

cervical culture a course of chloramphenicol was begun and the patient's general condition showed improvement, but extension of the pelvic mass was noted; subsequently the upper limit of this mass was defined at the level of the umbilicus. Two further exacerbations of pyrexia occurred. A course of tetracycline had no appreciable effect, and it was clear that no more could be expected from antibiotic therapy. There was a discharge of pus both per rectum and per vaginam, which probably accounted for a sudden fall of temperature on the 32nd day after admission, but this coincided also with the transfusion of 2 pints (1.1 litres) of fresh blood. Recovery was thereafter uneventful, and only a minor degree of pelvic thickening was detected at a recent examination.

Modern therapy has largely eliminated infection as a direct cause of death, and renal failure has now become the most dreaded complication of post-abortum sepsis. It was the cause of death in two of our four fatal cases; in the other two death occurred within 24 hours of admission and before chemotherapy could be effective. Bull *et al.* (1949) showed that shock, by causing ischaemia with resultant widespread damage to individual nephrons, is responsible for the renal failure. In the period under review, all cases with renal failure were also severely infected. Two types of renal damage are encountered (*Lancet*, 1954): (1) *massive renal cortical necrosis* in which the changes are irreversible and the prognosis is still hopeless; and (2) *renal tubular necrosis*. The prognosis now is relatively favourable. Limitation of fluid intake and the non-protein diet implicit in the principles of the Bull-Borst regime have made this possible. In practice we have found the fat content of the "Hammersmith cocktail" to be badly tolerated by many patients, and this may be halved without detracting from the value of the treatment. When vomiting persists to the extent of making it impossible to maintain the intake, intravenous administration of 40% glucose via the inferior vena cava has been tried (Russell *et al.*, 1954).

### Summary

A review is given of 995 cases of septic abortion treated in a special puerperal sepsis unit. The relative reliability of the common general and local signs of infection in regard to the diagnosis of uterine sepsis is fully discussed.

The bacteriological features of post-abortum, in contradistinction to post-partum, sepsis, are analysed and the value of bacteriological and haematological findings is discussed.

The management of the case of septic abortion is described. The need for adequate investigation before therapy is emphasized.

The value of sound chemotherapeutic control of the infected case is reflected in a considerably reduced mortality. There were four deaths in the series: two of these were wholly attributable to acute renal failure, and in the other two chemotherapy had very little chance to be effective.

We wish to thank Dr. D. D. Reid, of the London School of Hygiene and Tropical Medicine, for his helpful advice in the compilation of the tables.

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## INTESTINAL LENGTH IN MAN

BY

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Every medical student knows that the length of the small intestine is 22 ft. (6.7 m.) or thereabouts, for his textbook has taught him so. Every surgeon knows from his experience that there is great variation in intestinal length, but few realize the magnitude of this variation.

It is the aim of this paper to draw attention to the fact that the accepted measurements are averages and may be grossly misleading in any individual case, since the variation is of the order of 100%. The surgical applications of this fact are discussed. An account is given of the complications which arise when only a very short length of gut remains, and suggestions are made on their management.

### Accepted Measurements

The lengths of small and large intestine quoted by well-known textbooks are given in Table I.

TABLE I

Author	Small Intestine	Large Intestine
Cunningham (1940)	Over 20 ft. (6.1 m.)	5 to 6 ft. (1.5 to 1.8 m.)
Grant (1948)	20-odd ft.	Not stated
Gray (1942)	About 6 m. (19.5 ft.)	About 1.5 m. (5 ft.)
Ross (1939)	6.75 m. (22 ft.)	180-195 cm. (70.9-76.8 in.)

These figures are stated without qualification in the books, and no hint is given to the student that great deviations from the mean are not at all uncommon.

This investigation was prompted by a chance observation made in the post-mortem room.

