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RAPID COMMUNICATION

The Effect of Feeding on Defecation Behaviour in Pigs

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MUSIAL, F., M. D. CROWELL AND A. W. FRENCH. *The effect of feeding on defecation behaviour in pigs.* PHYSIOL BEHAV **51**(3) 643–646, 1992.—The effect of eating on defecation behaviour was investigated in four 20–30 kg pigs. Rectal distention stimulation was performed pre- and postprandially at 10 cm from the anus with a 5 cm latex balloon. Volume was increased in steps of 10 ml up to 200 ml of air or until balloon defecation. Dependent measures were volume, rectal pressure, determined with a solid state pressure transducer inside the balloon probe, rectal compliance, and an index of distention induced contractile activity. The volume and pressure required to elicit defecation was significantly lower after feeding ($p < 0.01$). Distention induced contractile activity was significantly increased near defecation threshold, but pre- and postprandial conditions were not different. There was no difference in rectal compliance pre- and postprandially. These results suggest that eating lowers defecation threshold in terms of distention volume and rectal pressure, and that these changes are not dependent on altered rectal compliance or changes in distention induced motor activity.

Pigs Defecation Feeding Rectal balloon distention Pressure Volume Compliance

AN understanding of the colonic and rectal motor responses to eating is important because many patients who suffer from gastrointestinal diseases experience bowel symptoms of bloating, pain, diarrhea, and/or fecal incontinence following meals. In man, colonic myoelectrical and contractile activity increases for up to 50 minutes after eating (16). The magnitude and duration of this effect depends on the caloric content of the meal (15) and is neurally mediated through muscarinic receptor type M2 (11). It can be abolished by pretreatment with an anticholinergic drug and stimulated with neostigmine (17). If the meal contains more than a minimal amount of fat there may be a second peak in colonic motility that is related to the amount of fat in the diet (19). The second peak is mediated by gastrointestinal hormones (16,14) and can be inhibited by amino acids (1,10).

Further support for eating-induced changes in colonic function is given by data from Erckenbrecht et al. (6) that show postprandial changes in colonic perception thresholds in healthy volunteers. Distention stimuli were applied via a balloon probe positioned about 30 cm from the anal verge. Volume to induce an urge to defecate was reduced during and immediately after a meal.

Measurement of perception thresholds in humans is problematic because the occurrence of the physiological signal is confounded with the decision of the individual to respond (8). This is a particular problem for the measurement of defecation threshold compared to pain threshold since the pain threshold is more distinct than the urge to defecate. Studying actual defecation rather than the reported urge to defecate would overcome many of these problems, but is difficult to do in humans and interacts with social and behavioral norms. Therefore, we attempted to overcome these methodological limitations by studying the actual defecatory response in an animal model.

One of the most appropriate models for studying human gastrointestinal physiology is the pig. The ratio of body weight/intestinal surface area, the microstructure of stomach, duodenum, jejunum, ileum, and colon of pigs are very similar to humans (9). Additionally pigs are omnivorous (2), and spontaneous diarrhea and constipation have been described (7). The development of the Yucatan Micropig at Colorado State University has eliminated earlier restrictions due to size and temperament (12) of the domestic farm pig. No physiological differences have been found between the micropig and the domestic pig other than size and temperament.

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A recently developed ambulatory solid-state recording system (3) has been used for the chronic monitoring of colonic motor activity in unrestrained pigs (4). The results show that the diurnal pattern of colonic motility in pigs is very similar to humans. The motility index was enhanced postprandially in humans and in pigs, and there were no significant differences in the postprandial responses between the species.

The purpose of this investigation was to evaluate the influence of eating on defecation threshold in pigs.

METHOD

Apparatus

Defecation threshold was recorded using a system consisting of a commercially available pressure transducer catheter containing a silicon diffused, solid-state, pressure transducer (Model SSD-382, Miller Instruments, Houston, TX). The catheter was one meter in length with an outer diameter of 2.7 mm. The transducer probe was connected to a programmable, solid-state data recorder (Omnidata PC 703, Orem, UT). Contractile activity and pressure were sampled once each second. The distention probe consisted of a rubber open tip catheter (18 F Foley) with a thin latex balloon (5 cm) tied airtight over the opening.

