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Relation of Wireless Motility Capsule Gastric Emptying Times and Gastrointestinal Pressure Parameters to Symptom Reports in Gastroparesis: The Search for a Motor Cause of Symptoms

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ABSTRACT

Background: Presenting symptoms of gastroparesis include nausea, vomiting, bloating, fullness, and pain. Large studies show inconsistent relations of any symptom with delayed gastric emptying of digestible solids on scintigraphy. Wireless motility capsules (WMC) quantify indigestible gastric emptying and gastrointestinal pressure activity. Relations of gastroparesis symptoms to WMC emptying and pressure parameters are unexplored. **Aims:** Relate gastroparesis symptoms to (i) WMC gastric emptying times, (ii) gastric contractions during different times of the emptying period, and (iii) small intestinal contractions. **Methods:** 45 patients with prior scintigraphy diagnosis of gastroparesis from 7 centers underwent concurrent 4 h gastric scintigraphy and WMC testing (SmartPill Corp.). Patients were stratified into normal (<5 hr) vs. delayed gastric emptying (>5 hr). Numbers of gastric contractions/hr and motility indices (MI= $\ln[1 + \text{sum of amplitudes} \times \text{no. contractions}]$) were quantified from (i) WMC ingestion to $t_{1/2}$ of scintigraphic emptying (1st half of digestible gastric emptying), (ii) $t_{1/2}$ to $t_{90\%}$ (2nd half of digestible emptying), and (iii) the hr before emptying (indigestible emptying). Numbers of small intestinal contractions and MI were quantified in the hr after gastric emptying. Subscores (0=none, 5=very severe) for nausea/vomiting, bloating, fullness, and upper and lower abdominal pain were calculated from 20 question surveys on study day. **Results:** No symptom subscores were increased in association with delayed vs. normal WMC gastric emptying and correlations of emptying times with N/V ($r=-0.17$), fullness ($r=0.10$), bloating ($r=-0.08$), and upper pain ($r=-0.20$) subscores were poor. Gastric hypomotility did not relate to increased symptoms. Rather, N/V scores trended higher with gastric contraction numbers >30/hr in the 2nd half of digestible emptying (2.5 ± 1.6 vs. 1.5 ± 1.0 , $P=0.03$) and were greater with gastric MI >10.5 in the hr before WMC emptying (2.6 ± 1.5 vs. 1.5 ± 1.0 , $P=0.03$). Increased contractility in the stomach or intestine was not associated with pain. Instead, lower pain scores were reduced with small intestinal contractions >60/hr (1.2 ± 1.2 vs. 2.2 ± 1.4 , $P=0.03$) and MI >11.5 (1.1 ± 1.2 vs. 2.3 ± 1.3 , $P=0.01$). **Conclusions:** As observed in large studies using scintigraphy, symptoms of gastroparesis correlated poorly with gastric emptying measured by wireless motility capsules in this small study. Likewise, gastric hypomotility measured by WMC pressure parameters did not relate to any symptom subscale in gastroparesis. Associations of increased gastric contractions with nausea and vomiting and reduced intestinal contractions with lower abdominal pain are of uncertain importance. These observations mandate performance of a much larger study in a standardized gastroparesis population to carefully relate validated symptom scores to WMC results.

BACKGROUND

- Presenting symptoms of gastroparesis include nausea, vomiting, bloating, fullness, and abdominal pain.
- Large studies show inconsistent relations of any symptom with delayed gastric emptying of digestible solids on scintigraphy.
- Wireless motility capsules (WMC) can quantify indigestible gastric emptying and gastrointestinal pressure activity.
- The relations of symptoms of gastroparesis to WMC gastric emptying and gastric and small intestinal pressure parameters are unexplored.

