Effects of ageing on gastrointestinal motor function

JAN L. MADSEN, JESPER GRAFF

Department of Clinical Physiology and Nuclear Medicine 239, Hvidovre Hospital, University Hospital of Copenhagen, Kettegård Allé 30, DK-2650 Hvidovre, Copenhagen, Denmark

Address correspondence to: J. L. Madsen. Fax: (+45) 3622 3750. Email: jan.lysgaard.madsen@hh.hosp.dk

Abstract

Background: existing data on the effect of ageing on gastrointestinal motility are few. In this study, we assessed the propulsive effect of all main segments of the gastrointestinal tract in a group of healthy older people.

Methods: 16 healthy volunteers (eight women, eight men) of mean age 81 years (range 74–85 years) participated in the study. Gastric emptying and small intestinal and colonic transit rates were determined by gamma camera technique. The

References


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Introduction

So far, relatively little work has been done to describe the gastrointestinal changes associated with normal ageing and in many instances normal data on which to base clinical comparisons are not available [1]. Thus, only a few studies have been published that describe normal colonic motility among older subjects, and similar limitations apply to gastric and small intestinal motor function. The studies that have been done commonly reveal conflicting results due to differences in the used methodology. In addition, the increasing prevalence of coexisting diseases and medications with age make studies on healthy individuals beyond the seventh decade of life difficult. However, owing to a large functional reserve capacity of the gastrointestinal tract ageing seems to have little direct clinical effect on most gastrointestinal functions [2].

Traditional techniques for studying gastrointestinal motor function are inconvenient, invasive, or imprecise. Radiological procedures with barium sulphate suspensions only provide qualitative results. Intubative techniques are inconvenient, and intubation itself may interfere with normal gastrointestinal motility. The hydrogen breath test gives an index of the time taken for the head of the fermentative substrate to pass from the mouth to the caecum. However, the test does not permit quantification of the passage of markers. The timed gastric emptying test can only be used to evaluate gastric motor function. In recent years, repetitive gamma camera imaging after oral intake of physiological radiolabelled markers has proven useful for the quantitative assessment of the motor function of all main segments of the gastrointestinal tract [3, 4]. In the present study, therefore, scintigraphy was used to assess gastric emptying rate and small bowel and colonic transit rate among healthy older volunteers. Furthermore, we evaluated the separate effects of gender, body mass index and smoking on these motility variables.

Methods

Subjects

Sixteen healthy volunteers (eight women, eight men) of mean age 24 years (range 20–30 years) and mean body mass index 22.4 kg/m² (range 18.9–26.5 kg/m²) [5]. Five were smokers. None of the participants had antecedents of abdominal surgery except for appendectomy, abuse of alcohol, or treatment with drugs including laxatives that were known to interfere with normal gastrointestinal motility. None of the volunteers had symptoms referable to gastrointestinal disease or reported constipation or obstructed defaecation during the investigations. All subjects were recruited by advertisement within the community. Written informed consent was obtained from all volunteers and the local medical ethics committee approved the study protocol.

Measurements

Gastrointestinal transit was measured with gamma camera technique [5, 6]. Studies began in the morning after an overnight fast. In 10 minutes, each subject ingested a 1600-kJ mixed liquid and solid meal (80 g of bread, 120 g of egg omelette, 200 g of water) containing radiolabelled markers. As a liquid marker 4 MBq of 111In diethylentriamine penta-acetic acid (111In-DTPA) was added to the water, and as a solid marker 20 MBq of 99mTc stannous colloid was added to the egg omelette. Anterior and posterior images were acquired with the subject in the upright position. Imaging was repeated at 30-minute intervals until no radioactivity could be detected in the small intestine. If the examinations had not already been finalized, the subjects had a further meal at 13.00 h and 17.00 h. For the following days, imaging was repeated at 24-hour intervals until all radioactivity had cleared from the colon. All volunteers kept their usual diet and smoking habits during the whole study period. Post-prandial frequency of antral contractions was assessed from anterior dynamic images of 1 sec each, which were acquired for 5 minutes at 60 minutes after the radiolabelled meal [7].

