measured by giving an oral dose of 200 μg of tritiated folic acid and measuring the amount excreted in the stools. Serum B_{12} levels were measured by microbiological assay using Euglena gracilis as the test organism (Ross, Hutner and Bach, 1957) and serum folate levels by microbiological assay using L. Casei fecalis as the test organism (Waters and Mollin, 1961). Haematological studies were carried out by the methods described by Dacie (1956). Jugal biopsies were carried out using either the intestinal biopsy capsule of Crosby (Crosby and Kugler, 1957) or the multiple retrieving biopsy tube (Baker and Hughes, 1960).

Radiological studies were carried out using a Phillips 500 mA machine with a 9 in. image intensifier and television chain. A standard meal of 4 oz. of 100 per cent w/w Micropaque barium sulphate was used. Large films of the jejunum and ileum were taken at 30 minutes, one hour, three hours, six hours, and at other times when indicated. A standard technique for small intestine films with the patient in the prone position was used (Paterson and Baker, 1958). Where details were not clear a repeat meal using the more adequately stabilised Ruybar suspension and/or an intubation method was used. On the basis of fluoroscopic or cine and radiographic observations, an overall grading was given for each

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case. These gradings are expressed in Tables II and III as + signs. The calibre of the widest loop of jejunum seen on a series of films was recorded to the nearest half-centimetre. Measurements of calibre in terms of millimetres would seem to be of doubtful significance (Laws, Booth, Shawdon and Stewart, 1963).

Measurements in millimetres of the thickness of the transverse mucosal folds of the jejunum were taken from the transverse line or bar shadow in the centre portion of the barium-filled lumen. Transit time for mouth to ileum was the time it took for the barium to reach loops of gut that have no transverse mucosal folds, whose outline is smooth, and where propulsive or peristaltic movements are no longer seen.

In 18 cases, cinefluorography was used to study intestinal movements in both the jejunum and the ileum. In some cases several such studies were undertaken to follow the changes occurring with improvement in the patient's condition.

**RESULTS**

Relation between radiological and other findings

Table I shows the average values obtained in the various tests in normal patients, in those whose radiological picture was grossly abnormal (group 4) and in those whose radiological picture was normal, yet whose clinical picture was that of sprue (group 1). Table II shows the findings in intermediate groups of patients.

Table III shows the incidence and the range of the various radiographic findings in the 27 control cases and the 32 sprue cases. It is seen that in this series 85 per cent of cases show the radiological abnormality of increased calibre of the jejunum, 59 per cent showed slow transit time through the jejunum, and 50 per cent showed thickening of the transverse mucosal folds. Where calibre was increased the transit time was slow, but increased calibre did not always show a corresponding thickening of the mucosal folds (Table II, group 3). Flocculation of barium suspension was unrelated to calibre and mucosal pattern and transit time. It occurred more frequently in the ileum than in the jejunum.

Table I and II show that in the individual cases there is little correlation between any one of the various haematological biochemical or biopye findings, and the various degrees of radiological abnormality that were recorded. However, considered as a group the degree of steatorrhoea was greater in group 4 than in the other groups (mean fat excretion in group 4, 22 g/day, in groups 1-3, 10-14 g/day). There was, however, no significant difference in the other parameters. There was also no correlation between the various tests and the occurrence of flocculation of Micropaque in the jejunum (six cases)

**TABLE I**

**Comparison of Kiliological with other findings in tropical sprue**

**GROUPS 1-4**

<table>
<thead>
<tr>
<th>Clinical</th>
<th>Absorption</th>
<th>Jejunal biopsy</th>
<th>Radiological</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case No.</td>
<td># Type</td>
<td>Duration of symptoms</td>
<td>Morphology</td>
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</tr>
<tr>
<td>8</td>
<td>3:5</td>
<td>126</td>
<td>1:3</td>
</tr>
</tbody>
</table>

* E: epidemic ** V: villous architecture T: tagmages L: loose C: convolutus
N: normal S: slight changes PVA: partial villous atrophy

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**TABLE II**

**COMPARISON OF RADIOLOGICAL WITH OTHER FINDINGS IN TROPICAL SPICE**

(GROUPS 2 AND 3)

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Type</th>
<th>Duration of symptoms</th>
<th>Presentation</th>
<th>Initial</th>
<th>Subsequent</th>
<th>Recovery</th>
<th>Infection</th>
<th>Arthritis</th>
<th>Pyelitis</th>
<th>Jejunal biopsy</th>
<th>Radiological</th>
<th>Fluctuation</th>
<th>Transit time</th>
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<td>2-6</td>
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<td>14</td>
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<tr>
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<td>E</td>
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<td>115-36</td>
<td>34</td>
<td>84</td>
<td>23</td>
<td>28</td>
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</table>