The transducer was placed inside the balloon catheter with the connection at the end airtight, so pressures in the balloon were conducted to the transducer and could be recorded. The rubber catheter had two openings: one with a valve through which the balloon could be manually inflated and deflated with air, and one through which the pressure transducer probe was placed inside the catheter.

This recording system has been validated against perfused manometry by enclosing both systems in an airtight container and applying controlled pressures (3). Both techniques accurately represent pressures compared to a mercury column. No significant differences were found between the solid-state system and perfused catheters in waveform characteristics such as shape, amplitude, or duration. The 1 Hz sampling rate yielded excellent reproductions of contractile activity at all frequencies up to approximately 16 cpm.

Subjects

Three Yucatan Micropigs (Charles River Co., Wilmington, MA) and one domestic pig (all females between 20 and 30 kg) were studied. The animals were housed individually in accordance with the American Association for Accreditation of Laboratory Animal Care guidelines in an air- and light-controlled room. The animals were fed 500 g commercial pig chow once a day (Lab Min-Pig Chow Breeder, Purina Mills, Inc).

Procedure

During rectal distention the pigs were comfortably restrained in a sling. Trials were performed with one investigator inserting the rectal probe and handling the recording equipment, and a second person supporting the pigs legs and calming them if necessary. No bowel preparation was used. Four sessions were performed in each pig: one adaptation session with no data recording and three recording sessions. Each session lasted approximately 1½ hours, including a feeding period of approximately 10–15 minutes. Pigs were restrained during rectal distention but not during feeding. Recording sessions were separated by at least 48 hours.

Rectal balloon distention was performed two times pre- and postprandially in steps of 10 ml of air until the balloon was expelled or 200 ml of air were reached. Unlike dogs, pigs were easily conditioned to defecate while in the sling. The within subjects design allowed the comparison of the two pre- and postprandial trials, thereby controlling for the effects of multiple distentions on the defecation threshold. Defecation threshold was defined as the volume and pressure in the balloon at the time it was defecated. Pressures were determined for every stimulation volume. Dependent measures were balloon volume, rectal pressure, and rectal compliance (calculated as the change in the volume/pressure ratio over all measurements).

An index of contractile activity was calculated for each distention volume as the sum of the area under the curve per unit time (13). Values for the first three-minute interval of each trial were compared to the values of the final three minute interval preceding defecation, as were pre- and postprandial predefecation intervals. Calculation of the contractile index was based on eight observations in four pigs.

Data Analysis

Differences in volume and pressure at defecation threshold were calculated nonparametrically with the Mann–Whitney *U*-test. Differences in compliance were determined by comparing the slopes for pre- and postprandial conditions (BMDP 1V) (5).

RESULTS

Volume and pressure characteristics at defecation threshold were not different between the micropigs and the domestic pig. Furthermore, no significant differences were seen between the two preprandial and the two postprandial trials. Therefore, trials were evaluated independently for all subsequent analyses.

Defecation thresholds defined both by pressure and volume at defecation were significantly reduced postprandially. As shown in Fig. 1, defecation of the balloon probe occurred at a significantly ($z = 2.77$, $p = 0.0028$) lower volume postprandially (85.8 ± 9.9 ml) compared to preprandially (130.8 ± 11.1 ml), and at a significantly ($z = 2.81$, $p = 0.0024$) lower pressure postprandially (55.3 ± 3.95 mmHg) compared to preprandially (72.1 ± 4.2 mmHg).