A woman aged 63 had been admitted to Chase Farm Hospital complaining of severe abdominal pain, diarrhoea, and the passage of blood per rectum of two weeks' duration. For the past week vomiting had been severe. The physical signs were those of intestinal obstruction, and the duty registrar had performed a laparotomy. The patient was found to have a mesenteric thrombosis which had caused a long loop of small intestine to become gangrenous. This loop was resected and side-to-side anastomosis performed between the remaining portions of small intestine. The resected portion was found to measure 8 ft. (2.4 m.). The patient did not recover from the operation, and at necropsy it was obvious that an unexpectedly short segment of gut remained. This segment measured only 3 ft. (91 cm.) from pylorus to ileo-caecal valve, allowance having been made for the overlap at the anastomosis. Apart from appendicectomy, she had had no previous operation on the gut, so her total length of small intestine was 11 ft. (3.3 m.). The shortness did not, however, extend to the large gut, as this structure measured 6 ft. (1.8 m.) from ileo-caecal valve to anal canal.

The literature was consulted and records were found of a few series of measurements. Treves, in 1885, measured the small and large intestine in 100 fresh adult bodies and found the average length of the small gut to be 22 ft. 6 in. (6.9 m.) in the male and 23 ft. 4 in. (7 m.) in the female, with extremes of 15 ft. 6 in. (4.7 m.) and 31 ft. 10 in. (9.7 m.), but he does not state the relative numbers of men and women, the ages of the women, or the percentage of subjects whose gut lengths varied greatly from the average. He concluded that the length of the bowel is independent, in the adult at least, of age, of height, and of weight; nor is the ratio between the measurements of the large and small intestine constant.

TABLE II

Author	No. of Bodies	Sex	Small Gut			Large Gut			Whole Gut		
			Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.
Present series (1955) .. .. .	65	M	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
	35	F	16 0	20 11	25 9	4 6	5 11	6 6	20 6	26 4	31 9
Bryant (1924) .. .. .	160	Both	11 0	19 5	23 6	4 6	5 2	6 0	17 0	24 2	29 6
	27	M	10 0	20 6	28 4	3 4	5 2	10 10	13 4	25 8	39 2
Dreike (1894) .. .. .	27	M	15 0	21 9	26 8	3 8	5 4	9 2	18 8	27 1	35 10
	17	F	13 4	19 3	25 0	3 4	4 6	6 8	16 8	23 9	31 8
Treves (1885) .. .. .	27	M	13 10	20 9	33 3	3 8	5 3	7 4	17 6	26 0	40 7
	23	F	11 2	17 3	28 2	3 8	5 0	6 4	14 10	22 3	34 6
Treves (1885) .. .. .	100	M	15 6	22 6	31 10	3 3	4 8	6 6	18 9	27 2	38 4
		F	18 10	23 4	29 4	3 3	4 6	6 6	22 1	27 6	35 10

1 foot equals 30.48 cm.

Further series are reported from Germany by Dreike (1894) and from America by Bryant (1924). It was shown, moreover, by Lamb (1893) that there are racial differences in intestinal length, the average being higher in India than in Europe and higher still among American negroes, in whom lengths of 40 ft. (12.2 m.) are not unknown. All these measurements refer to the cadaver. In life, intestinal length is considerably less. Alvarez (1940) says: "Recent studies show that during life the whole tract from mouth to anus is usually only 8 to 10 feet long, or from 2.4 to 3 metres." Noer and Johnston (1939) published a series of cases of intestinal obstruction treated by decompression, using a tube 10-12 ft. (3-3.7 m.) long. They found the average length of tube from mouth to anus to be 9 ft. (2.7 m.). In their paper a photograph is shown of a patient with the ends of a 10-ft. (3-m.) tube protruding from both mouth and anus.

Alvarez quotes experiments performed by Van der Reis and Schembra in 1924 showing that the tube does not have the gut telescoped upon it, but lies smoothly along the mesenteric border. Loss of tone appears to be responsible for the lengthening which takes place after death.

However, it seems reasonable to assume that variation in cadaveric length reflects variations which were present in life, so it seemed worth while to repeat the observations made by Treves on subjects in this country.

