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GASTRO-INTESTINAL FUNCTION AFTER ABDOMINAL COBALT IRRADIATION

by

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The gastro-intestinal tract is notorious for its radiosensitivity. Death due to total body irradiation is the consequence of damage to the haemopoietic system and, with higher doses, the digestive system. The radiation effect on the gastro-intestinal lining has been studied in animals by QUASTLER (1956), BOND (1950), CONRAD (1954, 1956), and others. Data relating to cell survival and the reparative capacity of the rat and mouse intestinal mucosa after continuous and single radiation exposure have been reported by QUASTLER et coll. (1959), BLOOM (1950), WILSON (1964), and WIERNICK et coll. (1966). Clinical observations in human gastro-intestinal reactions, following irradiation with injury and complications, have been reported by ASHBAUGH et coll. (1963), BROWN (1962), WOOD et coll. (1963), ROSEN et coll. (1964), GRAHAM et coll. (1963), HALLS (1965), and others.

During the last ten years isotope-labelled substances, such as ^{131}I-labelled triolein and oleic acid and ^{131}I-labelled polyvinylpyrrolidone, have become available for the investigation of the absorptive capacity and permeability of the gastro-intestinal mucosa following irradiation. Few reports on the func-

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tional reaction of the gastro-intestinal mucosa to therapeutic irradiation with telecobalt have been published, however (REEVES et coll. 1963, 1965, GOODRICH et coll. 1962).

The aim of the present investigation was to ascertain functional changes of the gastro-intestinal tract in patients suffering from abdominal carcinomatosis who received telecobalt therapy; each received 2 000 to 4 000 rad homogenous irradiation to a large part of or to the whole abdomen.

Material and Treatment. Seventy-five patients (67 females and 8 males) suffering from widespread malignancy of the abdomen were investigated. The mean age was 50.1 (range 12—78). The diagnoses in the 75 patients were as follows:

	Number of patients
Carcinoma of ovary	37
Carcinoma of uterus	5
Carcinoma of cervix	3
Generalized abdominal spread of unknown origin	4
Carcinoma of breast with general abdominal spread	4
Carcinoma of colon	3
Carcinoma of stomach	3
Carcinoma of rectosigmoid junction	2
Mesothelioma peritonei	1
Abdominal lymphoma	2
Splenic lymphoma	1
Reticulum cell sarcoma of stomach	1
Hodgkin's disease	4
Leiomyosarcoma	2
Neuroblastoma	1
Carcinoma of pancreas	2

In fifty-five patients the diagnosis was established by laparotomy, in seven patients cytologically from aspirated abdominal fluid, in eleven patients by biopsy and in two on the clinical evidence. The mean survival of fifty-four patients was 23 months (median survival 13 months, range 2—228 months). Eighteen patients were alive 3 months to 13 years after the diagnosis was established; for three patients the survival time was unknown.

The patients received cobalt 60 teletherapy in accordance with the clinical findings either to the lower or upper, or to the whole abdomen. The treat-

ment schedules, with field size 20 cm × 20 cm, or 20 cm × 16 cm, and 2 000 to 4 000 rad tissue dose, were as follows:

	Number of patients
Whole abdomen	34
Lower abdomen (4 fields)	14
Lower abdomen (2 fields)	9
Upper abdomen (4 fields)	10
Upper abdomen (2 fields)	3
No irradiation	5

Method of investigation. The following tests were carried out for an evaluation of the functional performance of the gastro-intestinal tract.

1. Absorption of vitamin B12 labelled by ^{60}Co (SHILLING 1963 test). Urinary excretion of more than 6 % of the orally administered dose was considered normal.

2. Fat absorption studied by ^{125}I-labelled triolein (SANDERS et coll. 1956, REEVES et coll. 1959, REITH et coll. 1961). Fecal radioactivity expressed as percentage of the dose administered was determined, and up to 3 % were considered as normal. Blood radioactivity was defined as percentage of test dose per liter of whole blood.

