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Clinical significance of small bowel manometry patterns suggestive of intestinal obstruction

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Abstract

Introduction: Minute rhythm and prolonged simultaneous contractions are patterns of postprandial small bowel contractile activity that historically have been considered as suggestive of mechanical intestinal obstruction; however, these patterns have been also encountered in patients with motility-like symptoms in the absence of bowel obstruction. The objective of this study was to determine the current diagnostic outcome of patients with these intestinal manometry patterns.

Methods: Retrospective study of patients with chronic digestive symptoms evaluated by intestinal manometry at our center between 2010 and 2018.

Results: The minute rhythm (MRP) or prolonged simultaneous contractions (PSC) postprandial patterns were detected in 61 of 488 patients (55 MRP and 6 PSC). Clinical work-up detected a previously non-diagnosed partial mechanical obstruction of the distal intestine in 10 (16%) and a systemic disorder causing intestinal neuropathy in 32 (53%). In the remaining 19 patients (31%, all with MRP), the origin of the contractile pattern was undetermined, but in 16, substantial fecal retention was detected within 7 days of the manometric procedure by abdominal imaging, and in 6 of them colonic cleansing completely normalized intestinal motility on a second manometry performed within 39 ± 30 days.

Conclusion and Inference: Currently, the most frequent origin of MRP and PSC encountered on small bowel manometry is intestinal neuropathy, while a previously undetected mechanical obstruction is rare. Still, in a substantial proportion of patients, no underlying disease can be identified, and in them, colonic fecal retention might play a role, because in a subgroup of these patients, manometry normalized after colonic cleansing. Hence, colonic preparation may be considered prior to intestinal manometry.

KEYWORDS
clustered contractions, constipation, intestinal manometry, intestinal neuropathy, minute rhythm, small bowel motility

1 | INTRODUCTION

Intestinal manometry is the current gold standard for the evaluation of small bowel motor function.[1,2] Manometric criteria for abnormality, indicative of intestinal dysmotility, were established by observational studies comparing normal recordings in healthy volunteers to recordings from patients with severe, unexplained, and long-standing symptoms and suspected dysmotility. Specific manometric criteria were developed to define dysmotility patterns associated with intestinal neuropathy, myopathy, or partial luminal occlusion, that is, criteria for neuropathic, myopathic, and occlusive dysmotility patterns (Table 1).[3–7] Occlusive manometric patterns are characterized by rhythmic activity repeating every 1–3 min in the postprandial period, lasting at least 30 minutes, and include two variants: the "minute rhythm pattern" (also denominated "clustered contractions pattern") and the "prolonged simultaneous contractions" pattern. The minute rhythm is characterized by short bursts (generally <1 min) of 3–8 contractions of >10 mmHg amplitude and 2–5 s duration each; the "prolonged simultaneous contractions" pattern is characterized by contractions of >20 mmHg amplitude and >8 s duration[2,8,9] (Figures 1 and 2). Clustered contractions observed during fasting or in shorter periods should not be considered abnormal, since they have been described in healthy subjects and in patients with irritable bowel syndrome.[10–13]

Both prolonged simultaneous contractions and the minute rhythm pattern have been observed in patients with mechanical intestinal obstruction, and resolve after surgical removal of the cause of occlusion.[14–16] However, these patterns have also been described in patients with intestinal neuropathy[3,17] and in patients with severe motility-like symptoms without bowel obstruction.[18–20] Hence, it remains uncertain whether or not these types of activity reflect a reaction to luminal compromise, that is, whether they are obstructive patterns. The objective of this study was to determine, in the current clinical setting, the diagnostic outcome of patients with the minute rhythm (MRP) and prolonged simultaneous contractions (PSC), that is, to determine to what extent they are indicative of intestinal obstruction.

Key Points

- Two small bowel manometry patterns, the minute rhythm and the prolonged simultaneous contractions patterns, have historically been considered suggestive of mechanical intestinal obstruction.
- We have found that currently, the most frequent origin of these patterns is intestinal neuropathy, while a previously undetected mechanical obstruction is rare.
- Colonic fecal retention may also generate occlusive patterns in the small bowel, since in some patients with pooling of solid stools in the colon, manometry normalized after colonic cleansing.

