Changes in the motility of the small intestine in digestive disorders

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EDITORIAL COMMENT The radiographic appearance of the small intestine is described in patients with impaired gastric and pancreatic secretion. Lack of digestive juice is compensated for by a slower rate of passage through the small intestine. The rate of passage is influenced by the rate of gastric emptying.

In our previous work dealing with the problem of the small intestine we were concerned with the relationship between the *x*-ray picture and the absorptive capacity of the small intestine. We provided evidence of a close relationship and reached the conclusion that the *x*-ray picture is a reliable indicator of the absorption capacity of the small intestine (Pirk and Vulterinová, 1964, 1966). In the present work we shall devote our attention to certain changes in the *x*-ray findings in conditions where digestive disorders can be anticipated.

METHOD

The subjects must be fasting; on the evening before the examination they take a light supper with maximum restriction of fats. For the examination 250 ml. contrast suspension (temperature 20°C.) is given and after the examination of the stomach and duodenum is complete the course of the contrast substance is followed through the small intestine. Checks are made after 15 and 30 minutes, and subsequently every 30 minutes till the contrast substance reaches the caecum. If the stomach is empty and the head of the contrast mixture has not reached the caecum within 180 min., dinner is served. In patients after gastrectomy this is done as a routine after 120 minutes. All check-up examinations are recorded on spot films. For the examinations we used one batch of non-flocculating contrast substance (Alubar) thus eliminating flocculation, which has an important bearing on the rate of the passage (Pirk and Bohdalová, 1959).

MATERIAL

We selected seven groups of subjects, differing as regards the secretion of digestive juice and the rate of gastric emptying. Fifty were volunteers, 53 subjects had had a gastrectomy, after which a certain degree of acidity

is preserved, 49 subjects after gastrectomy suffering from histamine-resistant achlorhydria, 14 patients with confirmed disorder of the external pancreatic secretion, seven patients after relapsing acute pancreatitis but with normal pancreatic function, and finally 39 patients after cholecystectomy. Only subjects who had undergone detailed clinical and biochemical examination were included.

The rate of gastric emptying, the time taken by contrast material to reach the aboral ileum, the time of ileostasis, and the time taken by contrast material to reach the caecum were evaluated. The reason why we divided the classical 'transit time' into the time taken to reach the aboral ileum plus the time of stasis in the ileum has already been explained (Pirk and Vulterinová, 1966). Briefly the term 'transit time' is usually considered a numerical indicator of the rate of passage through the small intestine, but data in the literature differ substantially and vary from 30 min. to eight hours. However, no attention is paid to the duration of stasis of the contrast substance in the ileum. The period for which the head of the contrast substance stops before it enters the caecum is very variable and may be very long and distort the results. In our opinion it is therefore important to differentiate the rate of passage of the head of the contrast substance through the small intestine from the transit time. It seems therefore more sensible to assess not only this transit time but also the time which elapses between ingestion of the contrast substance and the time the aboral loops of the ileum are reached, *i.e.*, the moment when the movement of the head of the contrast substance in the aboral ileum can no longer be detected radiologically. This period expresses more satisfactorily the rate by which the head of the contrast substance passes through the small intestine. The difference between the two values, *i.e.*, the time taken to reach the aboral ileum and the time taken to reach the caecum, corresponds to the duration of ileostasis. Only when we possess a carefully elaborated method, can we consider the influence of external and internal factors which may affect the change in the rate of passage of the contrast substance through the small intestine.

RESULTS

INFLUENCE OF RATE OF GASTRIC EMPTYING ON TRANSIT TIME IN SMALL INTESTINE One of the discussed factors which influence the rate of the advancing contrast substance in the small intestine is the rate of gastric emptying. Lönnerblad (1951), Golden (1959), Mattsson, Perman, and Lagerlöf (1960), and others refute any relationship. On the other hand, Schinz, Baensch, Friedl, and Uehlinger (1952), Chérigé, Hilleman, Proux, and Bourdon (1957), Věšín (1957), and others maintain that the rate of gastric emptying is an important factor determining the transit rate through the small intestine. To elucidate these relationships we analyzed the results in our subjects, using two independent approaches.

In healthy volunteers the stomach is emptied within 30 to 120 min. and in the same time the caecum is reached. The aboral ileum is reached usually within 30 to 90 minutes. The stasis in the ileum was only in four instances longer than 60 minutes. The analysis of the relationship of individual values and of the assessment of the correlation coefficient provided evidence that in healthy subjects the time taken to reach the aboral ileum ($r = +0.28$; $0.05 > P > 0.001$), as well as the time taken to reach the caecum ($r = +0.49$; $P < 0.001$), depends in a significant way on the rate of gastric emptying. Similarly we find these relationships in a group of non-operated subjects with achlorhydria ($r = +0.5$; $0.01 > P > 0.001$).