- E epidemic
- S sporadic
- **Villus architecture** T tongues
- **Histology** N normal
- L loops
- R ridges
- C convolutions
- PVA 'partial villus atrophy'

**TABLE III**

**RANGE OF RADIOGRAPHIC FINDINGS IN MALABSORPTION AND CONTROLS**

<table>
<thead>
<tr>
<th>Radiological observations</th>
<th>Control patients</th>
<th>32 malabsorption cases</th>
</tr>
</thead>
</table>
| Maximum calibre of jejunal loops | 1-5-2 cm cresanted or 1 mm thick | 2.5-5 cm
| Transverse mucosal folds, thickness | 1.5-3 mm | 27 |
| Fluctuation pattern (segmentation, clumping, granulation) | Jejunum nil | 16 |
| Transit times—from mouth to ileum | 0-5 hour | 19 |
| from mouth to caecum | 2-5 hours | 19 |
| Peristasis seen on fluoroscopy and cine—jejenum | Irregular or absent | 19 |
| ileum | Irregular | 19 |

or of the occurrence of fluctuation in the ileum (18 cases).

In two cases where the transverse folds were greatly thickened (2-5 and 5 mm) with a cog-wheel outline of the gut, stool fat was 7 g and 18 g/day and the xyllose 14 per cent and 12 per cent.

Jejunal biopsy also showed no evidence of radiological correlation with any of the other tests or the radiological findings. As seen under the dissecting microscope the biopsies showed the presence of "leaves", "ridges" or "convolutions" rather than true finger-like villi (Baker, Ignatius, Mathan, Vaish and Chacko, 1962). In no case was a completely flat mucosa seen. Histological changes were similar to those described previously (Chacko, J Ob, Johnson, and Baker, 1961) varying from slight cellular infiltration with little change in the villi, to short stumpy villi with more marked cellular infiltration, and in a
few cases going on to partial villous atrophy. In most
there was no particular increase in goblet cells
(Butterworth, Smith and Santiago, 1958).
In Case No. 8 (Fig. 1) where transverse folds were
moderately thickened (2 mm) jejunal calibre was not
greatly increased (2-5 cm), but cine studies showed
absence of jejunal peristalsis and transit to the
ileum was delayed till five and a half hours (even
with injection of Carbachol). Because of this absence
of peristalsis, the radiological grading was ++, +.
The patient subsequently died of "sprue coma", the
gut was preserved by an immediate intraperitoneal
injection of formalin, and post-mortem studies
showed that the thick transverse folds were asso-
ciated with submucosal oedema (Figs. 2 and 3).

Radiological techniques to detect obstructive and other
organic lesions
Flocculation of barium in ileal loops and delay in
transit time to the caecum are the factors that must
be overcome if progress is to be made in the radi-
ological differentiation between sprue and "second-
ary" malabsorption due to strictures, tuberculosis,

Fig. 2.
Autopsy specimen of jejunum from the same case as
Figs. 1 and 5.

etc. The flocculation of barium can be largely over-
come by the use of barium that has been passed
through a colloidal mill and is suspended by means
of carboxymethyl cellulose 1 per cent and gum
acacia 2 per cent. The commercial preparation of
Microopaque used in this study is perhaps slightly
better, and the preparation called Raybar is even
less likely to flocculate. Table IV shows the degree
of flocculation pattern observed in the jejunum and
ileum with various media in six series of routine
barium meal patients in this clinic.

Decreasing the time taken for a small intestine exami-
nation
Because of the time taken, and the radiation factor
in the above procedure, we have investigated other
methods as follows.
In a series of 15 cases where a routine Microopaque
meal failed to show details of ileal loops, jejunal
intubation and injection of small volumes of Raybar
or Microopaque followed by various types of "ram" or
"chaser" fluid was tried. The intubation methods of
Schatzki (1947) and of Scott Harden (1960) were
found to be difficult, and so a simpler method where-
by the patient swallowed a thin (1-5 mm) polythene
tube weighted with a mercury bag was usually em-
ployed. The bag was put through the nose and
swallowed at 6 p.m. The patient lay initially on his
right side, and the tube was anchored to the fore-
head by adhesive tape, enough tube being left free
for its transit into the jejunum during the night. In
most cases the tube was tolerated well and in the
morning the distal end of the tube was in the upper
jejunum. Measured quantities of opaque medium,
followed in about 15 minutes by the "ram," were injected with a 50 c.c. syringe and two-way cock.