Data analysis

Regions of interest for integration of radioactivity were delineated manually around the stomach and the colon on each image. To minimise errors in the interpretation, sequential images were displayed forwards and backwards in time, showing the movement of the markers. Counts were corrected for down scatter, gamma ray attenuation and physical decay. The...
percentage of marker in the small intestine was estimated from the percentage of marker in the stomach and in the colon. Due to the relatively quick input of radiolabelled marker into the stomach and the colon, the directly obtained time-activity curves reflected gastric and colonic transit quite well. By contrast, the relatively slow process of gastric emptying had considerable influence on the directly obtained small intestinal time-activity curves. Therefore, the mathematical principle known as deconvolution analysis was used to construct the time-activity curves to be expected from an instantaneous input of all radioactive marker into the small intestine [6]. For statistical comparisons, the information given by each time-activity curve was condensed into one single variable, the mean transit time, by dividing the area beneath the curve with its initial, maximum, value. This variable, which expresses the mean time for all radioactive material to enter and leave the corresponding gastrointestinal segment, does not presuppose particular emptying or transit kinetics [6]. Due to the short physical half-life of $^{99m}$Tc colonic mean transit times were only obtained for $^{111}$In-labelled liquid marker. The method used to process the dynamic images has been described elsewhere [5]. For precise presentation of the antrum, each set of dynamic images was at first reframed into a single image, and a box region of interest was localized over the distal antrum close to the pylorus. Then the position of the geometric centre of radioactivity was determined on each 1-second image. On the assumption that the horizontal oscillations of the geometric centre of radioactivity in the region of interest reflected the contractile activity of the antrum, fast Fourier transform analysis was used to find the frequency of these contractions.

**Statistical analysis**

Multiple regression analysis was used to evaluate the effects of age, gender, body mass index and smoking on the mean transit times. The level of significance was 0.05.

**Results**

Results of gastrointestinal motility assessments are shown in Figures 1–3 and in Table 1. Results of the multiple regression analysis appear in Table 2. Advanced age did not influence gastric emptying or small intestinal transit rate. Older individuals had a slower colonic transit than young individuals ($P=0.0008$). No difference was found in postprandial frequency of antral contractions between older and young subjects. None of the motility variables was affected by gender or body mass index. Smokers had a faster colonic transit than non-smokers [30 hours (14–44 hours) versus 59 hours (27–98 hours), $P = 0.0022$].

**Discussion**

There is relatively little information about the effects of ageing on gastrointestinal motor function in humans, although this is likely to be fundamental to an understanding of gastrointestinal symptoms, appetite regulation, and absorption of both nutrients and oral drugs. A number of studies have been performed in subjects who were hospitalised or taking drugs that might affect gastrointestinal function [8, 9]. The extrapolation of the results of such studies to healthy older populations is dubious. However, there seems to be an increase in gastrointestinal disorders of function and motility with ageing. The most frequent gastrointestinal motor problems encountered by the gastroenterologist in the older patient include dysphagia, dyspepsia, anorexia and constipation [2]. In some of the patients, delayed gastric emptying and decreased peristalsis with slowing of intestinal transit explain the symptoms. However, even though an increased prevalence of several common gastrointestinal motor disorders occurs in older people, ageing *per se* appears to have minor direct effect on most gastrointestinal functions, in large part because of the functional reserve capacity of the gastrointestinal tract [1].

In our study, multiple regression analyses with age, gender, body mass index and tobacco smoking as explaining variables were used to evaluate the separate effect of each variable on gastrointestinal motility. The analyses showed that advanced age did not influence gastric emptying, postprandial frequency of antral contractions or small intestinal transit rate, whereas the older subjects had a longer colonic mean transit time than the young subjects. The process of normal ageing, therefore, seems to reduce the propulsive efficacy of the colon.