The group of subjects after cholecystectomy has a significantly slower gastric evacuation rate than the group of healthy volunteers ($t = 3.17$; $0.01 > P > 0.001$), and therefore we used this group as a model of slower gastric emptying. In it we find a significant relationship between the time taken to reach the caecum and the slower rate of gastric emptying ($r = 0.35$; $0.05 > P > 0.01$). The gastric evacuation in subjects after cholecystectomy does not influence in a detectable way the time taken to reach the aboral ileum.

In the group of patients after gastrectomy gastric emptying is more rapid. In this group there is, however, no detectable relationship between the time taken to reach the aboral ileum or caecum and the rate of gastric emptying. Similarly in the group of subjects with affections of the pancreas the influence of the rate of gastric emptying is in the background and therefore no causal relationship can be proved.

The influence of gastric emptying on the transit time was also proved by another method, *i.e.*, by comparing the time taken to reach the aboral ileum and caecum in groups of investigated subjects with a different rate of gastric emptying (Fig. 1a and 1b).

In subjects after gastrectomy with achlorhydria

the aboral ileum and caecum are, due to the more rapid gastric emptying, reached sooner than in patients after cholecystectomy and than in subjects with an impaired external secretion of the pancreas and in non-operated patients with achlorhydria. In groups of subjects where the rate of gastric emptying does not differ there is no significant difference in the assessed rates. It is, of course, of no use to compare in this connexion two groups if only one suffers from impaired secretion of digestive juices, as a further unknown factor interferes. Thus, for instance, in cholecystectomized patients, in whom the rate of gastric emptying is significantly slower than in healthy subjects the time taken to reach the aboral ileum and caecum is also longer. This is, however, not only due to the different rate of gastric emptying but also, as will be demonstrated later, to the absence of concentrated bile. The value of the *t* test is higher than in the other comparisons ($t = 5.97$; $P < 0.001$).

The following findings, however, do not agree. In cholecystectomized subjects the rate of gastric emptying is significantly lower than in subjects with an impaired pancreatic secretion, but there is no difference between these two groups in the time taken to reach the aboral ileum and caecum. In our opinion this is due to the fact that lack of pancreatic juice interferes more with digestive processes than lack of concentrated bile.

INFLUENCE OF IMPAIRED SECRETION OF DIGESTIVE JUICES ON TIME TAKEN TO REACH THE ABORAL ILEUM AND CAECUM We have demonstrated that in the group of subjects after gastrectomy it was not possible to provide evidence of a relationship between the rate of gastric emptying and the time taken to reach the aboral ileum or caecum, but if we divide that group of subjects after gastrectomy into two sub-groups according to the acidity of gastric juice, we show, by analysis of the relationship of individual values and by assessing the correlation coefficient, that in the group of subjects after gastrectomy with a preserved acidity the time taken to reach the aboral ileum ($r = +0.35$; $0.05 > P > 0.01$) and caecum ($r = +0.36$; $0.01 > P > 0.001$) depends on the rate of gastric emptying. On the other hand, in the groups of subjects after gastrectomy with achlorhydria the lack of digestive juices plays such an important role that the influence of the rate of gastric emptying on the time taken to reach the aboral ileum and caecum vanishes ($r = -0.03$, -0.02 ; $P > 0.05$).

Similarly, we found that in the group of subjects with pancreatic affections it was no longer possible to provide evidence of a relationship between the rate of gastric emptying and the time taken to reach

the aboral ileum and caecum, but if we divide this group according to the disturbance of the excretory function of the pancreas, we find that in the group of subjects with pancreatic disease in whom the secretory function of the gland is preserved there is again a relationship between the transit time and the rate of gastric emptying, though this group is very small ($r = 0.80$; $0.05 > P > 0.01$). In the group of subjects with an impaired secretory function of the pancreas the lack of digestive juices is so important that the influence of gastric emptying diminishes.

The influence of lack of some digestive juice on the transit time through the small intestine can be proved also by comparing the times taken to reach the aboral ileum and caecum in individual groups. We must, however, not forget that at the same time

transit is influenced by the rate of gastric emptying. Therefore we can again compare only those groups in which there is no statistically significant difference between the rates of gastric emptying. In the group of subjects where some digestive juice is lacking the aboral ileum and caecum is reached later than in the group with intact secretion (Fig. 1c and 1d).

By comparing the duration of 'ileostasis' in groups of subjects in whom some digestive juice is lacking with that in subjects with normal secretion we find that in all four groups of such patients ileostasis is longer than in groups without any detectable disorder (Fig. 2). All 12 relationships are statistically significant. There is no statistically significant difference in the duration of ileostasis in the groups with impaired production of digestive juice.