3. Determination of macromolecule passage through the intestinal wall, protein loss, by ^{131}I-labelled polyvinylpyrrolidone (GORDON's 1959 PVP test). Up to 1.5 % of the administered dose found in the feces was considered normal.

4. Gastric acid secretion. After stimulation by the subcutaneous injection of 0.25 mg histamine, the total acidity (normal 50 to 100 degrees) and free hydrochloric acid (normal 25 to 50 degrees) were determined.

The patients were kept under close clinical observation during the investigation and controlled with blood counts, biochemical examinations and the necessary roentgendiagnostic procedures.

Clinical observations. The patients in this series were seriously ill. Large abdominal masses occasionally gave rise to partial obstruction or complete ileus. Diarrhoea during or after treatment in ten patients was probably due to the irradiation. Proctitis was recorded in two patients and in one patient cystitis; in four patients cellulitis of the abdominal wall appeared some time after irradiation. Two patients developed terminal signs of renal damage, possibly irradiation-induced. These clinical disturbances corresponded rarely with functional impairment as indicated by the tests. Nearly all patients receiving

Table 1

Results of the Schilling test at different dose levels

Radiation rad	Total tests	Abnormal tests		Mean excretion in per cent	
		Number	Percentage	Abnormal tests	All tests
None	9	—	—	—	17.45 (range 7.4—35.6)
800—2 000	12	4	33.3	5.02	11.9 (range 4.1—35.5)
2 000—3 000	28	9	32.1	3.0	10.5 (range 0.5—23.7)
< 3 000	23	7	30.4	3.21	10.75 (range 1.5—25)

Table 2

Irradiation of abdominal cavity with 2 000 rad and more — Schilling test performed at different time intervals

Time after irradiation	Number of tests	Number abnormal	Percentage abnormal	Percentage mean excretion	
				Abnormal tests	All tests
Within a week	30	11	36.6	3.18	10.07 (range 0.5—25.0)
1 to 12 months after treatment	10	2	20	3.3	12.66 (range 2.4—23.7)
1 to 10 years after treatment	11	3	27.3	2.6	8.9 (range 1.5—15)

irradiation to the upper abdomen complained of anorexia or nausea; no marked clinical changes were recorded.

Leucopenia was the main radiation-induced complication, leading to protraction or interruption of the treatment. This was particularly prominent in the irradiation of the lower abdomen. Thirty patients receiving 3 000 rad to the lower abdomen had a mean leucocyte count at the beginning of the treatment of 6 744/mm^3 but at the end of the treatment there was a mean drop of 42.5 %.

The aim was to follow the patients during and after treatment and to establish the functional ability of the gastro-intestinal tract before the commencement of therapy and following various doses of radiation. The study was however carried out on very ill patients and treatment had often therefore to be started before any tests were possible. Tests could sometimes not be repeat-

Table 3

Results of Shilling test in relation to irradiated area and irradiation doses

Irradiation area	Irradiation dose 800—2 000 rad				Irradiation dose over 2 000 rad			
	Total number of tests	Number and % abnormal tests	Mean excretion % of		Total number of tests	Number and % abnormal tests	Mean excretion % of	
			Abnormal tests	All tests			Abnormal tests	All tests
Lower abdomen	8	3 (36.5)	4.5	10.6	26	8 (30.8)	2.7	11.2
Upper abdomen	4	1 (25)	4.1	15.2	8	3 (37.5)	3.9	8.5
Whole abdomen					16	5 (31.3)	3.2	9.92

Table 4

Shilling tests repeated in the same patient

Results of repeated tests	Dose of radiation in rad			Time difference of 18 months between tests
	800—2 000 Difference between test and test	2 000—3 000 Dose difference	< 3 000 Dose difference	
No change	3	1	1	
From normal to abnormal	3	1		1
From higher to lower excretion	2	1		
From lower to higher excretion	2	1		

ed, and often only one of the gastro-intestinal functions could be investigated. This made it difficult to arrive at an accurate evaluation of the results.

Schilling test. Seventy-two tests were performed in 40 patients and twenty of these were abnormal (27.7 %). The results of the Schilling test at different radiation levels are given in Table 1, and the influence of the time interval after irradiation on B12 absorption is recorded in Table 2. The results of the Schilling test in relation to the irradiated area and the irradiation dose are given in Table 3.

