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SPECIAL REPORT

Fibers in pediatric functional gastrointestinal disorders. Practical considerations from clinical cases

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ABSTRACT

Introduction: Functional gastrointestinal disorders (FGIDs) are common in children and incur high direct and indirect social costs. Partially hydrolyzed guar gum (PHGG) is a natural and water-soluble dietary fiber that is derived from guar gum. It has been proposed as complementary therapy in pediatric FGIDs, especially in chronic functional constipation and irritable bowel syndrome.

Areas covered: By focusing on four clinical cases, this article illustrates the use of PHGG fiber as sole supplement ingredient or as a formula component in orally- and tube-fed children suffering from malnutrition due to FGIDs, with or without special medical conditions such as neurological disability. The formula used was a whey peptide-based nutritionally complete formula containing PHGG as a source of soluble dietary fiber. It was offered under medical supervision and after full consideration of all feeding options.

Expert opinion: Implementing appropriate feeding behaviors, adapted to age and potential comorbidities, is an essential requisite for therapeutic management of FGIDs. The use of a PHGG supplement or a nutritionally complete formula containing PHGG as a source of soluble dietary fiber can be helpful to manage pediatric FGIDs.

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Constipation; diarrhea; enteral nutrition; fibers; food intolerance; functional gastrointestinal disorders; irritable bowel syndrome; neurological impairment; partially hydrolyzed guar gum; short bowel syndrome

1. Introduction

Functional gastrointestinal disorders (FGIDs) cover a group of conditions associated with chronic or recurrent gastrointestinal symptoms, related to motility disorders, visceral hypersensitivity, impaired immune and mucosal functions, and alteration of the intestinal microbiota [1]. These symptoms are often age-dependent and cannot be explained by structural or biochemical anomalies. As for the diagnosis of FGIDs, it relies on the 2016 symptom-based Rome IV criteria [2,3].

Pediatric FGIDs are associated with significant morbidity and represent over 50% of outpatient consultations in pediatric gastroenterology [4]. An epidemiological study estimated that the worldwide prevalence of FGID-related abdominal pain is 13.5%, with irritable bowel syndrome (IBS) being the most frequent disorder [5]. The highest prevalence rates were reported in South America (16.8%) and Asia (16.5%), while prevalence was 10.5% in Europe [5]. Another study showed that FGIDs have a prevalence of 27% in newborns and infants based on the Rome III diagnostic criteria [6]. Regurgitation was the most frequent disorder in infants, and constipation in toddlers [6]. A 2018 study reported that 24.7% of infants and children aged 0–3 years and 25% of children and adolescents aged 4–18 years fulfilled the criteria for FGIDs symptoms according to the Rome IV criteria. The most commonly reported symptom was regurgitation (24.1%) in early infancy and functional constipation among infants (18.5%) and children and adolescents (14.1%) [7]. Also, these conditions seemed to impair the quality of life of patients and families [7].

As for the treatment of FGIDs, water-soluble fibers have an important role in the non-pharmacological approach, since they seem to modify bowel pattern, reduce intracolonic pressure, accelerate oral-to-anal transit with a good control and reduction of the symptoms [8,9]. Dietary fibers recommendation for children aged >2 years is to increase intake by up to an amount equal to or greater than their age plus 5 g/day until reaching 25–35 g/day at 20 years [10]. In particular, partially hydrolyzed guar gum (PHGG) is a vegetal, water-soluble, non-viscous, and non-gelling dietary fiber that is derived from guar gum. Guar gum is a water-soluble, viscous, gel-forming galactomannan [11] obtained by grinding the endosperm of the seeds of the guar plant, *Cyamoposis tetragonolobus*, growing in India and Pakistan. In recent years, the beneficial effects of PHGG have received attention as complementary therapy in pediatric FGIDs, especially in chronic functional constipation and IBS (with either diarrhea or constipation patterns). In addition, PHGG added to oral rehydration solutions (ORS) seems to reduce the duration of diarrhea and improve weight gain in severely malnourished (weight-by-length/weight-by-age <-3 Z-score) children aged 3 to 36 months with acute diarrhea [12].

An example of a child-adapted formula containing PHGG is Peptamen Junior® PHGG (Nestlé Health Science, Switzerland).

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Article highlights

- The best treatment for FGIDs should be based on a comprehensive and early assessment, including nutritional status, current diet, feeding tolerance and underlying medical conditions.
- The use of PHGG as a source of soluble dietary fiber seems to be efficient in the treatment of pediatric FGIDs.
- The use of PHGG for pediatric FGIDs may be considered routinely, even as first-line therapeutic approach.
- A nutritionally complete PHGG-containing formula contributes to reduce gastrointestinal symptoms, and improve weight gain, nutritional status, and quality of life of children with underlying medical conditions.
- Further studies are warranted, i.e. to evaluate whether PHGG can also be considered as a long-term treatment of FGIDs.