The effect of ageing on gastric motility has evoked some interest, but it is still controversial whether gastric emptying changes in advanced age. The present observation is consistent with most of the previous reports [10–12]. However, other studies showed that radiolabelled liquids or digestible solids...
emptied more slowly from the stomach in older subjects [13, 14]. In the majority of these studies, the magnitude of the changes were relatively small, so that the emptying rates were, for the most part, within the range observed in the younger subjects. A plausible mechanism leading to slower gastric emptying in older persons has not been defined. In a previous study, Clarkston and his colleagues noticed a high incidence of sympathetic or parasympathetic dysfunction in a group of older subjects, but there was no relationship between gastric emptying and autonomic nerve dysfunction [14]. Our observation that ageing did not influence the postprandial frequency of antral contractions is in accordance with the recent report from Shimamoto and his colleagues [15]. The enteric nervous system that is considered to control the frequency of the underlying gastric slow waves, therefore, appears to be preserved during normal ageing. Overall, ageing seems to have only minor effects on normal gastric motility.

So far, little attention has been directed towards small intestinal motility in advanced age. In a previous study based on ambulatory manometry, Husebye and Engedal found that the changes of the migrating motor complex were within the range of normality for young individuals [16]. Furthermore, the investigators noticed that the motility patterns after a meal were normal. In another recent study, the hydrogen breath test did not show any effect of ageing on orocaecal appearance time of lactulose [14]. Our finding that the propulsive activity of the small intestine was unchanged in

Table 1: Results of gastrointestinal motility assessments in older and young healthy volunteers

<table>
<thead>
<tr>
<th></th>
<th>Older volunteers (n = 16)</th>
<th>Young volunteers (n = 16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GMTT (liquids)</td>
<td>1.37 (1.07–1.85) hours</td>
<td>1.59 (1.18–1.96) hours</td>
</tr>
<tr>
<td>GMTT (solids)</td>
<td>2.07 (1.32–3.03) hours</td>
<td>2.12 (1.53–2.73) hours</td>
</tr>
<tr>
<td>SIMTT (liquids)</td>
<td>4.95 (2.21–8.00) hours</td>
<td>4.24 (2.70–6.60) hours</td>
</tr>
<tr>
<td>SIMTT (solids)</td>
<td>4.77 (2.53–8.13) hours</td>
<td>3.87 (2.48–5.89) hours</td>
</tr>
<tr>
<td>CMTT</td>
<td>66 (29–98) hours</td>
<td>39 (14–75) hours</td>
</tr>
<tr>
<td>PPFAC</td>
<td>3.3 (2.8–3.6) per minute</td>
<td>3.2 (3.0–3.4) per minute</td>
</tr>
</tbody>
</table>

Values are means (ranges); GMTT, gastric mean transit time; SIMTT, small intestinal mean transit time; CMTT, colonic mean transit time; PPFAC, postprandial frequency of antral contractions.

Table 2: Overall effects of age, gender, body mass index and smoking on gastrointestinal motility variables expressed as results of multiple regression analysis

<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>Gender</th>
<th>BMI</th>
<th>Smoking</th>
</tr>
</thead>
<tbody>
<tr>
<td>GMTT (liquids)</td>
<td>$P = 0.0540$</td>
<td>$P = 0.2349$</td>
<td>$P = 0.5027$</td>
<td>$P = 0.1783$</td>
</tr>
<tr>
<td>GMTT (solids)</td>
<td>$P = 0.8084$</td>
<td>$P = 0.1761$</td>
<td>$P = 0.4577$</td>
<td>$P = 0.0766$</td>
</tr>
<tr>
<td>SIMTT (liquids)</td>
<td>$P = 0.7791$</td>
<td>$P = 0.2544$</td>
<td>$P = 0.2123$</td>
<td>$P = 0.2478$</td>
</tr>
<tr>
<td>SIMTT (solids)</td>
<td>$P = 0.4345$</td>
<td>$P = 0.1502$</td>
<td>$P = 0.1540$</td>
<td>$P = 0.4156$</td>
</tr>
<tr>
<td>CMTT</td>
<td>$P = 0.0008$</td>
<td>$P = 0.4123$</td>
<td>$P = 0.6249$</td>
<td>$P = 0.0022$</td>
</tr>
<tr>
<td>PPFAC</td>
<td>$P = 0.4574$</td>
<td>$P = 0.4082$</td>
<td>$P = 0.9338$</td>
<td>$P = 0.4450$</td>
</tr>
</tbody>
</table>

BMI, body mass index; GMTT, gastric mean transit time; SIMTT, small intestinal mean transit time; CMTT, colonic mean transit time; PPFAC, postprandial frequency of antral contractions.
older healthy volunteers is in accordance with these observations. Thus, it is unlikely that small bowel abnormalities such as malabsorption and bacterial overgrowth are due to age-related motility changes.