2 | MATERIALS AND METHODS

2.1 | Study design

Manometric tracings from consecutive patients referred to the Vall d'Hebron Digestive Function Unit between 2010 and 2018 for evaluation of intestinal motility, due to severe, chronic digestive symptoms and suspected dysmotility, were reviewed, and a retrospective analysis of cases with patterns suggestive of intestinal obstruction (minute rhythm pattern and prolonged simultaneous contractions) was performed. The protocol was approved by the Ethics Committee of the University Hospital Vall d'Hebron. All patients provided written informed consent for the manometric evaluation; patients´ consent for the retrospective analysis was waived by the Ethical Committee. The study protocol was registered with the ClinicalTrials.gov (ID: NCT05230121). All co-authors had access to the study data, reviewed and approved the final manuscript.

2.2 | Patients' management

2.2.1 | Small bowel manometry

Small bowel manometry was performed using a standard technique, as previously described.[21] Briefly, after an overnight fast, a manometric tube (9012X1106 Special Manometric Catheter; Medtronic, Skovlunde, Denmark) was orally introduced into the jejunum. Eight water-perfused manometric ports (5 at 10 cm intervals and the proximal 3 at 1 cm intervals) were positioned from the proximal duodenum to the mid-jejunum with fluoroscopic assistance. Recordings were obtained for 3 h during fasting and 2 h after ingestion of a solid–liquid meal (450 kcal). In patients with gastroparesis diagnosed by a gastric emptying scintigraphy test or unable to finish the meal, a liquid meal (Ensure HN; Abbott, Zwolle, The Netherlands; 1 kcal/ml) was infused through the most proximal channel at 2 kcal/min to induce a postprandial activity pattern for 2 h. Manometric diagnosis of abnormal motility was established using the previously published criteria (Table 1).[6,22] Specifically, patterns suggestive of intestinal obstruction were defined as regular motor events repeating every 1–3 min and occurring over a ≥ 20-cm intestinal segment during a ≥ 30-min period in postprandial conditions. Following up previously established criteria, these patterns included two variants, depending on whether the repetitive motor events consisted in short clusters of contractions (minute rhythm pattern) or prolonged simultaneous contractions (>20 mmHg amplitude and >8 s duration) (Figure 1).

A report of the manometric study with full description of the dysmotility patterns encountered was filed with the medical record of each patient.

TABLE 1 Diagnostic criteria for abnormal intestinal manometry

Neuropathic pattern
• Abnormal configuration of Phase III: Tonic rises of baseline pressure over 30 mmHg amplitude ≥3-min duration.
• Abnormal propagation of Phase III: Simultaneous or retrograde propagation over ≥20-cm segment of small bowel.
• Inability of an adequate meal to induce a normal fed pattern: no changes in activity during postprandial period (no fed pattern) or phase III-like activity during postprandial period (while disregarding the first 20 min after beginning of meal).
• Bursts: At least one period of ≥5 min, or two periods of ≥2 min duration with continuous high-amplitude (≥20 mmHg) and high-frequency (10–12/min) phasic pressure activity not followed by motor quiescence.
• Sustained contractions: Prolonged (≥30 min duration), high-amplitude (≥20 mmHg) and high-frequency (10/min) phasic pressure activity that occurs in a segment of intestine with normal or reduced activity recorded at other levels.
Myopathic pattern
• Hypomotility: Low-amplitude contractions (i.e., contractions <10 mmHg) or contractions with amplitude <20 mmHg also during phase III.
Patterns suggestive of mechanical obstruction
• Minute rhythm (or clustered contractions): intermittent periodic activity (shorts bursts, generally lasting <1 min, and repeating every 1–3 min) occurring over a ≥ 20-cm intestinal segment, during a ≥ 30-min period in postprandial conditions.
• Prolonged simultaneous contractions: prolonged (>8 s duration), high-amplitude (>20 mmHg) contractions occurring simultaneously in recording sites at least 20 cm apart, during a ≥ 30-min period in postprandial conditions.