AIMS OF STUDY

- To relate symptoms of gastroparesis to:
 - WMC gastric emptying times
 - Gastric contractile parameters during different times in the gastric emptying period
 - Small intestinal contractile parameters in the hour after gastric emptying

EQUIPMENT AND SAMPLE WMC TRACING

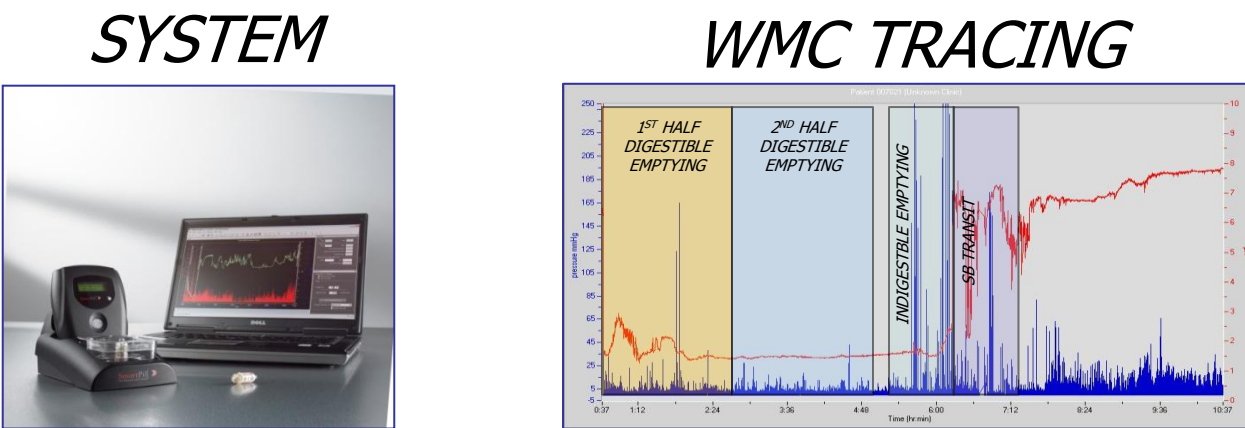


Figure 1: The figure on the left shows the equipment used for WMC testing, including the WMC, docking station, and laptop. The figure on the right shows a typical WMC gastric emptying profile from a gastroparesis patient with the pH in red and pressure in blue. Intervals analyzed for this study included the 1st half of digestible emptying (orange), 2nd half of digestible emptying (blue), indigestible emptying (green), and small bowel transit (purple).

METHODS

- 45 patients with a prior scintigraphy diagnosis of gastroparesis (using non-standardized methods) from 7 centers underwent concurrent 4 hr gastric scintigraphy and wireless motility capsule (WMC)(SmartPill®) testing.
- Gastric emptying was measured from WMC ingestion to pyloric passage defined by a ≥ 2 pH unit increase from the lowest postprandial value to at least 4 that did not decrease below 4 for >10 min at any subsequent time.
- Patients were stratified based on WMC results into those with normal (gastric emptying times <5 hr) vs. delayed (>5 hr) gastric emptying.

DATA ANALYSIS

- No. of gastric contractions/hr and motility indices (MI= $\ln[1 + \text{sum of amplitudes} \times \text{no. of contractions}]$) were quantified from:
 - WMC ingestion to $t_{1/2}$ of scintigraphic emptying (1st half of digestible emptying)
 - $t_{1/2}$ to $t_{90\%}$ of scintigraphic emptying (2nd half of digestible emptying)
 - the hr before WMC emptying (indigestible emptying)
- Numbers of small intestinal contractions and MI were quantified in the hr after gastric emptying.
- Scores (0=none, 5=very severe) for nausea/vomiting, bloating, fullness, and upper and lower pain were calculated from 20 question surveys on the study day.