Of the nine Schilling tests performed before irradiation, only four were repeated in the same patient during treatment: two gave no change after

Table 5

Fecal excretion of ^{125}I-labelled triolein before irradiation and at different radiation levels

Irradiation rad	Mean fecal excretion %	Range %	Number of examinations	Number and % of abnormal tests	Mean fecal excretion in % of	
					Abnormal tests	Normal tests
All examinations	4.96	0.07—26.2	76	32 (42.1)	10.14	1.18
Before irradiation	4.28	0.2 —12.2	11	4 (36.3)	9.22	1.46
After 800 and over	5.08	0.07—15.6	65	28 (43)	10.2	1.14
600—1 000	6.57	0.4 —18.1	7	4 (57.1)	10.2	1.7
After 2 000	5.22	0.07—26.2	52	22 (42.3)	10.4	1.18
After 3 000 and over, at least 3 months previously	3.88	0.07—10.8	15	7 (40.6)	6.9	1.23

Table 6

Results of ^{125}I-labelled triolein excretion test in relation to the irradiated area — Irradiation dose 2 000 rad and over

Irradiated area	Number of tests	Number of abnormal tests	Per cent of abnormal tests	Mean excretion in per cent of:		
				All tests	Abnormal tests	Normal tests
Lower abdomen	29	9	31	4.01	10.2	1.21
Upper abdomen	6	2	33.3	2.91	6.6	1.0
Whole abdomen	20	12	60	7.06	11.22	0.84

3 000 rad to the lower and 3 000 rad to the whole abdomen; in one test excretion of the isotope became abnormal after 3 500 rad to the upper abdomen, and in one it changed from 35.6 % to 13.6 % after 3 000 rad to the whole abdomen.

Sixteen patients underwent B12 absorption examinations during treatment; the results of these are presented in Table 4.

Six patients with abnormally low urinary excretion of the isotope were re-examined with due regard to the intrinsic factor. Three of these then had normal excretion, i.e. only three of the six patients suffered from malabsorption but the three others had enzyme deficiency.

Table 7

Comparison of fat absorption responses at different radiation levels (changes in fecal excretion) in sixteen patients who underwent repeat examinations

	After dose differences of		Upper abdominal added to lower abdominal irradiation	After time interval of 2 to 6 months
	2 000—3 000 rad	Over 3 000 rad		
Normal and no change	4		1	1
From normal to abnormal	1		4	1
From abnormal to normal		1		2
Abnormal, no change		1		

Table 8

Mean blood radioactivity in 64 patients after triolein test dose

Kind of patients examined	Number of examinations	Mean radioactivity %/l			Range per cent
		Mean after 4 hrs	Mean after 5 hrs	Mean peak within first 6 hrs	
All	64	2.43	2.68	2.80	0.7 —5.8
Patients with normal fecal excretion	36	2.52	2.61	2.88	0.9 —5.8
Patients with abnormal fecal excretion	27	2.26	2.52	2.66	0.7 —5.61
Before irradiation	6	2.31	2.8	2.8	0.98—4.6
Irradiation 800 rad and over	57	2.07	2.62	2.77	0.7 —5.8
Irradiation 2 000 rad and over	45	2.32	2.51	2.74	0.8 —5.5
3 000 rad and over at least 3 months previously	13	2.69	2.77	2.98	1.1 —5.61

^{125}*I-labelled triolein fat absorption studies.* Examinations were carried out in 52 patients, thirty-seven of which (45.1 %) had an abnormally high fecal excretion. Twenty-eight out of the fifty-two patients (53.8 %) had fat malabsorption at some time during the investigation. The mean fecal excretion in all the tests performed was 6.7 %, with a range of 0.07 %—82 %.