Peptamen Junior® PHGG is a whey peptide-based, nutritionally complete, easily tolerated and absorbable, semi-elemental enteral formula, providing 1 kcal/mL of energy (12% protein, 55% carbohydrate, and 33% fat). This formula was specifically designed for the dietary management of pediatric patients aged 1 to 13 years, with or at risk of malnutrition because of gastrointestinal problems such as diarrhea, constipation, bowel motility problems, gut pain and discomfort [11,13–16]. Peptamen Junior® PHGG can be used either for oral or tube feeding, especially when these patients have special dietary requirements and failed to tolerate and/or to thrive on other types of enteral formulas (polymeric or casein-based formula, etc.).

This article describes four clinical cases on the management of pediatric FGIDs using PHGG (either as a supplement ingredient or as a formula component) as a source of soluble dietary fiber. In particular, two patients (Patients 3 and 4) had or were at risk of malnutrition, or had very specific dietary needs due to special medical conditions such as neurological disability.

1.1. Ethics statement

Informed consent was obtained from the parents/legal representative of the four children for the publication of the present case reports.

2. Clinical cases

2.1. Patient 1 – use of PHGG for the treatment of a 12-year-old girl with FGID

2.1.1. Case description

A 12-year-old girl presented with a 1-year history of recurrent, almost daily, abdominal pain, especially after meals, associated with gastric and intestinal distension. No weight loss or change in bowel habits were reported. Due to symptoms, the patient often avoided going out with friends for lunch or dinner. Her overweight father was diagnosed with IBS, and her medical history only included recurrent upper respiratory tract infections. Treatment with antispasmodic drugs, lactose- and gluten-free diet was not effective. Physical examination was negative, although a tender mass likely due to fecal stasis was palpated on the left side of the abdominal wall. Based on the Rome IV criteria, no warning signs were detected and no instrumental investigations (i.e. abdominal ultrasound, esophagogastroduodenoscopy) were indicated.

2.1.2. Clinical course, treatment and outcomes

Daily oral supplementation of PHGG fiber soluble granulate (Benefibra®, GlaxoSmithKline Consumer Health, United Kingdom) was prescribed at a daily dose of 10 g. After 4 weeks of symptomatic treatment, there was a significant reduction in severity of the episodes of abdominal pain, as well as in frequency, occurring from once a day to one every 2 weeks. Daily activities were recovered, including going out with friends. PHGG supplementation was reduced to 5 g once daily and continued for 4 weeks before definitive discontinuation. No relapse of symptoms was registered at 2 months after discontinuation.

2.2. Patient 2 – use of PHGG for the treatment of an 11-year-old girl suffering from retentive fecal incontinence

2.2.1. Case description

An 11-year-old girl was referred for about 1–2 episodes per day of fecal soiling over the last 2 years. The girl was accompanied by her mother who had an accusatory attitude toward her daughter. The girl was an only child from separated parents and had a poor academic performance. Her clinical history included overweight and constipation since her first years of life, treated with polyethylene glycol for many years. She stopped all types of physical activity because of her fecal incontinence, and refused treatment to regularize her bowel habits. Physical examination was negative, although a tender mass likely due to fecal stasis was palpated on the left side of the abdominal wall. Few weeks before consultation, she underwent medical investigations, including celiac disease screening. Based on the anamnesis, the diagnosis of retentive fecal incontinence secondary to a chronic functional constipation was made.

2.2.2. Clinical course, treatment and outcomes

Since the girl refused polyethylene glycol therapy, supplementation with PHGG fiber soluble granulate (Benefibra®, GlaxoSmithKline Consumer Health, United Kingdom) was prescribed at a daily dose of 10 g for 4 weeks, together with an increase in daily water intake. After 4 weeks, fecal soiling was significantly reduced, and bowel habits almost normalized, no abdominal discomfort was reported. Accordingly, supplementation with PHGG was proposed to be reduced (5 g once daily), but the girl did not intend to change the dosage due to the significant therapeutic benefit. No further follow-up visits were made as the girl considered her problem resolved.

2.3. Patient 3 – use of enteral formula containing PHGG for the nutritional management of a 5-year-old boy with cerebral palsy and constipation

2.3.1. Case description

A 5-year-old boy with cerebral palsy was referred for severe malnutrition, oro-pharyngeal dysfunction, and recurrent

episodes of fever, likely secondary to aspiration pneumonia. The patient also had chronic constipation. Laboratory tests showed severe anemia and hypoalbuminemia.