CORRELATION OF WMC GASTRIC EMPTYING TIMES WITH SYMPTOM SUBSCALE SCORES

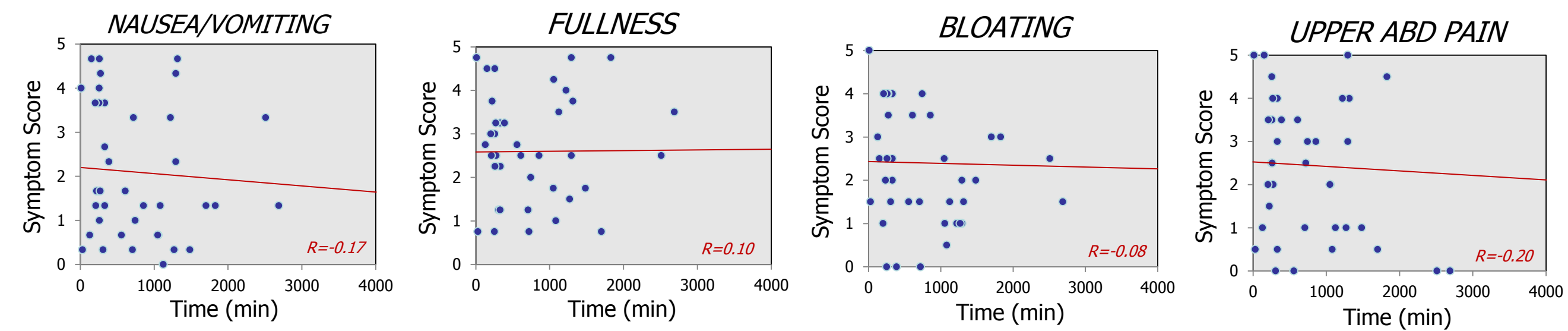


Figure 2: These scatterplots show the relations of symptom subscale scores for nausea/vomiting, fullness, bloating, and upper abdominal pain to WMC measures of gastric emptying time. For each symptom subscale score, there was no clear cut increase in relation to delayed emptying and correlations between symptoms and emptying rates were poor.

NAUSEA/VOMITING SUBSCALE SCORES: RELATION TO PRESSURE PARAMETERS

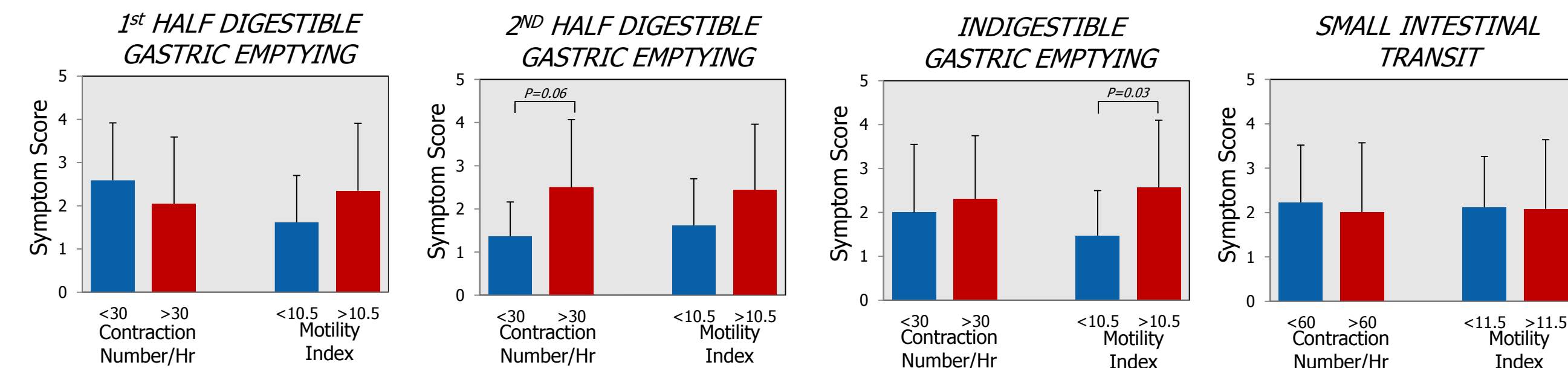


Figure 3: The bar graphs plot the relations of nausea and vomiting subscale scores to different gastrointestinal pressure parameters on WMC testing. There were trends to increased nausea/vomiting subscale scores in patients with increased numbers of gastric contractions in the 2nd half of digestible emptying of uncertain significance. There also were significant increases in nausea/vomiting scores in those with higher gastric motility indices in the indigestible gastric emptying phase in the hour before pyloric passage of the WMC.