### Method

Measurements were made of the length of small gut from pylorus to ileo-caecal valve, and of large gut from ileo-caecal valve to anal canal, in 100 unselected adult subjects. In some cases the post-mortem examination was conducted within a few hours of death; in others the body had been kept in the refrigerator for one to three days. In no case had any preservative been used. Subjects were not included if they had had previous gut resections (other than the case already mentioned in which the resected portion had been carefully measured) or if there was gross intestinal disease which distorted the tube or made accurate measurement impossible.

The intestine was removed from the body; the mesentery and omentum were cut off close to the tube, which was kept moist in a bowl. The gut was then measured by being laid without tension against a 1 ft. (30 cm.) metal ruler. The measurements were all made by Mr. Conlon, of the morbid anatomy department, or myself. Successive measurements of the same intestine by the same observer varied by less than 2%, and observations by the two workers differed by less than 7%.

The effect of tension was investigated. After routine measurement the gut was pulled with the hands as strongly as possible without rupturing it and was then remeasured. This treatment produced an increase in length of 4% in the small gut and of 14% in the large gut.

A measured length of 30 cm. of intestine was filled with water and the loop was left to hang from its two ends for 30 minutes, so mimicking the distension of a dependent loop in intestinal obstruction. The loop was then measured full of water, as it was, and after the water had been released. The length of small intestine had increased to 31 cm. (3.3%),

both full and empty, while the large gut remained 30 cm. long when full of water but stretched to 32 cm. (6.6%) after it had been emptied. These tests indicate that intestinal contents are accommodated by increase in girth rather than length.

### Results

Of the 100 subjects, 65 were men aged 27-91, and 35 were women aged 33-85. The measurements of their intestines are summarized in Table II, where they are compared with figures obtained by other workers. The length of the large intestine is shown to be very much more constant than is that of the small gut. The correspondence between the figures in the four series is, on the whole, a close one, though Treves alone found a greater average length of small gut in women than in men. In the present series the average length of the small gut was 8% and that of the large gut 14% greater in men than in women.

The distribution of cases round the mean was next investigated, with the result shown in Table III. That is to say, all but approximately 14% of subjects of both sexes have

TABLE III

	Subjects with Gut Less than 85% of Average	Subjects with Gut Longer than 115% of Average
Small gut { Males ..	5 (7.7%)	4 (6.1%)
{ Females ..	2 (5.7%)	3 (8.6%)
Large gut { Males ..	2 (3%)	0
{ Females ..	0	4 (11%)

small-gut lengths within plus or minus 15% of the average and the number who have unusually short large intestines is very small.

Furthermore, in the present series the shortest small gut in women is 47% of the longest and 56% of the mean; in men it is 62% of the longest and 75% of the mean. The shortest large gut in women is 75% of the longest and 87% of the mean; in men it is 70% of the longest and 76% of the mean.

Treves's (1885) statements were next checked concerning the absence of correlation between bowel length and age and height of the subject.

Figs. 1, 2, and 3 confirm that there is no relation between gut length and age. Bryant stated that there was an increase of 20% in colon length and a decrease of 7% in small-gut length with age rise from 20 to 80 years. This series does not bear out that contention.

Though Treves found that gut length was independent of the height of the subject, Figs. 4, 5, and 6 show clearly that small, large, and total gut lengths are so related.

Whereas the ratio between the lengths of small and large gut is not absolutely constant, Fig. 7 shows that the small gut is three to four times as long as the large in the majority of cases.

### Surgical Importance

The cases of surgical importance are obviously those in the group with the small gut abnormally short. In such patients the removal of what would in the average person be a perfectly "safe" length may leave them with a grossly inadequate absorptive surface.

The length of gut to be removed in a massive resection is seldom a matter of election, but if the surgeon realizes that he has been forced to leave a dangerously short segment of small gut he can institute appropriate treatment at once and may be able to forestall the development of serious nutritional deficiencies. It is wise, therefore, roughly to measure the length of bowel which remains after resection, rather than to infer its length after measuring the excised portion.

Haymond (1935), reviewing cases of massive resection of the gut, came to the conclusion that man can tolerate the resection of 33% of the total length of his intestine and

can subsequently return to normal, but if more than 50% is removed serious metabolic disturbances occur.