A ram of 500 c.c. ice-cold water and one teaspoonful of magnesium sulphate was found to cause flocculation even of Raybar and so to be useless. A ram of 500 c.c. 7.5% Preparol (carboxymethyl cellulose granules) was difficult to dissolve and inject down the small calibre tube, but it did not cause flocculation and there was good visualisation of ileal loops in most cases. In one or two cases too much dilution of the 40 c.c. Raybar in the lower jejunum occurred, but by the time the terminal ileum was reached the concentration was again good. In no case was the transit time to the caecum much reduced by this procedure, and in some malabsorption cases the transit time remained prolonged to six or eight hours. In one case where Raybar had flocculated badly and the jejunal juice showed the presence of a large quantity of mucus, a preliminary draught of Preparol 7.5% 500 c.c. by mouth enabled a second Raybar meal (3 oz.) to pass through the small intestine without flocculation in four hours.

In general intubation methods in sprue and possible intestinal obstructive cases have not proved superior to oral methods, and so they have been largely discontinued.

As the acetylcholinesterase inhibitor neostigmine has proved ineffective in sprue (Ingelfinger and Moss, 1943) and in other patients no more effective than ice-cold saline (Friedenburger, McAlister and Margulis, 1962), the injection of a readily available parasympathomimetic or acetylcholine-like drug, carbamylcholine chloride (Carbachol), was tried. In three sprue cases the injection of 0.25 mg Carbachol did produce markedly increased irregular contractions and shortening of the jejunum and ileum, but peristaltic or propulsive movements did not occur, and transit time in these cases was not affected.

In three other cases (one with a minor lymphadenomatous obstructive lesion) the insertion of a sausage-shaped, thin, rubber balloon coated internally with barium and filled with air was tried. Inflation of the bag in the lumen of the small intestine in these cases did not stimulate any propulsive peristaltic movements. In the mildly obstructive case, the presence of the bag appeared to cause gaseous distension of the gut of the ileus type, but on deflating the bag it finally passed out per rectum without being held up at the stricture.

Cinefluorography

Using a television monitor and a 35 mm cine-camera mounted on a 9 in. Philips image intensifier, we have been able to fluoroscope the patients at 90 kV and less than 0.3 mA, and to take cinefilms at only 1 or 2 mA. In a routine barium meal if 12 exposures at 115 kV and 10 mAs are given, the total mAs or quantity of radiation is 120 mAs. With cinefilm the radiographic appearances in a routine barium meal (using Kodak XX standard cinefilm X-ray standard developer, and six frames per second), can be recorded on short bursts of time that add up to a total time of only 50 seconds and about 75 mAs. In lengthy, small-intestine studies, very short bursts

<table>
<thead>
<tr>
<th>Type of medium</th>
<th>No. routine cases</th>
<th>Flocculation pattern</th>
<th>Jejunum</th>
<th>Ileum</th>
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<tbody>
<tr>
<td>4 oz. ordinary barium made up to 16 oz. volume with tragacanth</td>
<td>104</td>
<td>13</td>
<td>8</td>
<td>61</td>
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<tr>
<td>4 oz. barium from colloidal mill plain suspension in 8 oz. volume (4 oz. volume too thick)</td>
<td>8</td>
<td>2</td>
<td>25</td>
<td>4</td>
</tr>
<tr>
<td>4 oz. colloidal barium suspended with 0.125 per cent carboxymethyl cellulose and 2 per cent acetic in 4 oz. volume</td>
<td>13</td>
<td>1</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>4 oz. Micropaque colloidal barium and 1 per cent suspending agent made up to 4 oz. volume</td>
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<td>0</td>
<td>0</td>
<td>5</td>
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<tr>
<td>4 oz. Atohar (barium with aluminium hydroxide) made up to 4 oz. volume</td>
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<td>1</td>
<td>0.4</td>
<td>15</td>
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<tr>
<td>40 ml. Raybar jejunal intubation and ram of Preparol 7.5 per cent 500 c.c.</td>
<td>12</td>
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<td>0</td>
<td>2</td>
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</table>
of exposures can be taken by an assistant every 15 or 30 minutes, and the procedure can be observed by the radiologist with the aid of a monitor in his office. When an area of possible stricture is observed on the TV screen, further positions, Carbachol injection, etc., can be supervised with a minimum of time taken. In this way constant irregularities of the lower ileum were observed in two patients. At operation one was found to have lymphadenoma of the ileum and the other had X-ray evidence of lymphosarcoma of the terminal ileum. Where longer bursts of exposure were made for peristaltic studies in one thin patient, the total mAs (for 243 seconds) was only 75, in another patient 383 seconds of exposure were made at an average of 1 mA (Fig. 9).