SUBSCALE SCORES FOR OTHER SYMPTOMS: RELATION TO PRESSURE PARAMETERS

Symptom Subscale	1 st Half Digestible Gastric Emptying		2 nd Half Digestible Gastric Emptying		Indigestible Gastric Emptying		Small Intestinal Transit									
	Numbers/Hr	MI	Numbers/Hr	MI	Numbers/Hr	MI	Numbers/Hr	MI								
Fullness	2.6±1.3	2.8±1.1	2.6±1.2	2.8±1.1	2.4±1.1	2.9±1.1	2.6±1.2	2.9±1.1	2.9±1.1	2.9±1.1	2.9±1.1	2.9±1.1	2.9±1.1			
Bloating	2.2±1.3	2.5±1.2	2.1±1.4	2.5±1.2	2.6±1.1	2.4±1.3	2.1±1.4	2.6±1.1	2.2±0.9	2.6±1.3	2.5±1.1	2.4±1.3	2.6±1.3	2.3±1.2	2.7±1.3	2.3±1.2
Upper Abdominal Pain	2.9±1.6	2.4±1.5	2.3±1.3	2.6±1.6	2.2±1.5	2.7±1.5	2.3±1.3	2.7±1.6	2.4±1.6	2.7±1.5	2.2±1.1	2.8±1.5	2.7±1.4	2.4±1.6	2.5±1.4	2.5±1.6
Lower Abdominal Pain	1.6±1.6	1.4±1.3	1.9±1.2	1.4±1.4	1.6±1.6	1.5±1.3	1.9±1.2	1.4±1.4	1.9±1.6	1.4±1.3	1.5±1.2	1.6±1.5	2.2±1.4	1.2±1.3	2.3±1.3	1.1±1.2

Table 1: This table shows the subscale scores for all symptoms other than nausea/vomiting in relation to lower vs. higher numbers or motility indices in the different phases of the gastric emptying period and in the first hour of small intestinal activity after gastric emptying. Symptoms for the most part were very similar and showed little relation to any pressure parameter. However, patients with increased numbers of small intestinal contractions and higher intestinal motility indices did exhibit significant decreases in lower abdominal pain, ($P \leq 0.03$), of uncertain relevance.

CORRELATION OF PRESSURE PARAMETERS WITH SYMPTOM SUBSCALE SCORES

Symptom Subscale	Correlation Coefficients			
	1 st Half Digestible Emptying	2 nd Half Digestible Emptying	Indigestible Emptying	Small Intestinal Transit
Nausea/Vomiting	-0.10/0.07	0.11/0.10	0.10/0.17	-0.03/-0.04
Fullness	0.17/0.26	0.31/0.14	0.05/-0.14	-0.09/-0.14
Bloating	-0.22/-0.05	-0.08/0.11	-0.01/0.09	-0.26/-0.26
Upper Abd Pain	-0.11/-0.15	0.12/-0.12	0.08/0.16	0.00/-0.03
Lower Abd Pain	-0.16/-0.07	-0.08/0.03	-0.09/-0.07	-0.36/-0.36

Table 2: This table shows correlation coefficients relating symptom subscale scores to numbers of contractions and MI for the different phases of the gastric emptying period and for the intestinal recording. There was poor correlation for all symptoms with any pressure parameter.

CONCLUSIONS

- As observed in large studies using scintigraphy, gastroparesis symptoms correlate poorly with gastric emptying measured by WMC in this small study.
- Gastric hypomotility measured by WMC pressure parameters (numbers of contractions/motility indices) do not relate to any symptom subscale.
- Associations of increased gastric contractions with nausea and vomiting and reduced small intestinal contractions with lower abdominal pain are of uncertain significance.

IMPLICATIONS AND FUTURE DIRECTIONS

- This study is consistent with several studies of gastric scintigraphy that show no definitive cause of symptoms related to gastric emptying or phasic motor activity.
- These findings are consistent with the postulate that non-phasic motor and/or non-gastric factors are major contributors to symptom severity.
- However given the small sample size in this study, these observations mandate a larger investigation in a standardized gastroparesis population to rigorously relate validated symptom scores to WMC results.