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REVIEW ARTICLE

Intestinal manometry: who needs it?

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ABSTRACT

The use of manometry, i.e. the recording of pressures within hollow viscera, after being successfully applied to the study of esophageal and anorectal motor dysfunctions, has also been used to investigate physiological and pathological conditions of the small bowel. By means of this technique, it has been possible to understand better the normal motor functions of the small intestine, and their relationship and variations following physiologic events, such as food ingestion. Moreover, intestinal manometry has proved useful to document motor abnormalities of the small bowel, although recognition of altered patterns specific for a determinate pathologic condition is still unavailable. However, this technique often permits the detection of abnormal gut motility in patients with abdominal symptoms such as unexplained vomiting and diarrhea, and it is sometimes also useful to address therapeutic targeting.

Keywords: Intestinal, Manometry, Motility, Myopathy, Neuropathy.

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Introduction

Manometric techniques are methods that detect pressure events within hollow viscera. After being successfully employed to study upper (esophageal) and lower (anorectal) motility, manometry has also been applied to investigate the small (1) and the large bowel motility (2). Concerning the small bowel, these techniques have been extremely important to better elucidate several physiological mechanisms and demonstrate the pathophysiological bases of motor dysfunction in some pathologic disorders. Until recently, manometric techniques were based on the use of multilumen recording probes (with the lateral orifices arranged in various conformations to record different portions of the bowel), in turn connected to pressure transducers and to infusion systems (3). These techniques are presently often being replaced by the use of solid-state catheters that do not need perfusion, and may be directly connected to a recording system (polygraph, computer) for automated analyses (4), even though the perfused systems still maintain their validity.

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Physiological aspects

In humans, the motor activity of the upper parts (stomach and small bowel) features specific patterns that mostly depend from individuals in the fasted or fed state (5). In fact, the fasting state is characterized by a pattern that displays cyclic timing and sweeps the bowel according to a oro-aboral programme (6). This pattern is named

migrating motor complex (MMC) and is composed of three relatively well defined phases (7): phase I (in which with little or no contractile activity is present), phase II (in which intermittent and irregular contractions are documented), and phase III (the so-called activity front, which displays contractions occurring at a maximal rate, determined by the frequency of the slow waves in a specific segment) (Figure 1A).

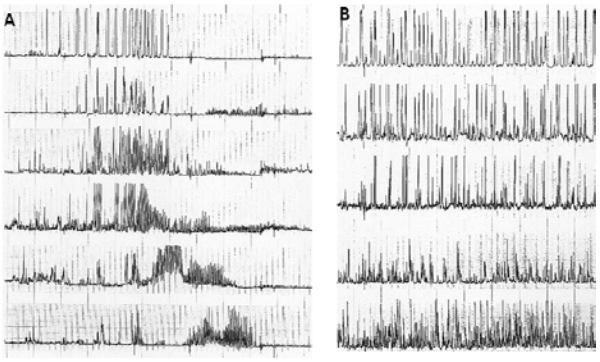

Figure 1. Antroduodenojejunal manometric recording in a healthy subject. A. During fasting, the three phases of the MMC are clearly identifiable; it is worth noting that the phase III is directed aborally from the antrum (first tracing) to the-jejunum (last tracing). B. After ingestion of a meal, a strong activation of contractile activity may be observed in all segments

The three phases recur on average every 90 minutes, with phase III being relatively short (10% or less of the MMC), as well as phase I and phase II occupying each about 30%-80% of the cycle (8). It is worth remembering that the MMC may start physiologically from the distal esophagus (9), and therefore propagates to the terminal ileum (10). This inter-digestive cycle is interrupted by the ingestion of food, it is then replaced by randomly occurring frequent contractions (Figure 1B); this activity lasts about 2.5-8 hours and is progressively replaced by a new MMC (11). The duration of the fed motor activity strongly depends on the composition of the meal, lasts longer after a caloric than a non-caloric meal (12), and after fat-rich meals than after ingestion of other nutrients (13).

Performing intestinal motility studies: when and in whom?

The first important point to be stressed is that manometric studies of gastrointestinal motility should be preceded by an accurate exclusion of other organic and/or metabolic disorders by means of radiologic and endoscopic studies. The availability of less invasive radioisotopic techniques in some centers (14) may represent a reasonable alternative to manometric investigations, although these techniques are more expensive and have a little collateral biologic risk (15).