Further studies of the actual R units received by the patient in both conventional and cineradiography are needed. There is no doubt, however, that cineradiography is a valuable method of studying the small intestine in difficult or time-consuming cases.

**Discussion**

*Relation between radiological and other findings*

There is general agreement (Ettinger, 1949; Marshak, Wolf and Adlersberg, 1954; Marshak and Eliasoph, 1957; Paterson and Baker, 1938; Golden, 1959; and Laws and Pitman, 1960) that sprue and malabsorption syndrome are accompanied in 70-90 per cent of cases by radiological changes in the small intestine. In some patients these changes are reversible after treatment. The significance of these radiological changes and their relation to the clinical, biochemical and histological aspects of the disease is, however, still obscure. Flohé, Caldwell and Sheehy (1962) in a study of 12 patients with tropical sprue in Puerto Rico found that no correlation was evident between any one radiographic abnormality and any one absorptive test. The present findings confirm this statement. Flohé et al. (1962) did find, however, that every patient who demonstrated a severely abnormal small bowel pattern had severely abnormal absorption findings, and that where X-ray findings were most abnormal biopsy revealed the most severe changes. Laws et al. (1963) found some evidence of correlation between the severity of clinical findings, the serum potassium level and the degree of dilatation of the jejunum.

One patient whom we have followed for five years (Fig. 3A) showed in 1958 a gross degree of dilatation of the jejunum (5 cm calibre), no evidence of malabsorption except for a flat glucose tolerance curve and an almost normal intestinal biopsy. Unlike

**Fig. 3.**

Malabsorption; glucose only;
(a) Gruously dilated jejunum, folds not thickened.
(b) Five years later, some improvement.

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Golden’s (1959, pp. 281–3) case this man became symptom free without any specific therapy and on re-examination in 1963 (Fig. 3b) the small-intestine pattern had improved. Thus an occasional patient with the gross radiological signs may have minimal signs of malabsorption, and have minimal clinical and other abnormalities. On the other hand patients with normal radiological appearances may have moderate degrees of malabsorption (Table 1).

Laws et al. (1963) in cases of idiopathic steatorrhea showed little correlation between jejunal biopsy findings and radiological signs. Similarly the fact that in this study little correlation has been found between the radiological signs of increase in jejunal calibre, increase in jejunal transit time, thick mucosal folds and flocculation, and the biochemical, haematological and biopsy findings, leads us to suppose that there may still be some other biochemical or neurophysiological phenomenon in tropical sprue that will correlate with radiological and clinical findings, and for which a search must be continued.

The transverse mucosal folds or valvulae con- ventes that are characteristic of the jejunum are not well seen in barium-meal studies in normal patients because the jejunum is usually in a state of contraction and so the transverse folds are bunched up in a crenated manner. It is these crenated folds that give rise to the normal “feathery” mucosal pattern of the jejunum. The calibre of the jejunum cannot accurately be measured unless a bolus passing down fills out the lumen. Sloan (1957) has illustrated very clearly the mechanism by which transverse mucosal folds become visible when the gut is distended. We have confirmed his findings by taking a length of jejunum obtained from an autopsy, tying it off at both ends and gradually distending it with a dilute suspension of barium and taking radiographs under standard conditions. Figure 4 shows how the ill-defined crenated folds gradually form a clear cut “ladder pattern” as the lumen is increased.

It is clear from this experiment and our normal control patients that the thickness of a transverse jejunal mucosal fold as it appears on the X-ray film is normally about 1 mm or less. The histology of a transverse mucosal fold in the contracted and in the dilated state of jejunal lumen is shown in Figs. 5 and 6. These folds are anatomical fixtures in the jejunal wall. They often have a circular vessel at their base (Fig. 6), are filled with connective tissue and covered with villi. The mucosal folds in the ileum are of quite different histological appearance (Fig. 6c). They are not a constant anatomical feature, they are “passive” folds that come and go with contractions and dilatations of the lumen and of the muscularis mucosae. Of course the shadows of the villous mucosal pattern cannot be seen on radiographs, and so we cannot directly compare jejunal biopsy findings with radiographic mucosal pattern, but we can occasionally compare whole thickness autopsy or biopsy specimens of jejunal wall with what we see on radiographs. Figure 5c shows that thickening of the transverse mucosal folds in a

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**Fig. 4.**

Development of “ladder pattern” in an autopsy of specimen of jejunum.