Among the 52 patients examined for fat absorption, two were suffering from generalized abdominal lymphoma, two from abdominal Hodgkin's disease and one patient from pancreatic carcinoma with spread into the gastric

Table 9

Fecal PVP excretion, radiation dose and clinical data in five patients with protein loss

Case	Excretion %	Irradiation dose, rad	Clinical data
1	1.6	2 000 to lower abdomen	Generalized abdominal malignancy of ovarian origin; some diarrhoea during treatment; proteins normal
	0,9	3 000 to lower, 1 800 to upper abdomen	
28	6	2 100 to lower abdomen	Generalized abdominal malignancy of ovarian origin; poor general condition during treatment; septic temperature
38	0.5	1 400 to lower abdomen	Abdominal malignancy due to ovarian carcinoma; good general condition at beginning of treatment; albumin/globulin ratio 3.8/2.8
	4.5	3 000 to lower, 2 000 to upper abdomen	Two weeks after treatment severe diarrhoea; death at 6 months after treatment from uremia; probable renal damage; albumin/globulin ratio 3.8/2.6
40	1.9	Before irradiation	Generalized abdominal lymphoma, cachexia, diarrhoea; albumin/globulin ratio 2.9/2.8
	0.25	2 000 to lower abdomen	No improvement
45	0.6	3 000 to lower abdomen	Carcinoma of rectosigmoid junction; 50 cm of large bowel resected
	0.03	3 000 to lower, 2 000 to upper abdomen	
	4.9	5 500 to lower, 2 400 to upper abdomen	Diarrhoea during treatment

lumen and bowel. The prominent symptom of three of these patients was persistent diarrhoea.

Intestinal lymphoma is frequently associated with fat malabsorption, as has been described in a number of reports (GOUGH et coll. 1962, SPRACKLEN 1963, RAMOT et coll. 1965). Five patients were therefore excluded from the study since they were considered unsuitable for assessing radiation-induced functional changes. The results of the examinations of these five patients will however be given separately below.

Seventy-six triolein examinations were carried out in the remaining 47 patients, and thirty-two of these (42.1 %) were abnormal. The mean fecal excretion of all the 76 tests was 4.96 % (range 0.07 %—26.2 %). The mean fecal excretion in 44 normal tests was 1.18 % (range 0.07 %—3 %), and in the

Table 10

Gastric acid secretion at various radiation levels

Irradiation rad	Total acidity				Free acidity				Abnormal
	Normal	Hyper	Hypo	An-acid	Normal	Hyper	Hypo	An-acid	
None	4	2	1		4	2	1		3/7 42.8 %
800—2 000	1		7		1		5	2	7/8 87.5 %
2 000—3 000	5		6		5		2	4	6/11 54.5 %
Over 3 000	1		4	1	1		1	4	5/6 83.3 %
Total	11	2	18	1	11	2	9	10	21/32 65.6 %

32 abnormals 10.14 % (range 3.3 %—26.2 %). The fecal excretion of triolein at different radiation levels is recorded in Table 5.

The fat absorption results in relation to the irradiated area are presented in Table 6.

Four of the triolein examinations, performed before irradiation, were repeated in the same patients after irradiation with 3 000 rad. The fecal excretion in these four patients were before irradiation 2.5 %, 0.7 %, 5.7 %, and 0.4 %, respectively. The repeat triolein tests gave the following values: 14.1 %, 1.8 %, 26,2 %, and 0.2 %, respectively.

Sixteen patients were re-examined during and after irradiation, the doses employed ranging from 1 000 to 4 000 rad. The fat absorption responses according to the triolein test are given in Table 7. Nine patients suffered from diarrhoea and one from proctitis during or after treatment; six of these had at some time abnormal fecal triolein excretion while in four patients the test was within normal limits.

The blood radioactivity was determined in 64 patients, the mean peak value during the first 6 hours after the test meal for all patients being 2.08 %/l. Nineteen patients reached the maximum level within 4 hours, thirty-three within 5 hours and twelve patients within 6 hours. The blood radioactivity in patients with normal and abnormal fecal excretion at different doses is summarized in Table 8.