Upper gastrointestinal manometry is chiefly used to investigate complaints of unexplained nausea, vomiting, abdominal pain and distention. in patients with an abnormal gastric emptying test in the absence of an etiological diagnosis (16, 17). However, it should be kept in mind that manometry in the stomach is reliable only to detect antral or antropyloric abnormalities, due to the large anatomical section of the viscus. When gastric emptying abnormalities are present, manometry is carried out to detect whether these abnormalities are limited to the stomach or belong to more generalized motility disorders (18). However, it must be stressed that intestinal manometry may reveal abnormal motor patterns in about only 50% of such patients (19-21). It is also worth noting that in most instances it is not possible to identify a specific motor pattern which can discriminate patients with severe motility-like dyspepsia from those with other diseases, or even from healthy individuals (22).

Manometric investigations may also help to identify the presence of abnormalities reconductable to neuropathic or myopathic disorders that affect the small bowel in both adult and pediatric patients (23-27). The therapeutic approach may vary according to the presence of neuropathic or myopathic features, with the myopathic ones being usually less responsive to a medical approach. These abnormalities might be

important to define patients with chronic intestinal pseudo-obstruction (28,29).

Also, manometric techniques may reveal postsurgical motor abnormalities (30, 31). These abnormalities may help to characterize the patient's symptoms in the postoperative period (32, 33). Further applications of intestinal manometry might help to define patients with severe intractable chronic constipation candidates for surgery, in whom the exclusion of motor abnormalities in the upper gut is important to avoid surgical failures or poor results (34).

More recently, intestinal manometry has been used to study patients with small bowel bacterial overgrowth. These studies have consistently shown the presence of small bowel motor abnormalities, suggesting that altered gut motility might likely predispose to the pathological growth of bacteria (35-37)

Can intestinal manometry identify pathophysiological processes?

Manometry is often able to provide evidence of a pathophysiological process; at the same time it is not usually diagnostic of a specific disease per se (38, 39). When available, manometry is useful to enforce the clinical suspicion of the presence of an abnormal motor activity by demonstration of a myopathic or neuropathic process. Manometry has a role in the process of diagnosis (Table 1). To date, it is possible to identify at least five main types of motor abnormalities in patients with suspected motility disorders using manometric techniques (40):

1) Patterns suggesting mechanical obstruction. These are represented by two events: a) a sustained (>30 minutes) postprandial pattern of "minute" clustered contractions separated by brief periods of motor quiescence (41); b) repetitive, simultaneous, prolonged contractions in the upper small bowel portions (42).

2) Generally low amplitude contractions, documented at several intestinal levels, and thought to be suggestive of a myopathic process. These low amplitudes (on average, below 15 mmHg) are mainly recorded in patients with hollow visceral myopathies or progressive systemic sclerosis (43, 44) (Figure 2A).

3) Normal amplitude, but "uncoordinated" (i.e., abnormally propagated) contractile activity in the gastric antrum and the small bowel, suggesting a neuropathic process. These motor abnormalities are usually present during phases II and III of the MMC (45) (Figure 2B); in addition, the

Table 1. Intestinal manometric abnormalities and their corresponding clinical situations

Manometric findings	Associated clinical situation
Sustained "minute" clustered contractions	Partial mechanical intestinal obstruction, Crohn's disease
Repetitive, simultaneous, prolonged contractions of proximal small bowel	Subacute mechanical intestinal obstruction
Normally propagated but low amplitude contractions	Hollow visceral myopathies, intestinal pseudo-obstruction (myopathic forms), scleroderma
Abnormal propagation of antral and intestinal contractions	Intestinal pseudo-obstruction (neuropathic forms), severe dyspepsia, idiopathic gastroparesis, diabetes mellitus
Postprandial antral hypomotility	Diabetes mellitus, idiopathic or post-infectious gastroparesis, surgical vagotomy, dyspepsia
Minute clustered contractions (bursts)	Irritable bowel syndrome, intestinal pseudo-obstruction (neuropathic forms), food allergies, celiac disease, Whipple's disease, Crohn's disease, acute enteric infections, small bowel overgrowth

persistence of a fasting pattern after eating a meal of >400 kcal is strongly suggestive of a neuropathic process (46).