There are, however, reports of some astonishing cases, such as that recorded by Shonyo and Jackson (1950). Their patient, a woman aged 41, had a resection of almost the whole of her small intestine for an adenocarcinoma of the jejunum which had involved adjacent loops. There remained only 15.3 in. (39 cm.) between the pylorus and

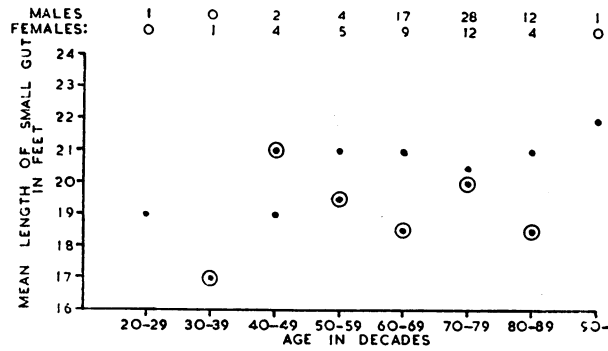


FIG. 1.—Correlation between length of small gut and age of subject. ●=Males; ○=females.

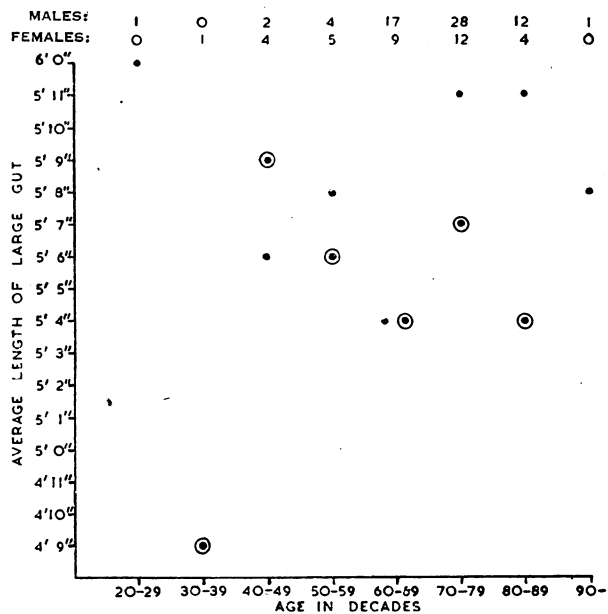


FIG. 2.—Correlation between length of large gut and age of subject. ●=Males; ○=females.

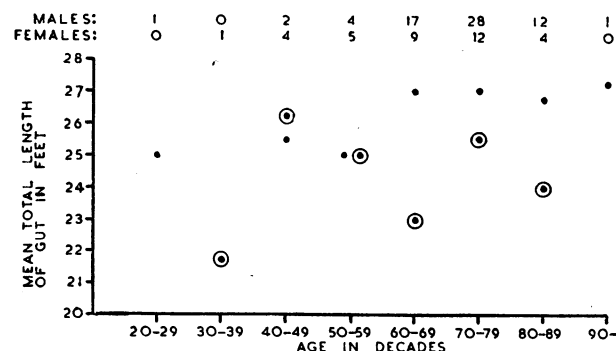


FIG. 3.—Correlation between total gut length and age of subject. ●=Males; ○=females.

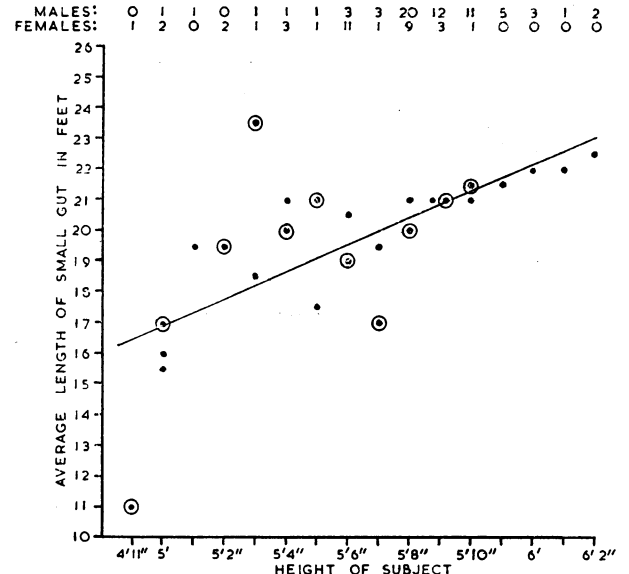


FIG. 4.—Correlation between length of small gut and height of subject. ●=Males; ○=females.

