Sustained mental stress alters human jejunal motor activity

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SUMMARY  The effect of prolonged mental stress on upper small bowel motility was studied in 11 healthy, medical students using a pressure-sensitive radio-pill. During eight hours of continuous observation, subjects were stressed for four hours with a modified dichotomous listening test. During the first two hours of stress, inhibition of fasting motor complexes occurred and this effect was marked in the seven subjects who showed an appreciable cardiovascular response to stress.

It is widely assumed, on the basis of every-day experience, that stress affects bowel function and often causes abnormalities such as 'spasm' and disorders of transit and defaecation. Almy has pointed out that alteration of bowel function is probably an important adaptive response to stress in man.

There are but few published observations of the effects of stress on digestive tract motility. That the results of these studies were inconclusive or contradictory may have resulted from the failure of the protocols to allow for the normal cyclical variation in fasting motor activity, as it has subsequently become clear that fasting motor activity at any point in the stomach and small bowel is characterised by alternating quiescence and activity with a period of about 90 minutes. Contractile activity consists of irregular contractions terminating in a sequence of regular phasic contractions lasting about five minutes (the activity front) followed by an abrupt transition to motor quiescence.

The indeterminate nature of the stress applied in earlier studies is also open to criticism – for example, 'provocative' interviews as used in some studies are not easily standardised. This prompted us to undertake a controlled study of the effect of mental stress on jejunal motility in healthy volunteers. In order to detect variations from normal periodicity, we used a technique for prolonged motility monitoring allied to a sustained, reproducible, and ethical method of applying stress.

Methods

The subjects were 11 healthy medical students (ages 19-22 years). All were normotensive and none had any history of psychiatric or functional gastrointestinal illness. The method of studying jejunal motor activity with the radio-pill has been described in detail elsewhere. Briefly, each subject swallowed the radio-pill on the evening before the study. After an overnight fast, the position of the radio-pill was adjusted under fluoroscopy so that it lay just distal to the ligament of Treitz. A radio aerial to receive the signal was then fastened around the abdomen and connected to a receiver whose output was continuously recorded on a Medilog 4-24 tape recorder. The subject, wearing stereo headphones, lay supine on a bed in an empty hospital ward for the study period of more than eight hours.

Each study consisted of four hours of control recording during which subjects listened to light entertainment (Capital Radio), an interval of about 10 minutes, and four hours of recording while subjected to the modified dichotomous listening test. In six subjects, the control period preceded the stress period; in the other five, the periods were reversed. During the stress period, the stereo headphones were connected to a stereo audio tape recorder. Each of the twin tracks of one magnetic tape contained a four hour spoken extract from a novel. The narrative differed on each track but the narrator was the same person in each case. At the beginning of the stress period, the subject was instructed to repeat aloud the narration heard through one ear while ignoring the narration in the other ear. Every 15 minutes, the subject was asked to change from one narrative to the other. To
encourage the subject to try harder, at the outset he or she was informed that it had been established that the ability to perform the test correctly was related to intelligent quotient, and that the subject would be evaluated on the basis of performance.

The degree to which the subjects were stressed was measured both objectively and subjectively. Objectively, measurement consisted of regular measurement of pulse rate and blood pressure, every 30 minutes during the control period and every 15 minutes during stress. Subjectively, subjects were asked every 60 minutes to rank four symptoms — headache, tension, nausea, and confusion — on a visual analogue scale between 0 (absent) and 10 (maximal). Jejunal motor activity was recorded and replayed, and the regular contractile phases of motor complexes identified from the replayed tape as previously described.10

Results

Subjective response to stress

It became clear that individuals differed widely in their estimate of these symptoms; some subjects recorded moderate or severe symptoms while they appeared to an observer to be serene and untroubled. When the scores were pooled (Fig. 1), it seemed that disagreeable sensations were more pronounced during the stress period, but this method of assessment did not prove to be useful in discriminating degrees of individual response.

Objective response to stress

Since variation of heart rate and blood pressure within and between subjects tended to obscure the trend, the systolic blood pressure and pulse rate during stress were compared with the average values during the equivalent control period. Thus, for any one subject, the mean systolic blood pressure during the control period was calculated, and the percentage deviation from this value was calculated for all measurements of systolic blood pressure throughout the study of that subject. This was repeated for each subject, and a similar analysis was made of pulse rate data; the results are shown in Figs 2 and 3. It is apparent that, although there was wide variation, both pulse rate and systolic blood pressure tended to be raised above the average control value during the stress period, and this rise was sustained throughout the period of stress.

During the study, some subjects appeared to be less stressed than others; this was confirmed by analysis of the cardiovascular changes. In order to derive an overall estimate of each subject’s response to stress, the arithmetical mean of the percentage changes in pulse rate and blood pressure during stress was calculated for each subject and the results are illustrated in Fig. 4. It will be noted that four subjects showed a change below 5%. The 5% level of change was used arbitrarily to divide the study group into sub-groups consisting of four subjects showing little or no response to stress and seven subjects showing an appreciable amount of stress.