It is commonly assumed that complaints of chronic constipation, as well as alterations in colonic functioning, are natural consequences of the process of normal ageing [17]. However, existing data do not clearly implicate colonic dysmotility in healthy older adults and chronic constipation does appear to be associated more frequently with abnormalities of reflex mechanisms that control the rectal function [1]. The ageing influence on colonic or whole gut transit rate has been the subject of few previous studies, which were all based on radiological principles [18–20]. None of these studies pointed out significant differences between young and older subjects, although Metcalf and her colleagues noted a tendency towards a longer mean colonic transit time in the older subjects [19]. The current results indicate a frequent delay in colonic transit during the seventh and eighth decade in individuals that do not report constipation or straining at defaecation. Age-related changes in both the neurons and the receptors of the enteric nervous system might be responsible for our observation. Thus, studies on ageing showed a substantial reduction in the number of neurons in the myenteric plexus [21] and an increased density of opioid receptors in the colon of aged guinea pigs [22]. Accordingly, specific opioid antagonists appeared to improve chronic constipation in geriatric patients [23]. It should be recognised, however, that variations in physical activity levels, eating habits and psychological factors might have influenced our recordings too.

Premenopausal women seem to have slower gastric emptying than postmenopausal women and men [24, 25]. Probably, the delayed emptying is due to the high progesterone level during the luteal phase of the menstrual cycle. In our study, gastric emptying assessment in young women was not done in a specific phase of the menstrual cycle and may explain why, therefore, we did not find gender-related differences in gastric emptying. In agreement with previous reports, our study did not show important effects of gender on small intestinal and colonic motility [12, 26].

We did not reveal a relationship between body mass index and gastrointestinal motility. It is probable, however, that we would have observed an effect of body composition if volunteers with very low or very high body mass index were included. It has been shown by others that obese people might have faster gastric emptying than those non-obese [27]. To the best of our knowledge an effect of body composition on small bowel or colonic motility has not been documented so far.

Smoking and transdermal or intravenous administration of nicotine has been shown to delay gastric emptying and accelerate colonic and rectosigmoid transit [28, 29]. In partial accordance with these reports, our study showed a considerably shorter colonic mean transit time among smokers than non-smokers. The precise mechanism is not known, but adrenergic as well as cholinergic systems in the gastrointestinal tract are activated by nicotine and the response seems to depend on the ratio of receptor types present. With a predominantly parasympathetic innervation of the colon, the expected effect of nicotine should be an increased motor activity that might explain our observation.

Key points

• No age-related changes were found in gastric emptying rate and postprandial frequency of antral contractions.
• Ageing did not influence the small intestinal transit rate.
• The colonic transit was delayed in the older group.

Acknowledgement

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References

Determinants of sleep quality in the healthy aged: the role of physical, psychological, circadian and naturalistic light variables

BERNADETTE HOOD, DOROTHY BRUCK, GERARD KENNEDY

Department of Psychology, Victoria University, Australia

Address correspondence to: B. Hood, Department of Psychology, Victoria University, PO Box 14428, MCMC 8001, Australia. Fax: (+61) 3 936 52218. Email: Bernadette.Hood@vu.edu.au

Abstract

Ageing is associated with a decrease in the quality of night-time sleep with 30% of aged persons experiencing chronic insomnia. Treatment of insomnia typically involves the use of hypnotic medications and these have been associated with a range of negative outcomes in this population cohort. The development of age-related insomnia has been linked, in part, to changes in the strength of the circadian regulation of sleep, these changes typically leading to increased fragmentation of the sleep–wake cycle. Management of insomnia may therefore be linked to strengthening of these regulatory control mechanisms. Previous research has indicated that both daily activity levels and ambient light exposure may act as zeitgebers to consolidate sleep–wakefulness cycles. The current study utilised a naturalistic design to explore the relationship between light, activity and...