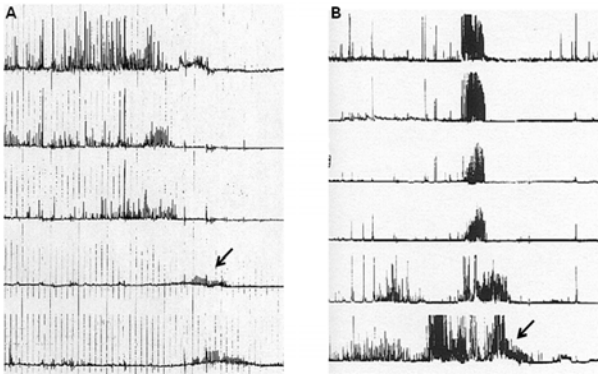

Figure 2. A. Manometric recording of a myopathic pattern. It is worth noting that the phase III of MMC features very low amplitude contractions (arrow). B. Manometric recording of a neuropathic pattern, featuring normal amplitude but uncoordinated (simultaneous) activity fronts and a sustained nonpropagated burst of activity in the last tracing (arrow).

4) Postprandial antral hypomotility (infrequent contractions of normal amplitude). This pattern is frequently found in patients with diabetes mellitus, post-vagotomy, and postviral or idiopathic gastroparesis (47, 48).

5) Minute clustered contractions associated with abdominal pain firstly reported in patients with irritable bowel syndrome (49, 50). This kind of motor activity has been described in other subgroups of patients, such as those with untreated celiac disease (51) and food allergy (52), and it is common in healthy subjects (53).

Limits of intestinal manometry

Even though in selected subgroups of patients, neuropathic and myopathic motility patterns have been described (54), their pathological correlates are available only rarely. Therefore, it is often impossible to distinguish different pathological conditions only on the basis of manometric abnormalities (55). From a motor point of view, the human intestine seems to respond, in a monotonous manner following different pathophysiological noxae (see point 5 above). Thus, in the interpretation of manometric tracings caution should be a rule, since motility in the interdigestive state is extremely variable in human beings (56). Short (e.g., up to 2-3 hours) recording periods may show only one (or even none) motor event, such as that represented by the MMC (57). Therefore, in order to reduce the bias due to technical limitations, it is wise to carry out prolonged recordings (preferably for 24 hours by ambulant manometric techniques) (58). The recent introduction of automated analysis systems (59) will also help to better identify, define and establish the real values of intestinal manometric findings.

Intestinal manometry: useful to establish therapeutic programs?

Treating subgroups of patients with intestinal motor abnormalities may be complex, unsuccessful, and not infrequently frustrating (60). However, some evidences indicate that manometric techniques in selected individuals might help to find mechanisms likely responsible for the patient's symptoms. Also, manometry may demonstrate the direct effect of possibly useful drugs on the motor abnormalities detected in these patients. For instance, it has been reported that octreotide injection stimulates MMC-like activity in scleroderma patients and reduces some of their symptoms (61), and other drugs have shown promising effects on intestinal motility (62, 63). Some authors tried to establish manometric findings as predictors of a therapeutic outcome. For instance, the persistence of fasting MMC may indicate a greater likelihood of response to prokinetic agents (64), and normalization of abnormal intestinal motility may predict the response to gluten-free diet, in both adults and children (65, 66). Again, the presence of intestinal

motor abnormalities in patients with inactive Crohn's disease could help management. The demonstration of the presence of a functional disorder may avoid g the risk of considering the ensuing symptoms as due to a disease's relapse (67).

Finally, intestinal manometry may help to explain the gut motor responses to different food formulas (68, 69), thus providing useful information for the use of food manipulations during enteral nutrition.

References

1. Keller J, Layer P. Intestinal and anorectal motility and functional disorders. Best Pract Res Clin Gastroenterol 2009; 23: 407-23.

2. Bassotti G, de Roberto G, Castellani D, Sediari L, Morelli A. Normal aspects of colorectal motility and abnormalities in slow transit constipation. World J Gastroenterol 2005; 11: 2691-96.

3. Arndorfer RC, Stef JJ, Dodds WJ, Linehan JH, Hogan WJ. Improved infusion system for intraluminal esophageal manometry. Gastoenterology 1977; 73: 23-27

4. Penning C, Gielkens HA, Hemelaar M, Lamers CB, Masclee AA. Reproducibility of antroduodenal motility during prolonged ambulatory recording. Neurogastroenterol Motil 2001; 13: 133-41.

5. Mazet B. Gastrointestinal motility and its enteric actors in mechanosensitivity: past and present. Pflugers Arch 2015; 467: 191-200.

6. Rees WDW, Malagelada JR, Miller LJ, Go VL. Human interdigestive and postprandial gastrointestinal motor and gastrointestinal hormone patterns. Dig Dis Sci 1982; 27: 321-29.