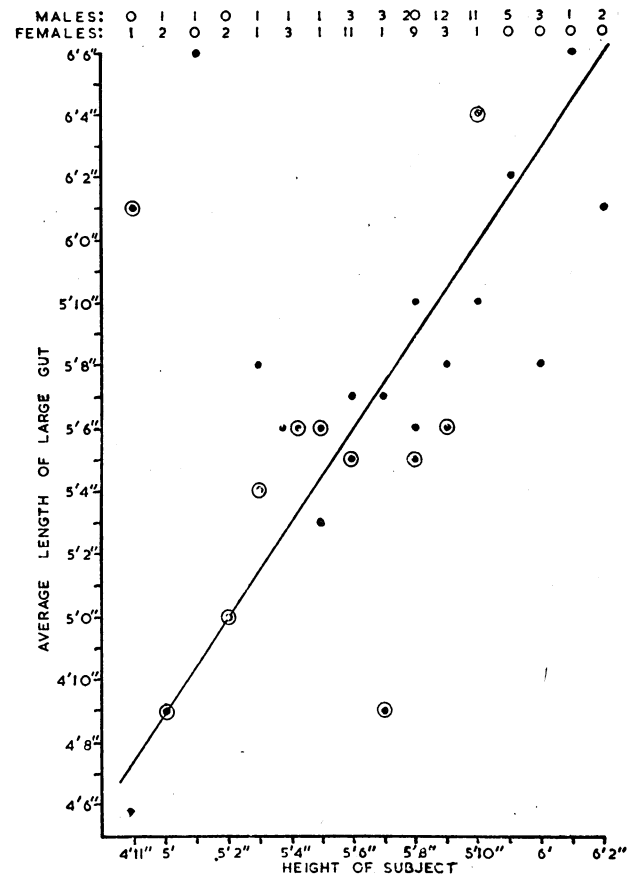


FIG. 5.—Correlation between length of large gut and height of subject. ●=Males; ○=females.

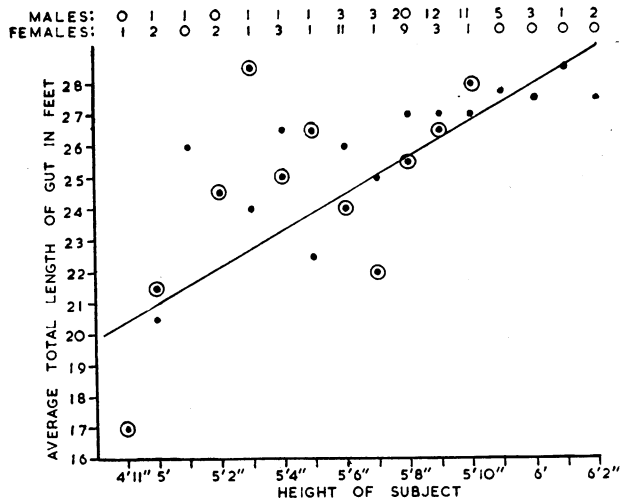


FIG. 6.—Correlation between total gut length and height of subject. ●=Males; ○=females.