(a) No distension—crenated mucosal folds.
(b) Slightly distended—“crazy paving” folds.
(c) Dilated jejunum—thin transverse folds.

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**Fig. 5.**

A longitudinal section of jejunal wall.

(a) Normal jejunum contracted (death from burns).
(b) Normal jejunum dilated—same case.
(c) Sprue coma case—submucosal oedema.
patient who died in sprue coma is due to submucosal oedema; other sections showed that this oedema extended to the ileum. Golden (1959) illustrates cases where a similar thickening due to oedema was seen in subacute yellow atrophy of the liver (p. 200) and to nephrosis (p. 287).

In our experience gross thickening of mucosal folds (3–5 mm) is not a common finding in malabsorption, but it is frequently seen in association with jejunitis with jejunal ulcer or with gastrocolic fistula (Fig. 7). In some cases where the silhouette of the gut presents a cog-wheel appearance the degree of thickening of the transverse folds is difficult to assess. Figure 8 shows a loop of jejunum in a case of tuberculous peritonitis at half-hour and a reversed print of the same loop at three-quarter-hour. Comparing successive exposures of this loop of gut we see that the mucosal folds are not grossly thickened. The “cog-wheel” edge of the gut in this case may be due to contractions of circular muscles in small segments between a pair of mucosal folds. The mid-gut shadow of the mucosal fold in these areas is not more than 1 cm across.

Where mucosal folds are crowded together cine-film study showed a shortening of the gut that is presumably due to a contraction of longitudinal muscle (that may quicken transit time). Where folds are far apart the gut is lengthened and transit time slow. It may be that thickening of transverse mucosal folds are (as in the stomach) influenced by contraction of muscularis mucosae and by inflammation. Further studies of these points are needed as and when fresh autopsy material from such cases is available.

Flocculation patterns

Some physicians (Lepore quoted by Golden, 1959, p. 276) still favour non-flocculating media and so they describe “flocculation, puddling, and segmentation of barium” as a significant finding (Floch et al., 1962). If ordinary barium suspension is used, flocculation occurs in so many conditions that it does not appear to be a useful radiological sign (Paterson and Baker, 1958). If, however, a “non-flocculating” colloidal suspension of barium like Micropaque or Raybar flocculates, there must be some biochemical significance in this phenomenon. Following the work of Frazer, French and Thompson (1949), Golden (1959) has reviewed the flocculation effects in nutritional disorders, fat and mucus in the gut, the variable occurrence of the flocculation effect in patients with slow transit of barium to the caecum, and the reversible nature of flocculation in the jejunum (p. 73). Golden suggests (p. 273) that flocculation may depend on the quantity of barium and the quality of the mucus in the gut.

Marshak (1961) and Caldwell and Floch (1963) favour a larger quantity of colloidal barium (16–20 oz.). We have found that a more concentrated 100 per cent w/v suspension of colloidal barium forms a very thick unsuitable paste, but 4 oz. colloidal barium made up to 4 oz. total volume with the aid of suspending and stabilising agents such as carboxymethyl cellulose 1 per cent and acacia 2 per cent, form a nice free-flowing cream. Using this more concentrated suspension the degree of flocculation is reduced. Such barium also has the advantage of resisting water absorption and alteration of its concentration in the middle jejenum. It does not
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and flocculate, and a second 4 oz. dose (given half an hour later) may show the jejunal mucosal pattern and calibre without flocculation. Another method of clearing mucus from the gut is to give a “scavenging” draught of non-opaque 7½% Precapac (carboxymethyl cellulose) jelly. In examining a malabsorption case with a view to detecting stricture in the ileum the use of different types of “scavenging agents” before the barium and different suspending agents for the barium may be needed before the entire ileal lumen can be demonstrated. Further cooperation between biochemist and radiologist is needed to discover the actual cause of flocculation of barium. Such a discovery may help in the elucidation of some of the problems of tropical sprue.