Six examinations were carried out in the five patients excluded (four patients with abdominal lymphatic disease and one with carcinoma of the

pancreas); the mean fecal excretion was 28.7 %. Four of the tests were performed before irradiation, one after 2 000 rad (9.3 %) and one after 3 500 rad (1.9 %). The blood radioactivity was determined in four of the patients. The one patient, with normal fecal excretion, had the same blood radioactivity (2.5 %/l and 2.8 %/l) as was noted earlier in the other patients (see p. 423). The three patients with severe fat malabsorption had a much lower blood radioactivity, the mean peak being at 4 hours 0.85 %/l, at 5 hours 1.41 %/l, and at 6 hours 1.54 %/l.

PVP test as an indicator of protein loss from the digestive tract. Fifty-one PVP examinations were carried out in 39 patients; five tests (9.8 %) indicated abnormally high fecal excretion of isotope. The mean fecal excretion in all the 51 examinations was 0.84 % (range 0.03 %—6 %). In the 46 normal tests, the mean fecal excretion was 0.52 % (range 0.03 %—1.5 %), in the five abnormal tests 3.7 % (range 1.6 %—6 %).

Repeat PVP tests were performed in 10 patients including four patients who at some time of the investigation had abnormal permeability of the gastro-intestinal mucosa for macromolecules. The results of the various tests in patients, representing protein loss, radiation doses and clinical details, are summed up in Table 9.

Gastric acid secretion. Thirty-two gastric acid examinations were carried out in 24 patients, twenty-one of the examinations (65.6 %) revealing abnormal values. The total acidity tests in these patients revealed hyperacidity in 2, hypoacidity in 18, and anacidity in one patient, while the free acidity tests disclosed hyperacidity in 2, hypoacidity in 9, and anacidity in 10 patients.

Correlation of the various irradiation doses to gastric acid secretion rendered the results reported in Table 10. The gastric acid examinations were repeated in six patients. Further irradiation diminished the gastric acid secretion. The gastric acidity returned to normal 6 months after irradiation in one patient.

The four tests (Schilling, triolein, PVP, gastric acid secretion) were, as previously mentioned, carried out in 75 patients. In 4 patients, all four of the tests, in 26 three, and in 14 patients two of the tests were applied, and sixteen out of 47 patients (34 %) had gastro-intestinal dysfunction proven by different parameters.

Discussion

No series of normal healthy people can receive high doses of abdominal irradiation for comparison, and investigations in irradiated healthy animals can be correlated only in so far as they demonstrate a good recovery potential

for the intestinal mucosa. Animal experiments are made with continuous exposure, or with large single exposures at different dose levels, and cannot be compared with fractionated and protracted therapy in human subjects.

In evaluating the present study we met with another difficulty. Only a limited number of baseline data (pre-treatment levels) for our own patients could be obtained, the reasons being given above. Moreover, progress of the disease or its improvement following treatment are factors likely to influence the performance of the gastro-intestinal tract and have to be taken into consideration. The data obtained in this study seem however to permit reliable conclusions as to whether therapeutic cobalt irradiation causes severe impairment of the gastro-intestinal function or not. No severe clinical side effects were observed apart from leukopenia, which produced no serious haematologic complications.

B12-absorption. Irradiation caused impairment of the B12 absorption (Table 1) in about a third of the patients; with rising dose levels, impairment in these susceptible patients increased as shown by the mean abnormal urinary excretion which fell from 5.02 % to 3 %.

The time factor (Table 2) appears to have some influence, as the percentage of patients affected by B12 absorption disturbance fell to less than 25 % a month after cessation of therapy; the severity of impairment did not alter.

What part of the abdomen was irradiated had no influence on the B12 absorption (Table 3) but, again, higher dose levels caused more severe disturbances. Furthermore, repeated Schilling tests indicated that added radiation doses affected the B12 absorption in more than 30 % of the patients (Table 4). Because of the small number of tests modified by the intrinsic factor no conclusion can be drawn as to whether enzyme deficiency can be caused by irradiation.

Fat absorption. It is more difficult to judge the results of the fat absorption examinations since four (36.3 %) of the eleven tests performed before treatment was started were abnormal. Tables 5, 6 and 7 suggest however that fat absorption impairment be caused by irradiation within the therapeutic dose range in about 25 % of the patients.