2.2.2 | Clinical follow-up

Based on the manometric findings and the clinical context, patients underwent further clinical evaluation to try to identify potential causes of intestinal dysmotility. Patients with dysmotility were evaluated to determine whether other regions of the gut, such as the esophagus, stomach, and colon, were affected by esophageal manometry, gastric emptying scintigraphy, colonic transit, and abdominal imaging. If suspected, small bowel bacterial overgrowth (SIBO) was investigated by glucose breath tests. Diabetes, autoimmune disorders, or other systemic disorders were sought for by specific tests following clinical criteria. Since postprandial minute rhythm and prolonged simultaneous contractions are considered characteristic of luminal compromise of the distal gut, patients with these motor patterns routinely underwent an exhaustive radiological evaluation of the gut, to detect or exclude causes of partial mechanical obstruction.[2] In the absence of mechanical obstruction, in patients with MRP or PSC the diagnosis of intestinal neuropathy was established in the presence of (a) other manometric criteria of neuropathy, (b) previous history of a systemic disorder causing intestinal neuropathy (either long-standing diabetes with other neuropathic complications or predisposing neurological or autoimmune disorders), (c) evidence of an advanced gastrointestinal motility disorder (chronic intestinal pseudo-obstruction and/or severe gastroparesis), or (d) iatrogenic neural injury. In none of the patients a surgical exploration for an intestinal full-thickness biopsy was indicated.

2.3 | Retrospective analysis

For the present study, the manometric reports of all patients with intestinal manometry performed between 2010 and 2018 were revised, and the manometric recordings that had been reported of minute rhythm or prolonged simultaneous contraction pattern in the postprandial period were retrieved and re-analyzed by two investigators (HM and CM) to confirm the original report. The clinical records of these patients were reviewed to obtain: (a) demographic data, (b) digestive symptoms at the time of evaluation, (c) history of abdomino-pelvic surgeries or radiotherapy prior to manometry, (d) diagnosis of systemic disorders, and (e) presence of esophageal, gastric, or colonic dysmotility. Results from radiological and other investigations were also revised, as well as therapeutic decisions and clinical outcome. Particularly, it was documented whether abdominal imaging studies (simple abdominal X-ray or abdominal CT scans) were performed within 7 days of the manometric study, and the studies were reviewed in search of pooling of solid stools in the right colon.

2.4 | Statistical analysis

Statistical analysis was performed with SPSS Statistics for Windows (V22.0, IBM, Armonk, New York). Normality of data distribution was evaluated by the Shapiro–Wilk test. Comparisons of parametric, normally distributed data were made by Student's *t*-test, paired tests for intragroup comparisons, and unpaired tests for intergroup comparisons; otherwise, the Wilcoxon signed rank test was used for paired data within groups and the Mann–Whitney *U*-test for unpaired data between groups. Continuous variables were compared using Pearson's R. Differences were considered significant at a p value <0.05.

3 | RESULTS

3.1 | Demographic and clinical data

During the 9-year study period, between 2010 and 2018, 488 patients (16–84 age range, 363 women) who had been referred for evaluation of intestinal motility underwent small bowel manometry. Patterns considered suggestive of intestinal obstruction were detected in 13% of the patients (61 patients, 23–80 age range, 40 women). In the great majority of these patients ($n = 55$), the pattern consisted of minute rhythm, while prolonged simultaneous contractions were only present in 6 patients. Re-analysis of their manometric