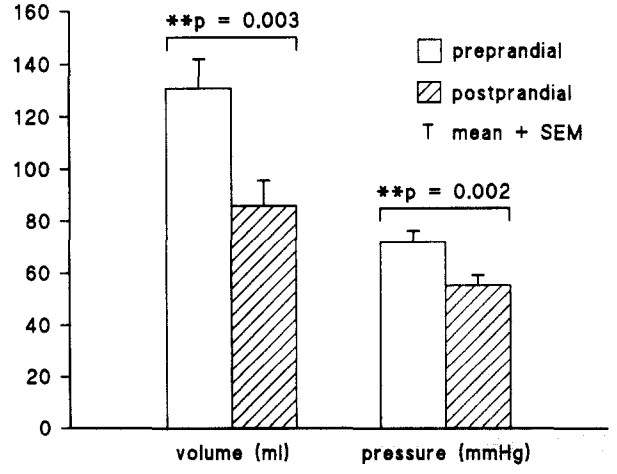

FIG. 1. Comparison of means ± SEM between distention volume and pressure at defecation threshold before and after feeding. Differences were calculated with Mann–Whitney *U*-test across $n = 24$ observations in four animals. Postprandial defecation threshold was significantly lower in terms of distention volume and pressure than preprandial defecation threshold.

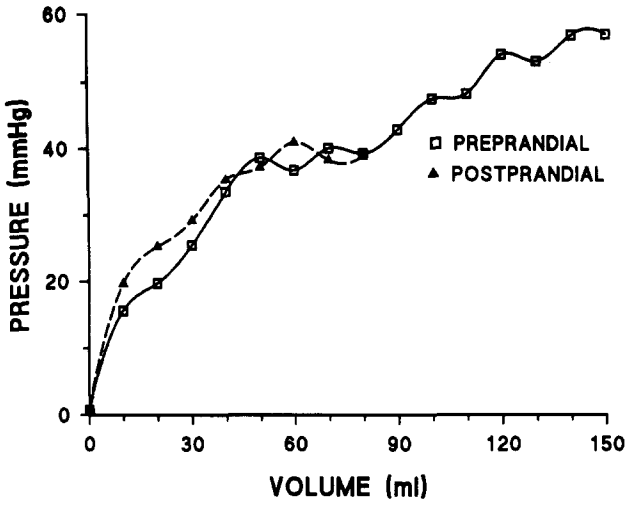

FIG. 2. Pre- and postprandial rectal compliance curves (volume/pressure for each stimulation volume) across $n = 24$ observations in four animals. The comparison of slopes (BMDP 1V) showed no difference in compliance before and after feeding.

Evaluation of directional changes over individual observations for volume and pressure showed a consistent effect of eating on the defecation threshold. Volume and pressure thresholds increased after eating in only three of 24 observations. These anomalous observations were randomly distributed across all pigs.

No significant differences were found between the slopes of the pre- and postprandial compliance curves (Fig. 2) [slopes: preprandial = 0.46; postprandial = 0.41; $F(1/14) = 0.19$, $p = 0.67$]. Differences in the number of data points occurred due to differences in defecation threshold. Comparison of slopes was calculated only for data points available under both conditions. The characteristics of the rectal compliance curves in pigs appear to be similar to those reported in humans (18).

Contractile activity increased as a function of distention volumes both before and after the meal. Before the meal, the index of contractile activity increased from 1.68 ± 0.5 for the first 3 minute interval (distention at 10, 20, 30 ml) to 7.05 ± 1.2 for the 3 minutes preceding defecation ($z = 2.78$, $p = 0.003$). After the meal, the contractile index increased from 0.82 ± 0.33 for the first 3 minutes to 4.27 ± 0.86 at defecation threshold ($z = 2.64$, $p = 0.004$). There was no significant effect of feeding on distention induced contractile activity.

DISCUSSION

These results show that feeding in pigs lowers the defecation threshold in terms of intrarectal pressure and distention volume without changing rectal compliance. Changes in distention-induced contractile activity were excluded as the mediator for lowered defecation threshold since there were no significant differences in the amount of contractile activity during distention pre- or postprandially.

This eating-induced change in defecation threshold might be due to peripheral changes in receptor sensitivity in the gastrointestinal system as a response to food ingestion and digestion. It could also be a cephalic phenomenon induced through the process of food intake. The fact that the animals defecated at lower volumes and pressures could suggest a perception phenomenon. Sham feeding with an esophageal fistula would help to clarify the role of the central nervous system in the rectal response to eating.

The fact that the rectal response to stepwise distention stimulation in pigs showed the same curve characteristics previously described in humans (18) provides further evidence of the usefulness of the pig as a model for human gastrointestinal physiology beyond the investigation of motility (4) and nutritional uptake (2).