The tabulated data further indicate (1) that the mean fecal excretion of the isotope is considerably higher after than before irradiation, (2) the mean fecal excretion of patients with fat malabsorption is higher after irradiation than before, (3) the percentage of abnormal tests is higher after irradiation than before, the peak being in the dose range 600 to 1 000 rad, (4) three months after irradiation the percentage of abnormal tests does not change much, but

the mean fecal excretion in the abnormal tests in much lower, perhaps indicating recovery. The follow-up examinations were however insufficient in number to determine recovery or delayed effects of irradiation on fat absorption.

The highest percentage of abnormal examinations and the highest mean abnormal excretion occurred after irradiation of the whole abdomen.

Some comparable data appear in the literature. SANDERS et coll. (1956) found transient malabsorption in 13 out of 29 patients after 200 kV roentgen irradiation within a dose range of 945 to 3 100 R, the highest incidence occurring during the third week after 2 000 R. REEVES et coll. (1959, 1963) confirmed the incidence of fat malabsorption after irradiation, with a greater percentage of abnormal tests after telecobalt than after conventional therapy; the authors reported the majority of abnormal triolein absorption tests after 2 000 rad and during the third week of therapy. The investigations of GOODRICH et coll. (1962) indicated a very low incidence of fat malabsorption as determined by the oleic ^{131}I absorption tests; only the lower abdomen was irradiated in these studies.

The mean blood radioactivity as well as the mean peak blood values (according to Table 8) were within the normal range even in patients with abnormal fecal triolein excretion. It has been pointed out by many authors (CORREIA et coll. 1963, ISLEY et coll. 1963, REEVES et coll. 1963) that fecal triolein excretion is a more reliable indicator of fat absorption disturbance than blood radioactivity.

Very low blood levels have been described as significant of triolein malabsorption (CORREIA et coll.), an observation confirmed in the patients of the present series with abdominal lymphoma and pancreas carcinoma. Not only did these patients have a much higher fecal triolein excretion than all the other patients, but their blood radioactivity was significantly lower, 0.85 %/l as against 2.85 %/l.

Protein absorption. Only 9.8 % of the PVP examinations gave abnormal results, suggesting that the macromolecule passage through the mucosal barrier is only rarely affected by irradiation. The analysis of the abnormal results (Table 9) indicates that Case 1 improved with additional irradiation. Case 38, a patient who died from uremia following irradiation, might have had a particular hypersensitivity affecting not only the gastro-intestinal tract. Case 40 was one of the lymphoma patients excluded from the evaluation of fat absorption; he failed to improve clinically after irradiation but according to the PVP test no longer suffered from macromolecule loss. Case 45 developed abnormal fecal excretion only after a high irradiation dose; resection of a large

part of the bowel must however be considered as a contributory cause of malabsorption in this instance.

We have found no comparable investigations in human subjects in the literature; in animal experiments radiation caused protein loss through the gastro-intestinal wall in the dose range 250 to 1 000 rad (SULLIVAN 1960).

Gastric acid secretion. The influence of irradiation on the gastric acid secretion has been recognized for many decades (CASE et coll. 1928, PALMER et coll. 1939) and as doses of 1 000 to 2 500 R have produced transient anacidity in two-thirds of patients, this radiation effect has been used as treatment in peptic ulceration (RICKETS et coll. 1948). About two-thirds of the present examinations had abnormal values (Table 10) but as differences at various radiation levels were insignificant, no dose relationship could be established; as little as 800 rad however induced hypoacidity. Gastric acidity returned to normal in one patient 6 months after 3 000 rad. The point of recovery has not been especially investigated in this study as it has been established previously.

When evaluating the results of the four different tests, a differential radiosensitivity of the gastro-intestinal tract in its absorptive capacity for various substances appears to exist. B12 and fat absorption are more often impaired than protein absorption. These conclusions are supported by the multiple investigations carried out in the same patients. Gastric acid secretion is easily influenced by irradiation, but the relation to the other tests could not be established directly in the study, as gastric secretion was often the sole test carried out in a given patient.