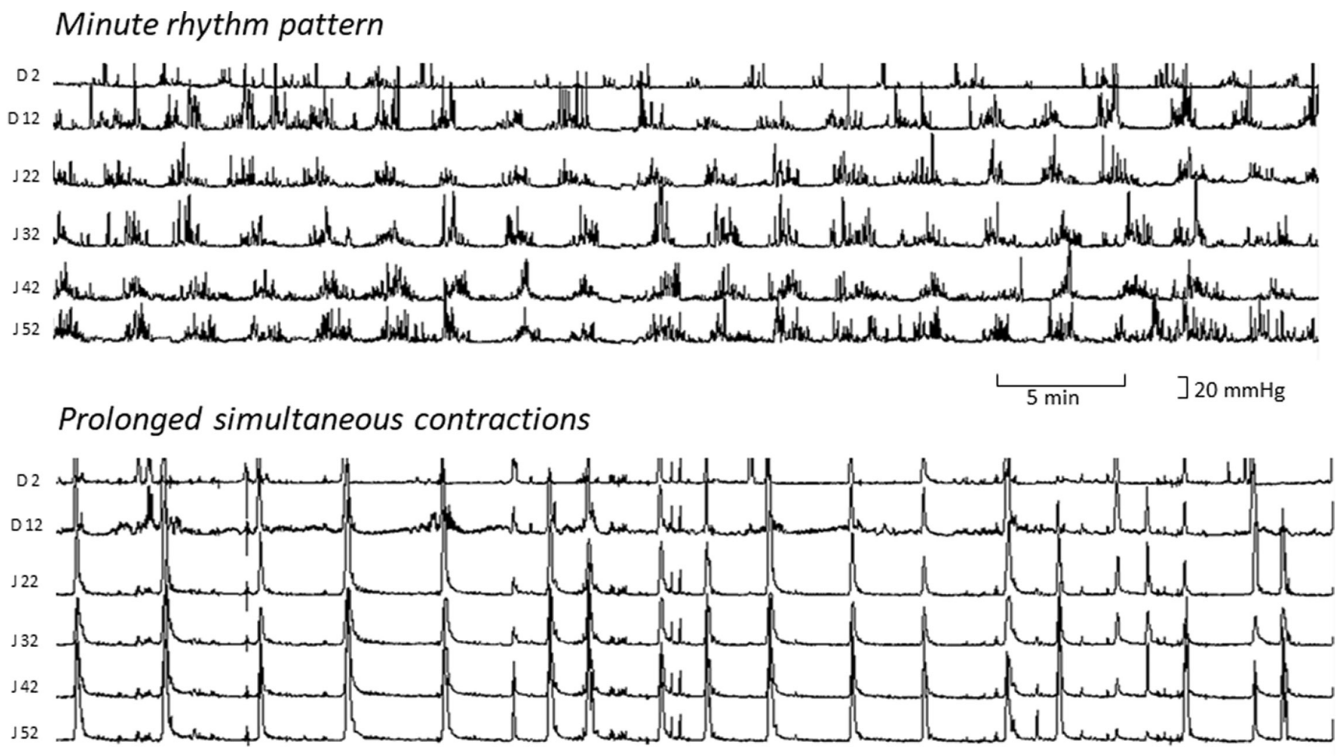

FIGURE 1 Examples of the prolonged simultaneous contractions and minute rhythm patterns in the postprandial state

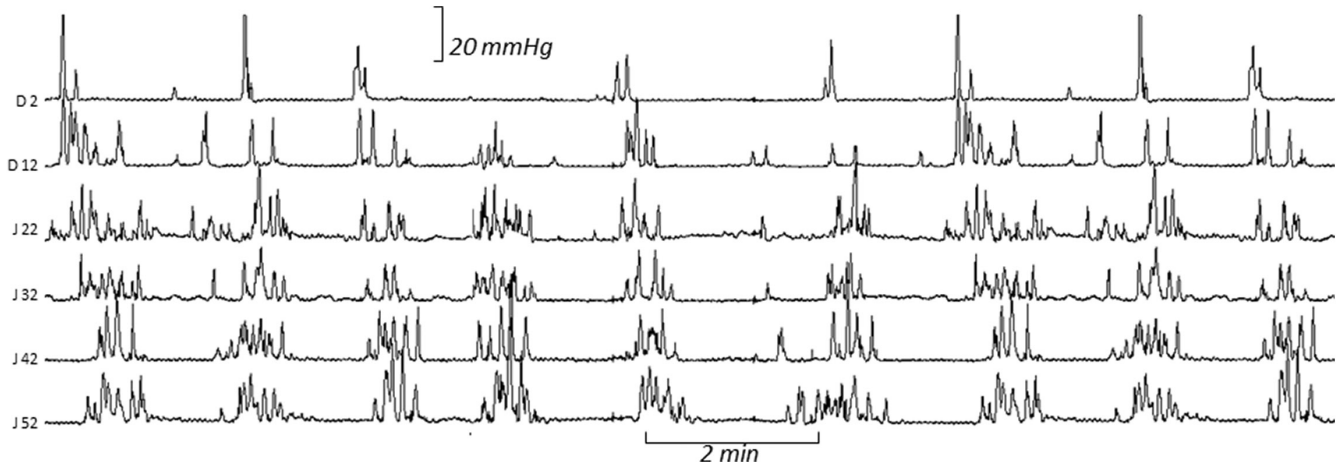

FIGURE 2 Example of minute rhythm pattern: expanded view. Note characteristic short bursts of 3–8 contractions repeating every 1–3 min

tracings confirmed the original report in all cases. Review of their clinical records showed that all patients had severe chronic digestive symptoms (abdominal pain, abdominal bloating, chronic constipation, chronic diarrhea, chronic vomiting) of 3.5 years median duration (range 0.5–25 years). Based on the manometric and clinical data, 10 patients were ascribed to mechanical obstruction and 32 patients to intestinal neuropathy, and in the remaining 19 patients, the minute rhythm pattern was of undetermined origin (Figure 3). All 6 patients exhibiting the prolonged simultaneous contraction pattern had either mechanical obstruction ($n = 2$) or intestinal neuropathy ($n = 4$) and none undetermined origin (see below). No differences in the characteristics of the minute rhythm pattern (time to initiate the pattern after the meal, duration of the pattern, or length of intestine affected by the pattern) were detected among the three categories of patients or between the two manometric variants (minute rhythm and prolonged simultaneous contractions).