2.3.2. Clinical course, treatment and outcomes

The patient underwent a percutaneous endoscopic gastrostomy (PEG). An exclusive enteral nutrition (EN) program with a normocaloric (1 Kcal/ml) polymeric formula was started, with four meals per day, and an increasing intake of calories up to 75% of the daily energy requirement. As soon as 60% of the energy requirement was reached, the patient did not seem to tolerate any further increase in daily volumes due to vomiting episodes. Consequently, the polymeric formula was replaced with a whey-based, partially hydrolyzed, normocaloric formula (Peptamen Junior®, Nestlé Health Science, Switzerland). Tolerance to EN improved, and 75% of the daily energy requirement was achieved. Nonetheless, bowel habits did not significantly improve. Therefore, it was attempted the substitution with same formula but containing soluble fibers (PHGG) at 6 g/l (Peptamen Junior® PHGG, Nestlé Health Science, Switzerland). Six weeks later, the patient gained weight and constipation improved.

2.4. Patient 4 – use of a partially hydrolyzed normocaloric formula added with PHGG for the treatment of a premature baby boy with periventricular leukomalacia and short bowel syndrome suffering from diarrhea

2.4.1. Case description

A baby boy was born at 26 weeks of gestation with a low birthweight (900 g) and respiratory problems. He underwent positive-pressure ventilation in the neonatal intensive care unit (NICU) where he was diagnosed with periventricular leukomalacia. After 10 days of nasogastric tube feeding with breast milk, he underwent urgent surgery because of a necrotizing enterocolitis with an extensive jejunal-ileal resection. After surgery, parenteral nutrition (PN) was initiated to promote calorie intake. After a hospital stay of several months, PEG placement was performed, due to feeding difficulty and lack of effective sucking. Upon discharge from NICU, the patient had a satisfying growth. Nutritional support included EN and partial PN.

2.4.2. Clinical course, treatment and outcomes

At 12 months of life, the boy had a faltering growth with weight and length below the 3rd percentile according to the standard WHO growth charts. He was receiving nocturnal PN and a continuous diurnal protein whey-based formula through gastrostomy. Moreover, the boy had 6–9 bowel movements per day, with liquid stools. The protein whey-based formula was replaced with a semi-elementary peptides-based formula with a high medium-chain triglyceride (MCT): long-chain triglycerides (LCT) ratio while continuing the nocturnal PN scheme. After 2 weeks, further weight loss of 200 g was reported. The formula was replaced with a whey-based partially hydrolyzed normocaloric (1 kcal/ml) formula added with 6 g/l of PHGG (Peptamen Junior® PHGG, Nestlé Health Science, Switzerland) while continuing the nocturnal PN scheme. Three months later, bowel movements reduced to 4 per day, and stool consistency improved. Weight and length increased, even if they remained below the 3rd centile. We hypothesized the overall improvement to be likely multifactorial, with contributions from PHGG, semi-elemental formulation, and small bowel adaptation following jejunal-ileal resection. Moreover, the boy underwent a speech therapy program to better evaluate the swallowing potential. At the age of 2 years, PN was administered only every other day, as it was assumed that the partially hydrolyzed formula with PHGG covered 90% of the boy's caloric needs. The number of bowel movements was reduced to 2–3 per day with formed stools.

3. Conclusion

These four cases focused on the dietary management of children with FGIDs without (Patients 1 and 2) or with special medical conditions such as cerebral palsy (Patient 3), and periventricular leukomalacia and short bowel syndrome (Patient 4).

A proper and early assessment of pediatric FGIDs, together with the concomitant underlying medical conditions, nutritional status, current diet, and feeding tolerance were necessary to choose the best diagnostic and therapeutic approach. As such, feeding regimen was modified for these four patients, and the correct feeding behaviors were shaped taking into account the child's medical history and comorbidities, current nutritional needs, gastrointestinal impairment, and food intake abilities. In this context, mean fiber intake among children with developmental delay is expected to be lower due to high rates of oral motor dysfunction and feeding difficulties.

Furthermore, the use of PHGG as a source of soluble dietary fiber was considered whether the children were orally fed and healthy (Patients 1 and 2), even as first-line treatment, or tube-fed and having underlying chronic diseases (Patients 3 and 4). The choice of the formula with PHGG was aimed to: (1) improve gastric emptying through the use of semi-elementary formulas [17]; (2) restore the intestinal microbiota to reduce intestinal meteorism [15,17]; (3) optimize stool consistency; and (4) provide children with neurodevelopmental disabilities with adequate amounts of dietary fibers.