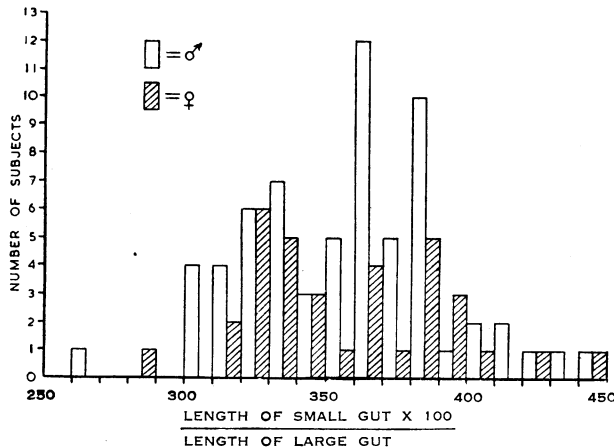


FIG. 7.—Correlation between length of small and of large gut.

the ileo-caecal valve. This patient lost a little weight post-operatively, but had no diarrhoea. Metabolic studies carried out one year after resection showed that albumin was deficient in her blood, but absorption and utilization of water, food, minerals, and vitamins were not seriously disturbed. Unfortunately this patient developed a recurrence of her growth, from which she died 18 months after the original resection. Still, it is comforting to the surgeon faced with an extensive resection to know that a patient can live an almost normal life with only a little over a foot of small intestine.

**Effects of Small-gut Deficiency**

It is usual, however, for patients having only a few feet of small intestine to develop fairly severe complications. The most trying of these is an intractable diarrhoea which cannot be stopped by any drugs but must be controlled by diet.

The chief absorptive defect is that of fats. These are well digested, but 45% of all ingested fat is excreted in the faeces, 80% of this being in the form of fatty acids (West *et al.*, 1939; Todd *et al.*, 1940). Calcium and vitamin D are lost with the fats and tetany readily develops. Carbohydrate utilization is normal, but 25% of dietary protein passes out in the faeces.

There is often "intestinal hurry" which leaves little time for the formation of vitamin B<sub>12</sub> and K by bacterial action in the colon, so these vitamins must be supplied in the diet.

In some patients a sprue-like hyperchromic megaloblastic anaemia develops, for which large doses of folic acid must be given.

**Management**

Lawrence (1953) outlined the treatment of patients subjected to a massive gut resection. In the immediate post-operative period, he stressed the necessity for blood transfusion and parenteral vitamins in addition to the usual gastric suction and intravenous fluid and electrolyte therapy.

As ileus passes off and the diet is increased, a watery diarrhoea usually begins. This is best controlled by frequent feeds of a non-residue diet containing abundant carbohydrates, a moderate amount of protein, and little fat. The patient should have adequate iron therapy, as this element is poorly absorbed after loss of the jejunum. He should take calcium, 1 g., and one polyvitamin capsule three times a day. His metabolic requirements should be kept low, so a quiet life is advised.

When these measures are adopted, the loss of a very large proportion of the bowel is not incompatible with health and comfort.

**Summary**

The small and large intestines of 65 male and 35 female subjects have been measured.

It is shown that there may be variations of as much as 100% in the length of the small intestine, but the large gut is much more constant in its dimensions.

Intestinal length in the adult is independent of age but is correlated with the height of the subject.

The deficiencies occurring after massive gut resection are described and a scheme of post-operative management is noted.

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The centenary of the birth of Sir D'Arcy Power (1855-1941) was commemorated by the Osler Club of London on November 11. Mr. W. R. LEFANU, librarian of the Royal College of Surgeons, spoke of D'Arcy Power's work as honorary librarian of the College. During his term of office at the College he greatly improved the library facilities. He encouraged younger men, especially in the study of medical history and biography, to which he himself made many contributions, including the revision and publication of Plarr's *Lives of the Fellows*. Dr. A. W. FRANKLIN paid a tribute to the character of D'Arcy Power, who had been a member of the Osler Club during its first ten years. The *Selected Writings of D'Arcy Power, 1877-1930*, presented to him on his 75th birthday, had been gathered together by the Club. It included a bibliography of 609 books and papers, including 184 biographies for the *Dictionary of National Biography*. Other speakers included Sir HARRY PLATT, P.R.C.S., and Sir D'Arcy Power's son, Air Vice-Marshal D'ARCY POWER. Dr. HAROLD AVERY presided.