7. Takahashi T. Interdigestive migrating motor complex - its mechanism and clinical importance. J Smooth Muscle Res 2013; 49: 99-11.

8. Sarna SK. Cyclic motor activity: migrating motor complex: 1985. Gastroenterology 1985; 89: 894-13.

9. Janssens J, Annese V, Vantrappen G. Bursts of non-deglutitive simultaneous contractions may be a normal oesophageal motility pattern. Gut 1993; 34: 1021-24.

10. Kerlin P, Phillips SF. Variability of motility of the ileum and jejunum in healthy man. Gastroenterology 1982; 82: 694-700.

11. Deloose E, Janssen P, Depoortere I, Tack J. The migrating motor complex: control mechanisms and its role in health and disease. Nat Rev Gastroenterol Hepatol 2012; 9: 271-85.

12. Schemann M, Ehrlein HJ. Postprandial patterns of canine jejunal motility and transit of luminal content. Gastroenterology 1986; 90: 991-1000.

13. De Wever I, Eeckout C, Vantrappen G, Hellemans J. Disruptive effect of test meal on interdigestive motor complex in dogs. Am J Physiol 1978; 235: E661-65.

14. Madsen JL. Scintigraphic assessment of gastrointestinal motility: a brief review of techniques and data interpretation. Clin Physiol Funct Imaging 2014; 34: 243-53.

15. Camilleri M, Zinsmeister AR, Greydanus MP, Brown ML, Proano M. Towards a less costly but accurate test of gastric emptying and small bowel transit. Dig Dis Sci 1991; 36: 609-15.

16. Camilleri M, Hasler WL, Parkman HP, Quigley EM, Soffer E. Measurement of gastrointestinal motility in the GI laboratory. Gastroenterology 1998; 115: 747-62

17. Hansen MB. Small intestinal manometry. Physiol Res 2002; 51: 541-56.

18. Michoux N, Lalaude O, Maheu B, Helluin C, Ducrot F, Denis P, et al. Postprandial duodenojejunal motility in health and idiopathic severe gastroparesis: from conventional analysis to nonlinear dynamics analysis. Neurogastroenterol Motil 2000; 12: 75-85.

19. Jebbink HJ, vanBerge-Henegouwen GP, Akkermans LM, Smout AJ. Small intestinal motor abnormalities in patients with functional dyspepsia demonstrated by ambulatory manometry. Gut 1996; 38: 694-700.

20. Gu C, Ke M, Wang Z. Temporal and spatial relationship of pylorus to antroduodenal motility in functional dyspepsia. Chin Med J (Engl) 1998; 111: 906-909.

21. Sha W, Pasricha PJ, Chen JD. Correlations among electrogastrogram, gastric dysmotility, and duodenal dysmotility in patients with functional dyspepsia. J Clin Gastroenterol 2009; 43: 716-22.

22. Wilmer A, Van Cutsem E, Andrioli A, Tack J, Coremans G, Janssens J. Ambulatory gastrojejunal manometry in severe motility-like dyspepsia: lack of correlation between dysmotility, symptoms, and gastric emptying. Gut 1998; 42: 235-42.

23. Dooley CP, El Newihi HM, Zeidler A, Valenzuela JE. Abnormalities of the migrating motor complex in diabetics with autonomic neuropathy and diarrhea. Scand J Gastroenterol 1988; 23: 217-33.

24. Bassotti G, Battaglia E, Debernardi V, Germani U, Quiriconi F, Dughera L, et al. Esophageal dysfunction in

scleroderma: relationship with disease subsets. Arthritis Rheum 1997; 40: 2252-59.

25. Marie I, Levesque H, Ducrotté P, Denis P, Benichou J, Hellot MF, et al. Manometry of the upper intestinal tract in patients with systemic sclerosis: a prospective study. Arthritis Rheum 1998; 41: 1874-83.

26. Hyman PE, Napolitano JA, Diego A, Patel S, Flores AF, Grill BB, et al. Antroduodenal manometry in the evaluation of chronic functional gastrointestinal symptoms. Pediatrics 1990; 86: 39-44.

27. Stanghellini V, Cogliandro RF, De Giorgio R, Barbara G, Cremon C, Antonucci A, et al. Natural history of intestinal failure induced by chronic idiopathic intestinal pseudo-obstruction. Transplant Proc 2010; 42: 15-18.

28. Smout AJ. Manometry of the gastrointestinal tract: toy or tool? Scand J Gastroenterol 2001; 234: 22-8.

29. Patcharatrakul T, Gonlachanvit S. Technique of functional and motility test: how to perform antroduodenal manometry. J Neurogastroenterol Motil 2013; 19: 395-404.