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REFERENCES

1. Battle, W.; Cohen, S.; Snape, W. J. Inhibition of postprandial colonic motility after ingestion of an amino acid mixture. Dig. Dis. Sci. 25: 647–652; 1980.
2. Bjorkmann, O.; Crump, M.; Phillips, R. W. Intestinal metabolism of orally administered glucose and fructose in Yucatan miniature swine. Br. J. Nutr. 114:1413–1420; 1984.
3. Crowell, M. D.; Whitehead, W. E.; Cheskin, L. J.; Schuster, M. M. Twenty-four hour ambulatory monitoring of peristaltic activity from the colon in normals and constipation predominant IBS patients. Am. J. Physiol. Gastrointest. Liver Physiol. 261(24):G263–G268; 1991.
4. Crowell, M. D.; French, W.; Anderson, D.; Whitehead, W. E. A new model for the chronic monitoring of colonic motor activity in the pig. Gastroenterology 99:1210; 1990.
5. Dixon, W. J.; Brown, M. B.; Engelman, L.; Frane, J. W.; Hill, M. A.; Jennrich, R. I.; Toporek, J. D. BMDP statistical software. Berkeley: University of California Press; 1983.
6. Erckenbrecht, J. F.; Lefhalm, C.; Wallstein, U.; Enck, P. The gastrocolonic response to eating is not only a motor but also a sensory event. Gastroenterology 96:A141; 1989.
7. Fioramonti, J.; Bueno, L. Motor activity in the large intestine of the pig related to dietary fibre and retention time. Br. J. Nutr. 43:155–162; 1980.
8. Green, D. M.; Swets, J. Signal detection theory and psychophysics. New York: Wiley; 1966.
9. Kurihara-Bergstroem, T.; Woodworth, M.; Feisullin, S.; Beall, P. Characterisation of the Yucatan miniature pig skin and small intestine for pharmaceutical applications. Lab. Animal Sci. 36:396–399; 1986.
10. Levinson, S.; Bhasker, M.; Gibson, Th. R.; Morin, R.; Snape, W. J. Comparison of intraluminal and intravenious mediators of colonic response to eating. Dig. Dis. Sci. 30:33–39; 1985.
11. Narducci, F.; Basotti, G.; Daniotti, S.; Del Soldato, P.; Pelli, M. A.; Morelli, A. Identification of muscarinic receptor subtype mediating colonic response to eating. Dig. Dis. Sci. 30:124–128; 1985.
12. Panepinto, L. M.; Phillips, R. W. The Yucatan miniature pig: Characterisation and utilisation in biomedical research. Lab. Animal Sci. 36:344–347; 1986.
13. Parker, R.; Whitehead, W. E.; Schuster, M. M. Pattern recognition program for analysis of colon myoelectric and pressure data. Dig. Dis. Sci. 32:953–961; 1987.

14. Renny, A.; Snape, W. J.; Sun, E. A.; London, R.; Cohen, S. Role of cholecystokinin in the gastrocolonic response to a fat meal. Gastroenterology 85:17–21; 1983.
15. Snape, W. J.; Wright, S. H.; Battle, W. M.; Cohen, S. The gastrocolonic response: Evidence for a neural mechanism. Gastroenterology 77:1235–1240; 1979.
16. Snape, W. J.; Matarazzo, S. A.; Cohen, S. Effect of eating and gastrointestinal hormones on human colonic myoelectrical and motor activity. Gastroenterology 75:373–378; 1978.
17. Sun, E. A.; Snape, W. J.; Cohen, S.; Renny, A. The role of opiate receptors and cholinergic neurons in the gastrocolonic response. Gastroenterology 82:689–693; 1982.
18. Sun, W. M.; Read, N. W.; Prior, A.; Daly, J.-A.; Cheah, S. K.; Grundy, D. Sensory and motor responses to rectal distention vary according to rate and pattern of balloon inflation. Gastroenterology 99:1008–1015; 1990.
19. Wright, S. H.; Snape, W. J.; Battle, W.; Cohen, S.; London, R. Effect of dietary components on gastrocolonic response. Am. J. Physiol. 238:G228–G232; 1980.