Effect of drugs of jejunal movements

Intra-muscular injections of the acetyl cholinesterase inhibitor prostigmine (Inglefinger and Moss, 1943; Golden, 1959) did not have the effect, as in non-sprue patients (Friedenburg et al., 1962), of stimulating propulsive movements in the jejunum. In Inglefinger’s cases injections of a parasympathomimetic drug acetyl-β-methylcholine (mecholyl) produced “increase in intestinal motor activity” and in Golden’s case powerful contraction and rapid movement of barium were produced. In three sprue cases we have confirmed that an acetylcholine-like drug (carbamylcholine chloride) does increase motor activity in the small gut, but it does not restore the more complicated propulsive peristaltic movements in the jejunum. May, McCreary and Blackfan (1943) found that in coeliac disease injections of mecholyl produced improvements in intestinal movements and of the absorption of glucose. Golden (1959) has postulated that in cases where there is insufficiency of vitamin B complex there is inadequate production of choline acetylase and its co-enzyme containing pantothenic acid which is present in certain food stuffs. Choline acetylase and the co-enzyme are both needed for the deposition of acetylcholine in nerve tissues. Golden suggests that there is a deficiency of acetylcholine in sprue and allied disorders and so nerve impulses cannot be well transmitted across the ganglionic synapses or at the nerve endings. Acetylcholinesterase which also exists only in nerve tissue inactivates acetylcholine (if there is any) and so acetylcholinesterase inhibitors like prostigmine only increase muscular contractions in the gut if there is acetylcholine present at the nerve endings. Inglefinger and Moss (1943) found that under treatment the intestine of sprue patients recovered their ability to respond to prostigmine.
Cinefluorography of the small intestine

Few reports so far have been published on the cineradiography of the small intestine. McLaren, Ardran and Stults (1950) took two films per second of a 5 in. square area of duodenal and jejunum loops, and from their series of films made a cinefilm to show normal jejunal movements.

Porcher, Buffard and Sauvageau (1954) and Porcher (1956) have enthusiastically advocated the image intensifier and the cinecamera for study of the small intestine, and the effect of drugs in these movements.

Liljeblad, Mattsen and Persson (1958) studying the effect of prostigmin infusions used a 5 in. image intensifier and a cinecamera with rotating shutter with a light sector of 180 deg. They found that even at 125 kV the milliamperage needed was between 5 and 15. In a case of "intestinal paralysis" they showed that prostigmine changed the shape of the gut and produced peristaltic waves.

With the Philips 9 in. image intensifier (as above) we were able to study larger areas of small intestine with considerably reduced quantities of radiation (0.5–2 mA only). Figure 9 illustrates a case where a cinefilm was useful in eliminating organic defects.

In two other recent cases cinefluorography was able to demonstrate the site of minimal strictures in the ileum. With further technical improvements such as the orthicon type of television camera, still better results may be expected. Because of the trouble involved in cutting up and editing and viewing cinefilm we have not used it for routine barium meals. If one small intestine case per day is studied with one length of cinefilm, however, this may be accomplished at the minimum interference with routine work and minimum radiation danger to patient and staff. Accurate comparison (using an R chamber) of the amount of radiation used both in a conventional barium meal series and in a cinefluorographic series are needed.

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SUMMARY

1. Radiological signs are present in the majority of cases of tropical sprue of both endemic and epidemic forms.

2. In a series of 32 cases, the radiological signs of increased jejunal calibre, slow jejunal transit time, thickness of transverse mucosal folds, and flocculation of "non-floculating" media show little correlation with haemoglobin levels, vitamin B12, folic acid, xylose and fat absorption, or with jejunal biopsy findings.

3. In one case where there was a radiological appearance of thickened mucosal folds in the jejunum, post-mortem showed marked oedema of the submucosa including the primary mucosal folds.

4. The exclusion, by radiological methods, of minimal strictures and other lesions of the ileum that might cause malabsorption is a slow and tedious procedure. The time taken cannot be shortened by any known means, but the quality of radiographs of the ileum can be improved by use of special barium suspensions and by preliminary "cleansing" agents. By means of cinefluorographic methods more adequate records can be obtained with minimal radiation hazard.

5. Absence of propulsive peristaltic movements in the jejunum is a feature of sprue. In three cases parasympathomimetic drugs restored only contractile movements but did not restore propulsive movements.

6. Further studies of the phenomena of flocculation of barium suspension in the gut and of the action of various

FIG. 9.

(a) Half-hour.
(b) One hour.
(c) Two and a half hours.

Epidemic sprue, gross jejunal dilatation six-hour jejunal stasis—cinefilm taken using only 1 mA.
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