3.2 | Mechanical obstruction

In 10 patients (16%) (8 patients featuring minute rhythm and 2 prolonged simultaneous contractions), mechanical intestinal obstruction was documented during follow-up by either radiology or surgery. The cause of the obstruction was inflammatory bowel

disease with intestinal stenosis in 2 patients, radiation enteritis consecutive to previous radiotherapy in 3 patients, anastomotic stricture in 1 patient, colonic volvulation in 1 patient, and adhesions in the remaining 3 patients (all with previous abdominal surgeries). In this group of patients with documented mechanical obstruction, no other manometric abnormalities were detected.

3.3 | Intestinal neuropathy

In 32 patients (53%) (28 patients featuring minute rhythm and 4 prolonged simultaneous contractions), the diagnosis of intestinal neuropathy was established, as follows. Twenty-two patients presented disorders known to cause intestinal neuropathy (long-standing diabetes mellitus with other neuropathic complications in 10 patients, autoimmune/systemic disorder in 9 patients, and iatrogenic vagal nerve damage post-fundoplication in 3 patients); 4 patients in this group (2 patients with diabetes and 2 with a systemic disorder) presented also other manometric criteria of neuropathy. In 6 patients, the diagnosis of intestinal neuropathy was established by presence of concomitant manometric criteria of intestinal neuropathy (uncoordinated bursts in 4 patients, and postprandial phase III in 2 patients). A third group of 4 patients had evidence of an advanced gastrointestinal motility disorder with radiological criteria of intestinal pseudo-obstruction ($n = 2$) and/or severe gastroparesis ($n = 3$). Patients with intestinal neuropathy exhibited higher incidence of SIBO than the other categories (73% vs 33% in the rest; $p = 0.005$).

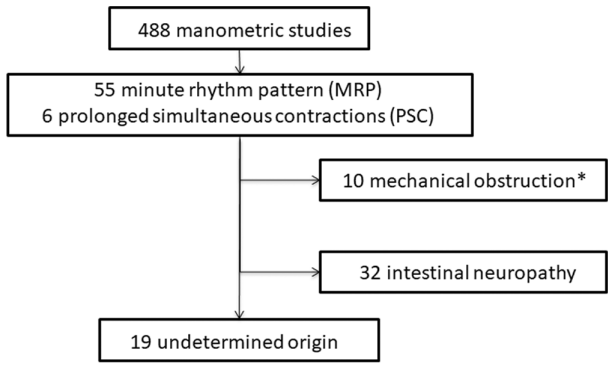

FIGURE 3 Study flow chart showing the classification of patients with manometric patterns suggestive of intestinal obstruction during the 9-year study period

3.4 | Minute rhythm of undetermined origin

In the remaining 19 patients (31%), no mechanical cause of intestinal obstruction was detected nor was a diagnosis of intestinal neuropathy supported by other manometric or clinical criteria, and hence, the origin of the manometric pattern could not be determined; to note, all these patients exhibited a "minute rhythm pattern." As compared to the other categories, patients with minute rhythm of undetermined origin had a higher prevalence of chronic constipation (63% vs 19% in patients with neuropathy and 10% in mechanical obstruction; $p = 0.001$).