30. Mathias JR, Fernandez A, Sninsky CA, Clench MH, Davis RH. Nausea, vomiting, and abdominal pain after Roux-en-Y anastomosis: motility of the jejunal limb. Gastroenterology 1985; 88: 101-07.

31. Bassotti G, Chiarinelli ML, Germani U, Chiarioni G, Morelli A. Effect of some abdominal surgical operations on small bowel motility in humans: our experience. J Clin Gastroenterol 1995; 21: 211-16.

32. Le Blanc-Louvry I, Ducrotté P, Peillon C, Testart J, Denis P, Michot F, et al. Upper jejunal motility after pancreatoduodenectomy according to the type of anastomosis, pancreaticojejunal or pancreaticogastric. J Am Coll Surg 1999; 188: 261-70.

33. Le Blanc-Louvry I, Denis P, Ducrotté P. The effect of cholecystectomy on duodenojejunal motility in humans. Neurogastroenterol Motil 2002; 14: 279-85.

34. Bassotti G, Stanghellini V, Chiarioni G, Germani U, De Giorgio R, Vantini I, et al. Upper gastrointestinal motor activity in patients with slow-transit constipation. Further evidence for an enteric neuropathy. Dig Dis Sci 1996; 41: 1999-2005.

35. Madrid AM, Poniachik J, Quera R, Defilippi C. Small intestinal clustered contractions and bacterial overgrowth: a frequent finding in obese patients. Dig Dis Sci 2011; 56: 155-60.

36. Miller LS, Vegesna AK, Sampath AM, Prabhu S, Kotapati SK, Makipour K. Ileocecal valve dysfunction in small intestinal bacterial overgrowth: a pilot study. World J Gastroenterol 2012; 18: 6801-808.

37. Jacobs C, Coss Adame E, Attaluri A, Valestin J, Rao SS. Dysmotility and proton pump inhibitor use are independent risk factors for small intestinal bacterial and/or fungal overgrowth. Aliment Pharmacol Ther 2013; 37: 1103-11.

38. Malagelada JR, Camilleri M, Stanghellini V. Manometric Diagnosis of gastointestinal motility disorders. New York: Thieme; 1986.

39. Camilleri M. Disorders of gastrointestinal motility in neurologic diseases. Mayo Clin Proc 1990; 65: 825-46.

40. Camilleri M, Bharucha AE, di Lorenzo C, Hasler WL, Prather CM, Rao SS, et al. American Neurogastroenterology and Motility Society consensus statement on intraluminal measurement of gastrointestinal and colonic motility in clinical practice. Neurogastroenterol Motil 2008; 20: 1269-82.

41. Summers RW, Anuras S, Green J. Jejunal manometry patterns in health, partial intestinal obstruction, and pseudoobstruction. Gastroenterology 1983; 85: 1290-300.

42. Camilleri M. Jejunal manometry in distal subacute mechanical obstruction: significance of prolonged simultaneous contractions. Gut 1989; 30: 468-75.

43. Colemont LJ, Camilleri M. Chronic intestinal pseudo-obstruction: diagnosis and treatment. Mayo Clin Proc 1989; 64: 60-70.

44. Sjölund K, Bartosik I, Lindberg G, Scheja A, Wildt M, Akesson A. Small intestinal manometry in patients with systemic sclerosis. Eur J Gastroenterol Hepatol 2005; 17: 1205-12.

45. Bassotti G, Germani U, Calcara C, Spinozzi F, Roselli P, Morelli A. Effects of octreotide on manometric variables in patients with neuropathic abnormalities of the small bowel. Dig Dis Sci 1997; 42: 1634-39.

46. Stanghellini V, Camilleri M, Malagelada JR. Chronic idiopathic intestinal pseudoobstruction: clinical and intestinal manometric findings. Gut 1987; 28: 5-12.

47. Malagelada JR, Rees WDW, Mazzotta LJ, Go VLW. Gastric motor abnormalities in diabetic and post-vagotomy gastroparesis: effect of metoclopramide and bethanechol. Gastroenterology 1980; 78: 286-92.

48. Narducci F, Bassotti G, Granata MT, Gaburri M, Farroni F, Palumbo R, et al. Functional dyspepsia and chronic idiopathic gastric stasis. Role of endogenous opiates. Arch Int Med 1986; 146: 716-20.