FIG. 1a. Averages and standard deviations of times taken to reach the aboral ileum in groups of subjects with somewhat impaired secretion of digestive juice.

CH = patients after cholecystectomy. IP = patient with impaired pancreatic function. A = patients not operated, with achlorhydria. GA = patients after gastrectomy with achlorhydria.

FIG. 1b. Averages and standard deviations of time taken to reach caecum in groups with somewhat impaired secretion of digestive juice.

FIG. 1c. Averages and standard deviations of the time taken to reach the aboral ileum in groups with equal rates of gastric emptying. In the first two groups secretion of juice is somewhat impaired; in the other two groups the secretion is intact.

A = patients not operated with achlorhydria. IP = patients with impaired pancreatic function. V = healthy volunteers. PN = pancreatic disease with normal secretion.

FIG. 1d. Averages and standard deviations of time taken to reach the caecum in groups with the same rate of gastric emptying. In the first two groups the secretion of digestive juice is impaired; in the remaining two groups the secretion of juices is preserved.

FIG. 2. Averages and standard deviations of duration of ileostasis in individual groups. In the first four groups the secretion of juice is somewhat impaired; in the last three groups the secretion is intact.

GN = patient after gastrectomy with normal acidity.

There is also no difference in the duration of ileostasis in groups of subjects in whom evidence was provided of impaired secretion of digestive enzymes.

Last but not least, attention must be paid to the finding that the average ileostasis in subjects with impaired function of the pancreas is markedly longer ($m = 78.2$ min. and $m = 90.0$ min. respectively) than in the group of subjects with impaired production of some other digestive juice ($m = 63.2$, 58.2 , and 68.5 min.), though these differences are not statistically significant. All these findings appear to be due to the fact that the impaired secretion of pancreatic juice is a greater interference with digestive processes than the lack of concentrated bile or of hydrochloric acid.

We also wished to test whether the duration of ileostasis is influenced by the rate of gastric emptying, although the above results practically rule out this possibility, as all relationships are also obvious between groups regardless of the rate of gastric emptying. Nevertheless we analyzed the relationship between the rate of gastric emptying and ileostasis in individual groups and found that in none of the groups did the period of ileostasis depend on the rate of gastric emptying.

CONCLUSIONS

The 'transit time' does not express the rate of

passage through the small intestine. The rate of passage depends in the first place on the rate of gastric emptying. The greater the number of participating pathological factors, the smaller the decisive influence of the rate of gastric emptying on the rate of the passage through the small intestine.

The impaired secretion of some digestive juice leads to a slower passage of the investigated substance through the small intestine. Impaired secretion of some digestive juice leads to prolonged stasis in the ileum.

The rate of gastric emptying does not influence the duration of ileostasis.

Even from rates of passage and ileostasis assessed radiologically it is obvious that the impaired secretion of pancreatic juice is a more serious interference with digestive processes than impaired secretion of other digestive juices investigated in the present work.

SUMMARY

Seven groups of patients subjected to x-ray examinations of the small intestine were examined by a non-flocculating contrast substance. Four groups were included in which impaired secretion of digestive juices was revealed and three groups lacking detectable disorders of secretion of digestive juices. From findings in 50 volunteers normal values for the rate of gastric emptying were assessed as well as the time taken for the contrast medium to reach the aboral ileum, the duration of ileostasis, and the time taken to reach the caecum.

Some groups differed as regards the rate of gastric emptying. The assessed values were computed statistically by two methods. Both methods, though using a quite different approach, arrived at the same conclusions.

The present work was focused on the question whether and how the absence of some digestive juice is manifested in the x-ray picture. From the results it is apparent that the lack of digestive juice which may lead to a digestive disorder is compensated for by the organism by a slower rate of passage through the small intestine and longer ileostasis. This mechanism is so fixed that it can be observed even during the passage of an indifferent substance when digestion does not take place. The rate of passage is, however, influenced by the rate of gastric emptying, which is one of the main factors determining the rate of movement of the contrast substance in the small intestine. The relationship of the rate of passage on the rate of gastric emptying can be followed in those subjects in whom it is not too much distorted by the opposite inhibiting effect of impaired digestion. The duration of ileostasis, however, is not influenced by

the rate of gastric emptying and its protraction depends in the first place on the lack of some digestive juice. If we thus take into account the rate of gastric emptying, the relative slowing down of the passage of contrast medium and protracted ileostasis may draw our attention to possible digestive disorders, similarly as a pathological picture of the small intestine draws our attention to the existence or even the degree of impaired absorption.

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