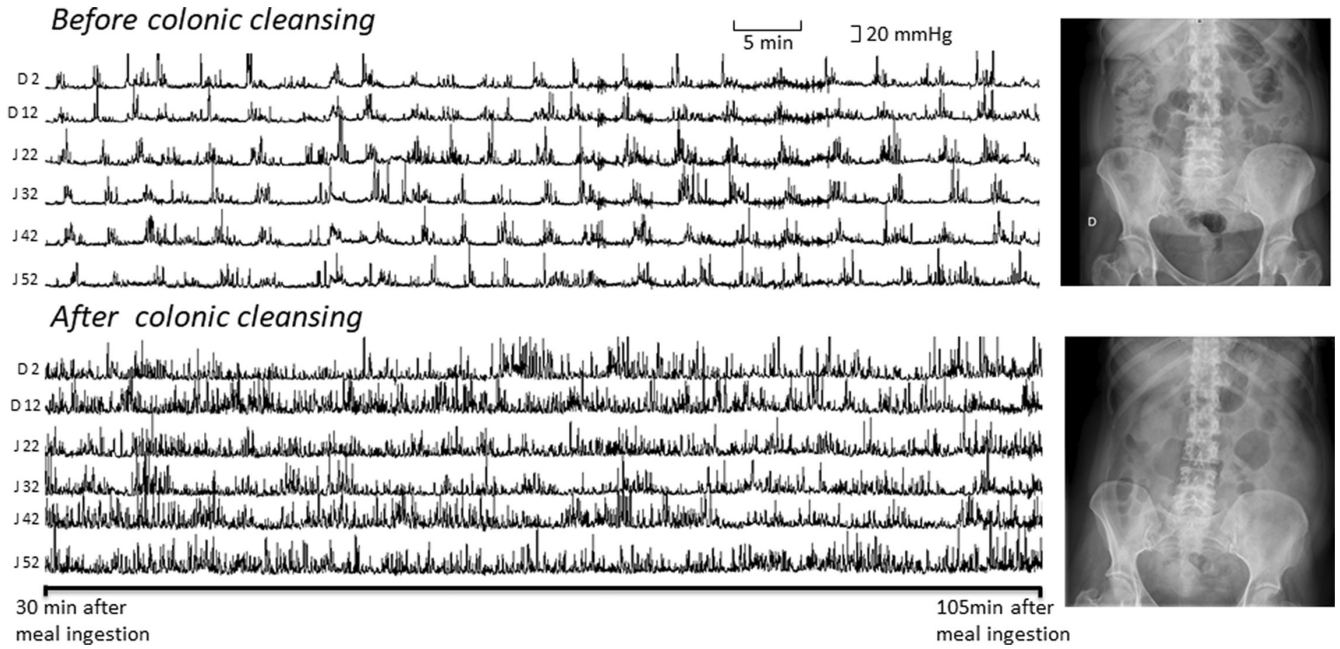

FIGURE 4 Example of the effect of bowel cleansing on the postprandial minute rhythm pattern in a patent with fecal retention. Manometric tracings and the corresponding abdominal X-ray images, before (upper panel) and after colonic cleansing (lower panel) in the same patient. Note that in the same postprandial interval, colonic cleansing is associated with a complete resolution of the minute rhythm pattern

In 16 patients with minute rhythm of undetermined origin, abdominal imaging (abdominal X-ray or CT scan) was performed within 7 days of the manometric procedure, and 11 of them presented substantial fecal retention in the proximal colon. In 6 of these patients with fecal retention, a second intestinal manometry was performed with prior colonic cleansing within 39 ± 30 days after the first test. Colonic cleansing was performed by a combination of oral laxatives and enemas, and was confirmed by a subsequent abdominal X-ray. In all 6 patients, the second manometry was normal without criteria of minute rhythm or other dysmotility patterns (Figure 4).

4 | DISCUSSION

This study shows that currently the most frequent cause of the minute rhythm and prolonged simultaneous contractions patterns in small bowel manometry is a neuropathic disorder affecting the gut, whereas a previously undetected mechanical obstruction is rare. Still, in approximately one third of our patients, no underlying disease could be identified, and the pattern might be related to colonic fecal retention, because in a subgroup of patients with severe constipation manometry normalized after the colon was cleansed.