Similarly to previously published data [11–15], normalizing effect of PHGG on bowel movements was observed in all cases. In addition to PHGG to support gastrointestinal function and homeostasis, using a whey peptide-based product also containing eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), and MCT has likely contributed to improve feeding tolerance by improving lipid absorption [18–22]. In some cases, the overall symptoms improvement was likely multifactorial, with contributions from PHGG, semi-elemental formulation, and small bowel adaptation following intestinal resection (i.e. Patient 4).

4. Expert opinion

FGIDs are currently considered disorders of gut–brain interaction, related to any combination of motility disturbance, visceral hypersensitivity, and altered mucosal and immune function, gut microbiota, and central nervous system

processing. This most recent definition is consistent with the evolving understanding of multiple mechanisms that determine the symptom features that characterize the Rome classification of disorders. Functional gastrointestinal symptoms have a high impact on the quality of life of children and families, and on health-care costs. A complete medical history and clinical examination are often sufficient to guide the primary care provider in the diagnosis, further work-up or referral to a pediatric gastroenterologist. A lack of understanding of pathogenic mechanisms often leads to extensive investigations, non-effective therapies, and staggering health-care costs. There is little evidence on the efficacy of conventional medical treatment, while there is a moderate evidence on the efficacy of complementary or adjuvant therapies (diet, fibers, herbal therapy, and low-lactose intake) in the adult population. Similarly, non-pharmacological therapies in children may include dietary interventions (high-fiber or elimination diet), probiotics, and bio-psychosocial modifying therapies mainly hypnotherapy, cognitive behavioral therapy, yoga, acupuncture and physiotherapy [23,24]. In particular, implementing the appropriate feeding behaviors in children with FGIDs with or without chronic medical conditions such as neurological disorders seems to be effective in improving gastrointestinal function and ensuring long-term improvement of nutritional status [23]. Fibers may represent a mainstay in the FGIDs therapeutic strategies. Current evidence seems to show that fibers decrease whole oral-to-anal transit time and intracolonic pressure reducing abdominal pain [8,9]. The main distinction between soluble and insoluble fibers is essential as only soluble fibers, such as PHGG, dissolve in water and are widely metabolized in the large bowel, thus producing short-chain fatty acids, leading to selective stimulation of microbial growth. PHGG is a soluble fiber with important properties, such as non-viscous texture, normal fermentation, non-gelling, high hydrophilic potential, and no interference with micronutrient absorption. PHGG may also act as a prebiotic, thus modulating intestinal microbiota. The addition of a nutritionally complete formula containing PHGG seems to be favorable in the management of children with FGIDs, taking into account the child's age and anthropometric measurements, nutritional and medical history, and gastrointestinal symptoms.

The amount of fiber supplementation, even in fiber-enriched formulas, may not be enough to correct gastrointestinal problems. It has been suggested that ≥10 g/day of extra fiber may be needed, especially in non-ambulatory children. The clinical cases support the feasibility of enhancing the amount of PHGG in diets, even routinely and/or as first-line therapeutic approach to FGIDs. Furthermore, more controlled trials should be carried out to define the most efficient dose of fiber in pediatric patients.

In recent years, increasing interest has been shown in the diagnosis and management of FGIDs, especially regarding the non-pharmacological therapeutic approach, which can include soluble fiber (i.e. PHGG) supplementation. However, specific data on the pediatric population are lacking, both in otherwise healthy children and in those suffering from chronic medical conditions, such as neurological impairment. The main sources of data are relatively small adult trials, with the support of case reports, cases series, and observational studies. These studies aimed to show that fiber supplementation can improve symptoms in patients with FGIDs without the need to prescribe pharmacological therapies. The extension to larger-scale, placebo-controlled, specifically addressed studies (i.e. PHGG versus other forms of soluble fiber, or PHGG as part of a polymeric versus semi-elemental enteral formula) is warranted. In the upcoming years, studies will better define pathophysiological mechanisms underlying FGIDs, and probably stimulate the trend to enhance conservative therapeutic strategies, such as dietary supplementation, even as first-line therapeutic approach. The ultimate goal could be the compliance to treatment for these benign, but often disabling conditions, especially because children (and their parents) often dislike taking medicines daily. Currently, PHGG supplementation can be considered an important therapeutic option in many pediatric FGIDs, especially functional constipation and IBS. Further studies are needed to evaluate the hypothesized prebiotic effect of PHGG, and whether PHGG can also be considered as long-term therapy of FGIDs.

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Author contributions

All authors: conceptualization, data curation, investigation, provision of resources, supervision of patients, validation of results, data visualization, article writing, review and editing. CR, SP, UC, and VD: methodology SP and PA: project management. All authors reviewed and approved the final version of this manuscript.

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