49. Kumar D, Wingate DL. The irritable bowel syndrome: a paroxysmal motor disorder. Lancet 1985; 2: 973-77.

50. Kellow JE, Phillips SF. Altered small bowel motility in irritable bowel syndrome is correlated with symptoms. Gastroenterology 1987; 92: 1885-83.

51. Bassotti G, Castellucci G, Betti C, Fusaro C, Cavalletti ML, Bertotto A, et al. Abnormal gastrointestinal motility in patients with celiac sprue. Dig Dis Sci 1994; 39: 1947-54.

52. Bassotti G, Bertotto A, Spinozzi F. Heretical thoughts about food hypersensitivity: small bowel manometry as an objective way to document gut reactions. Eur J Clin Nutr 1997; 51: 567-72.

53. Quigley EMM, Donovan JP, Lane MJ, Gallagher TF. Antroduodenal manometry: limitations and usefulness as an outpatient study. Dig Dis Sci 1992; 37: 20-28.

54. Camilleri M, Malagelada JR. Abnormal intestinal motility in diabetics with the gastroparesis syndrome. Eur J Clin Invest 1984; 14: 420-27.

55. Read NW. Functional gastroenterological disorders: the name's the thing. Gut 1987; 28: 281-84.

56. Kellow JE, Borody TJ, Phillips SF, Tucker RL, Haddad AC. Human interdigestive motility: variations in patterns from esophagus to colon. Gastroenterology 1986; 91: 386-95.

57. Bharucha AE, Camilleri M, Low PA, Zinsmeister AR. Autonomic dysfunction in gastrointestinal motility disorders. Gut 1993; 34: 397-401.

58. Samsom M, Fraser R, Smout AJ, Verhagen MA, Adachi K, Horowitz M, et al. Characterization of small intestinal pressure waves in ambulant subjects recorded with a novel portable manometric system. Dig Dis Sci 1999; 44: 2157-64.

59. Scott SM, Picon L, Knowles CH, Fourquet F, Yazaki E, Williams NS, et al. Automated quantitative analysis of nocturnal jejunal motor activity identifies abnormalities in individuals and subgroups of patients with slow transit constipation. Am J Gastroenterol 2003; 98: 1123-34.

60. Camilleri M. Appraisal of medium- and long-term treatment of gastroparesis and chronic intestinal dysmotility. Am J Gastroenterol 1994; 89: 1769-74.

61. Soudah HC, Hasler WL, Owyang C. Effect of octreotide on intestinal motility and bacterial overgrowth in scleroderma. N Engl J Med 1991; 325: 1461-67.

62. Nasr I, Rao SS, Attaluri A, Hashmi SM, Summers R. Effects of tegaserod and erythromycin in upper gut dysmotility: a comparative study. Indian J Gastroenterol 2009; 28: 136-42.

63. Chini P, Toskes PP, Waseem S, Hou W, McDonald R, Moshiree B. Effect of azithromycin on small bowel motility in patients with gastrointestinal dysmotility. Scand J Gastroenterol 2012; 47: 422-27.

64. Hyman PE, Di Lorenzo C, McAdams L, Flores AF, Tomomasa T, Garvey TQ 3rd. Predicting the clinical response to cisapride in children with chronic intestinal pseudo-obstruction. Am J Gastroenterol 1993; 88: 832-36.

65. Cucchiara S, Bassotti G, Castellucci G, Minella R, Betti C, Fusaro C, et al. Upper gastrointestinal motor abnormalities in children with active celiac disease. J Pediatr Gastroenterol Nutr 1995; 21: 435-42.

66. Bassotti G, Villanacci V, Mazzocchi A, Mariano M, Incardona P, Clerici C, et al. Antroduodenojejunal motor activity in untreated and treated celiac disease patients. J Gastroenterol Hepatol 2008; 23: e23-28.

67. Annese V, Bassotti G, Napolitano G, Usai P, Andriulli A, Vantrappen G. Gastrointestinal motility disorders in patients with inactive Crohn's disease. Scand J Gastroenterol 1997; 32: 1107-17.

68. Guedon C, Ducrotte P, Chayvialle JA, Lerebours E, Denis P, Colin R. Effects of intravenous and intraduodenal fat on jejunal motility and on plasma cholecystokinin in man. Dig Dis Sci 1988; 33: 558-64.

69. Bouin M, Savoye G, Maillot C, Hellot MF, Guédon C, Denis P, et al. How do fiber-supplemented formulas affect antroduodenal motility during enteral nutrition? A comparative study between mixed and insoluble fibers. Am J Clin Nutr 2000; 72: 1040-46.