Previous studies dating over 20 years ago reported that 60–70% of patients exhibiting minute rhythm or prolonged simultaneous contractions in the postprandial period had an underlying mechanical intestinal obstruction;[16,17] furthermore, surgical removal of the cause of obstruction was shown to normalize the manometric pattern. By contrast, our data reflect that mechanical obstruction is only found in a minority of cases, less than one fifth of our patients. The most plausible explanation for this observation is the marked improvement of imaging studies, which now allow accurate and prompt diagnosis of mechanical obstruction in the early stages of the diagnostic work-up, before second line studies, such as intestinal manometry, come into play. MRP and PSC patterns are a form of repetitive rhythmic activity that may represent a motor reaction, attempting to overcome the obstruction to flow. The significance of the two variants, minute rhythm versus prolonged simultaneous contractions, is uncertain. Both types of motor events display the same temporal organization, with the prolonged contractions seemingly representing a fusion of repeated contractions into a sustained event. Alternatively, it has been proposed that the prolonged contractions reflect a common cavity phenomenon in a dilated loop of intestine upstream the obstruction, which is plausible considering the simultaneous pressure rise over a long intestinal segment.[17] Previous data indicate that MRPs may be propagated; however, we acknowledge that conventional manometric catheters, such as the ones used in this study, have limitations to determine the propagation of contractile events.

In our cohort, the most frequent cause of minute rhythm or prolonged simultaneous contractions was intestinal neuropathy, generally caused by an underlying systemic disorder. The intestine affected by a neuropathic disorder may be inefficient in achieving a proper flow of contents. In analogy to organic occlusion, the MRP and PSC patterns in patients with intestinal neuropathy may be a reaction to a downstream functional obstruction. In a recent study using an ex-vivo animal model, minute rhythm was induced by intestinal distension and found to be dependent on cholinergic nerves of the enteric nervous system and nitric oxide.[23]

In one third of cases, the origin of the minute rhythm pattern could not be determined and finally fell into the undetermined category. Interestingly in this group of patients, constipation was more prevalent than in the rest of the patients with the MRP or PSC patterns. This finding fits with previous manometric studies in patients with slow-transit constipation, which also reported increased clustered contractions compared to healthy controls, although in these studies it is not specified if the pattern was observed during the postprandial period or if it lasted more than 30 min.[24–27] In a subgroup of patients with minute rhythm of undetermined origin, abdominal imaging was performed closely before or after the manometric study, and in the majority (16 out of 19) prominent fecal retention in the proximal colon was observed. Anecdotally, in six patients a second manometric study was performed after colonic cleansing, and in all of them, the minute rhythm disappeared and the motor activity normalized. We acknowledge that the value of these non-systematic and retrospective observations is orientative at most, but it may indicate that the minute rhythm pattern may be related to a reaction to downstream pooling of contents and dumped flow; hence, it could be speculated that under these circumstances, the manometric pattern reflects a reactive pattern triggered by fecal retention. Vis-a-vis this information, we recently performed an experimental study in healthy subjects, to determine the effect of colonic filling on small bowel motility.[28] The study showed that mild colonic filling with gas triggered a long-distance retrograde reflex: high-resolution jejunal manometry detected repeat fronts of propagated contractions, with inhibition of background of segmental contractions, a motor pattern reminiscent of the minute rhythm pattern described in this study. Conceivably, advances in the recording techniques will help to understand the significance of reactive small bowel propagated activity.

We acknowledge that we used stringent criteria to define dysmotility patterns, and particularly MRP and PSC, which restricts the validity of our observation to very clear, severe cases. More compliant criteria (shorter segment of intestine involved, less duration or appearance in fasting conditions) would reduce the specificity of the observations, and as discussed above, minor or incomplete minute rhythm patterns can be observed in a number of functional digestive disorders and even in healthy subjects.[10,12,13] Appearance of the MRP and PSC during postprandial conditions was a key criterion. Passage of chyme into the small bowel during the postprandial period may activate small bowel motility in case of downstream resistance to flow; indeed, in the experimental study in healthy subjects, colonic gas filling during fasting conditions did not modify small bowel activity, and the reactive pattern was only triggered with concomitant infusion of nutrients in the small bowel.[28]

We also acknowledge that in this retrospective study the adscription of individual patients to each category may be questionable, but this does not invalidate the broad observations on the etiology of MRP and PSC, particularly of luminal obstruction and intestinal neuropathy, and the potential role of colonic fecal retention in case of undetermined origin. As a practical implication, colonic preparation may be recommended prior to intestinal manometry.

AUTHOR CONTRIBUTIONS

LA was involved in data analysis and manuscript preparation; CM was involved in study design, study management, data analysis and manuscript preparation; HM was involved in collecting and interpreting data; MM was involved in collecting and interpreting data; AA was involved in conduction of studies and data interpretation; JRM was involved in study design and data interpretation; FA was involved in study design, data interpretation and manuscript preparation.

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CONFLICT OF INTEREST

No conflicts of interest.

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