The relatively minor functional impairment of the gastro-intestinal tract in the human material corresponds well with observations in animal experiments on intestinal cell survival and irradiation response. QUASTLER et coll. (1959) demonstrated experimentally that the intestinal mucosa of the rat at dose rates up to 415 rad per day maintained normal crypt size, generation time, and mature cell life span; at 415 rad per day, however, the percentage of proliferating cells diminished. This steady state failed to change with a continuation of the irradiation and it is quite possible that no functional disturbance ensued. WILSON (1964) interpreted the experimental results of QUASTLER on the basis of cell survival data and reached the same results as the latter by calculation. WIERNICK (1966) studied the effect of various fractionated irradiation regimes in human subjects by jejunal biopsies; after a single dose of 1 000 rad the intestinal mucosa was damaged beyond repair. This corresponds with the threshold dose reported by QUASTLER (1956) and QUASTLER & ZUCKER (1959), causing the 'intestinal syndrome I' and 'intestinal syndrome II' and the death of the animal. With two weekly doses of 500 R

and six treatments spread over 18 or 19 days, WIERNICK et coll. (1966) obtained progressive recovery of the jejunal mucosa in human subjects. He proposed a fractionation method consisting of large doses spread in such a way as to enable sufficient recovery of the intestinal lining and controlled by repeated biopsies. He hoped thereby to produce greater tumour destruction.

All these investigations did not deal with the functional state of the gastro-intestinal tract but they explain why therapeutic telecobalt irradiation according to our results gave rise to an impairment of the gastro-intestinal functional capacity, which generally resulted in only mild disturbances in a limited number of patients. This negative finding is of practical importance as it enables the continuation of an effective palliative treatment measure. The results may perhaps be further improved by larger fractionations controlled by repeated biopsies and functional studies.

Conclusions

Seventy-five patients with generalized abdominal malignancy were given therapeutic telecobalt irradiation to a part or the whole of the abdomen with 2 000 to 4 000 rad. The functioning condition of the gastro-intestinal mucosa was studied by B12 absorption, triolein absorption, PVP and gastric acid secretion tests.

The B12 absorption was impaired in about one third of the patients to a degree directly related to the dose. The number of patients affected began to diminish one month after the cessation of treatment. The fecal triolein excretion was high in about 25 per cent of the patients, the peak excretion being in the dose range 600 to 1 000 rad. The greatest percentage of abnormal tests and highest mean abnormal fecal excretion were noted after the irradiation of the whole abdominal cavity. The blood radioactivity was not a sensitive indicator of fat malabsorption. The PVP test revealed almost no macromolecule loss through the gastro-intestinal mucosa in the therapeutic dose ranges. The gastric acid secretion was diminished in about two-thirds of the patients after more than 800 rad but the restoration to normal acid levels occurred in most of them.

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SUMMARY

Therapeutic telecobalt irradiation with 2 000 to 4 000 rad was administered in 75 patients with generalized abdominal malignancy. The effect upon the intestinal mucosa, as indicated by the B_{12} absorption, triolein absorption, PVP, and gastric acid secretion tests, is discussed.

ZUSAMMENFASSUNG

Telekobaltbestrahlung von 75 Patienten mit generalisierter abdomineller Malignität wurde mit Dosen von 2 000 bis 4 000 rad vorgenommen. Der Einfluss der Bestrahlung auf die Darmschleimhaut, mit Bezug auf die Vitamin-B_{12}-Absorption, Trioleinabsorption, PVP und die Sekretion der Magensäure, wird diskutiert.

RÉSUMÉ

Une série de 75 malades atteints d'affection maligne généralisée de l'abdomen ont été traités par télécobalt-thérapie par des doses de 2 000 à 4 000 rad. Les auteurs en ont étudié l'effet sur la muqueuse intestinale au moyen de l'absorption de la vitamine B_{12}, l'absorption de la trioléïne, de PVP, et par des épreuves de la sécrétion acide gastrique.

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