Response and non-response to stress

The use of a 5% dividing line between ‘response’ and ‘non-response’ correlated well with the observers’ subjective assessment of the individuals under study. The common factor in diminution of the response to stress appeared to be familiarity with some aspect of the study. Of the four showing less than 5% cardiovascular change, two (SM, RM) had detailed knowledge of the methodology before being studied, one (HR) is a frequent volunteer for a wide variety of clinical studies, while the remaining individual (BG) has considerable experience of radiotelemetry studies on human bowel motility,10 as does the subject (LA) ranked next.10

The latter showed a response slightly greater than 5%, and was included in the ‘responding’ sub-group of seven subjects, but it is pertinent to note that she was the only subject in this group to show two activity fronts during the first two hours of stress. The remaining six subjects lacked both experience of clinical study and also prior knowledge of the nature of the stress. These data suggest that prior knowledge or experience may improve the subject’s defences against stress induced in this way.

Jejunal motility

The temporal incidence of motor complexes (MCs) for the two sub-groups was plotted. In the sub-group of four subjects with little response to stress, there
Fig. 2  Pulse rate. Each line indicates the percentage deviation from the average pulse rate during the control period for a single subject, during control and stress periods.

Fig. 3  Systolic blood pressure. Percentage deviation plotted as described in Fig. 2.
Stress and small bowel motility

was no obvious difference between the control and stress periods (Fig. 5). In the remaining seven subjects, shown in Fig. 6, there was a marked absence of motor complexes during the early phase of the period of stress. The data were analysed using two non-parametric tests, as shown in the Table. When the incidence of motor complexes during the four hour periods of stress was compared with the incidence during the four hour control periods, either for the whole group or for the sub-group of seven with a marked stress response, there was no significant change. When the incidence of motor complexes in the first two hours of stress was compared with the incidence of complexes during the first two hours of control period for the whole group, it can be seen that there was a significant difference with only one of the two statistical tests. However, the difference for the sub-group of seven 'responders' was statistically significant using both tests. In contrast, there were no significant differences between the groups when the incidence of motor complexes in the second two hours of each period was compared.

Discussion

Although the number of subjects was not large, the data indicate that stress may impair the incidence of motor complexes during the initial phase of stress. Surprisingly, the cardiovascular response did not show any such difference between the first and

Table  Values of p for difference in incidence of motor complexes between control and stress periods

<table>
<thead>
<tr>
<th>Hours</th>
<th>Subjects (no.)</th>
<th>Wilcoxon m-p s-r 2-tail sign test</th>
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<tbody>
<tr>
<td>4</td>
<td>11</td>
<td>0-294 0-726</td>
</tr>
<tr>
<td>1st 2</td>
<td>11</td>
<td>0-059 0-040</td>
</tr>
<tr>
<td>2nd 2</td>
<td>11</td>
<td>0-347 *</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>0-734 *</td>
</tr>
</tbody>
</table>

Values are italicised where p is less than 0.05.
* Test not applicable.

Fig. 4  Each bar represents the mean percentage change for aggregate pulse and systolic blood pressure during stress compared with the control period. The horizontal broken line separates the sub-group of subjects in whom the mean change was less than 5% (see text).

Fig. 5  Incidence of jejunal activity fronts (MCs) during control and stress periods in four subjects who showed less than 5% change in aggregate pulse and systolic blood pressure under stress.

Control period

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<tr>
<th>Control period</th>
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<tbody>
<tr>
<td>SM</td>
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<td>HR</td>
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<tr>
<td>RM</td>
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<td>BG</td>
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Stress period

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<tbody>
<tr>
<td>SM</td>
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second two hours of stress. This discrepancy suggests that some adaptive response to stress is taking place which is not reflected in cardiovascular performance but can be detected in the bowel. The effect of stress on motor complexes may be relevant to the prolongation of the interval between complexes which we reported in a fasted subject suffering from an 'irritable colon' while awake but not during sleep. As the functional consequences - if any - of the induced changes in motor activity are as yet unknown, the immediate significance of our study resides perhaps in the demonstration that sustained stress may be applied to subjects without drugs, pain, 'stressful interviews', or the use of hoaxes to induce fear, thus allowing the study of its effects on ultradian rhythms. Likewise, the modulation of periodic motor activity by external stimuli seems to warrant further study. No attempt was made to measure differences in personality factors within the group, but it should be emphasised that healthy volunteer medical students come from a cohort which shows marked differences in ability, achievement, and culture from the general population. It would be unwise to conclude that these responses are typical of the responses of all adults, or even age- and sex-matched healthy adults, in the population as a whole. This study has shown that stress can alter periodicity in healthy volunteers drawn from the medical community. It remains to be seen whether the changes in motility might be more marked in lay persons or in patients with 'functional' or organic bowel disorders.

Our thanks are due to the volunteers who submitted themselves for study. This project was undertaken by SMcR and KY as a course unit project for an intercalated BSc degree in Physiology; a preliminary account of the work was given to the Physiological Society at Cambridge in June 1980.

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doi: 10.1136/gut.23.5.404

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