

Intestinal cleaning for colonoscopy in children: effectiveness, adherence and adverse effects of schemes differentiated by age

Limpieza intestinal para colonoscopia en niños: efectividad, adherencia y efectos adversos de esquemas diferenciados por edad

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Abstract

Introduction: Adequate intestinal cleanliness is crucial to achieve optimal colonoscopy performance. Several bowel preparation (BP) schemes have been proposed, but there is still no consensus as regards which is the most suitable in paediatric patients. **Objective:** To describe the effectiveness, adherence, and adverse effects of BP protocols differentiated by age group in paediatric patients subjected to colonoscopy. **Patients and Method:** Prospective study that included patients < 18 years subjected to colonoscopy. BP protocols differentiated by age group were indicated as follows: < 6 m (glycerine suppository); 6 m-3y 11 m (poly-ethylene-glycol (PEG 3350 without electrolytes); 4y-9y 11 m (PEG 3350 without electrolytes + bisacodyl); 10 y-18 y (PEG 3350 with electrolytes). Demographic, clinical information, adherence and adverse effects were registered. Effectiveness was determined using a validated scale (Boston modified) during colonoscopy. **Results:** A total of 159 patients were included, of which 87 (55%) were males, and with a median age of 4 years (range 1 m-17 years). Seventy eight percent of patients achieved successful BP. The higher effectiveness was observed in the groups of < 6 m (96%) and 10-18 y (91%). Constipation was significantly more frequent (29%) in the 4 yo-9 yo 11 m in which lower effectiveness was observed (69%). Good adherence was observed in 87% of patients. Adverse effects were observed in a third of patients, although they were mild and did not lead to the suspension of the BP. **Conclusions:** Satisfactory results were achieved with the BP schemes used, with a successful BP being obtained in 4 out of 5 patients. Results were different between groups, which is probably related to previous bowel transit and indicated medication.

Keywords:

Colonoscopy preparation;
Bowel preparation solutions;
Cathartics

Introduction

Colonoscopy is an endoscopic procedure that consists of visualizing the mucosa of the colon and part of the terminal ileum. In pediatrics, it is an important tool, both for diagnostic and therapeutic purposes¹. The success of colonoscopy depends on several factors. One of the most important factor is Bowel cleansing (BC) that allows an adequate visualization of the mucosa^{2,3}, which is a challenge in the pediatric population⁴. Inadequate preparation not only limits vision, but also increases the duration, risks and It could eventually induce the repetition of the procedure^{4,5}. Pediatric studies have reported that up to 37% of procedures need to be repeated for inadequate preparation^{5,6}.

An ideal BC is that which is effective, well tolerated and does not have relevant adverse effects, however until now we do not have protocols that fulfill with all these characteristics⁴. Currently, there are numerous schemes for BC in pediatric patients, but there is little evidence to support the superiority of some over others, which has hindered to reach an agreement with which is the most appropriate preparation system^{4,7,8}. Most publications recommend a diet with liquids and low residue in the days prior to the test, and oral laxatives and/or enemas the day before or the same day of the procedure^{4,7-9}. In practice, each institution has its own preparation scheme that varies in duration, changes in diet, type and dose of prescribed medications^{4,7,8}.

In children, BC protocols based on osmotic laxatives (polyethylene glycol (PEG) 4,000, and 3,350 solutions with and without electrolytes) and stimulant laxatives (phosphosoda, bisacodyl, sodium picosulfate solutions) have been used. PEG 3,350 with electrolytes has shown adequate efficacy in the pediatric patients (75-95%). However, it requires a large volume of fluid for its administration (3-4 µl), which can cause nausea, vomiting and abdominal pain^{4,10-12}. PEG 3,350 without electrolytes is a medication commonly used in the management of chronic constipation in pediatrics, showing its effectiveness and safety in this context^{13,14}. In recent years, several articles have referred to its use in colonoscopy preparation. These studies have reported few adverse effects and more than 85% of effective-

tiveness using different schemes, ranging from one to four days of duration and with doses of 1.5 to 2 g/kg/day¹⁵⁻²⁰.

One of the limitations of these protocols is its endurance, since it involves several days of soft stools and eventual school absence. Bisacodyl is a safe and effective stimulant laxative that has been used as adjuvant in several colonic preparation schemes^{11,17,21,22}. Oral sodium phosphate liquid solutions have also been used in children^{10,12}, with an effectiveness up to 95% and acceptable tolerance. However, in recent years severe adverse effects have been reported especially in children under 5 years and patients with renal failure²³⁻²⁵. Thus, *The Food and Drug Administration* (FDA) has questioned its use in these patients²⁶. More recently, sodium picosulfate tests have been shown to have a similar efficacy to PEG with electrolytes, with better tolerance and adherence, which has been really promising²².

The success of BC can be determined not only by the preparation protocol, but also by the level of understanding of the patient (and their parents), the degree of adherence to the indications and the type of previous intestinal transit of the patient. In this sense, the age of the patients could influence their adherence and response to the preparation protocol^{4,27}. In our institution we have designed an BC protocol based on the evidence previously mentioned, and according to the age of the patients. The objective of this study was to describe the effectiveness, adherence and adverse effects of these BC scheme, separated by age group in pediatric patients undergoing colonoscopy in our institution.

Patients and Method

Design

Descriptive study, which included patients younger than 18 years of age who had a colonoscopy on an outpatient basis at Clínica Alemana from Santiago, Chile, between August 2010 and May 2013. A guideline for colonoscopy preparation according to age and weight was indicated (Table 1). The study was approved by the institution's ethics committee.

Table 1. Protocols for intestinal cleaning indicated according to age group in 159 pediatric patients undergoing colonoscopy

Age group	Medication	Dose
New borns to 6 months	Glycerine suppository	1 suppository 3 h before the procedure
6 months to 3 years and 11 months	PEG 3350 without electrolytes	1,5 g/kg/d per 4 days
4 years to 9 years and 11 months	PEG 3350 without electrolytes + bisacodyl	1,5 g/kg/d per 4 days + 5 mg (for ≤ 23 kg), 10 mg (for > 23 kg)
10 to 18 years	PEG 3350 with electrolytes	3 l in 4 h

PEG: polyethylen glycol.

Colonoscopies of patients younger than 6 months examined up to the splenic flexure performed without sedation. In children of 6 months or older a complete colonoscopy was performed, under deep sedation or general anesthesia supervised by an anesthetist. We excluded patients who did not agree to participate in this study and those who required administration of the nasogastric tube preparation.

Effectiveness evaluation

Colonoscopies were performed by the same team of children's gastroenterologists. The effectiveness of the preparation was assessed using a scale based in one previously validated in adults, which has been used in other studies in children (Boston scale)^{22,28-30}. Briefly, this scale evaluates 3 segments (left colon, transverse colon and right colon) and each one give a score according to the possibility of visualization. For this protocol, children under 6 months were evaluated only with 2 segments (rectum and left colon). Score 1 was assigned to the optimal visualization due to absence of stools and score 4 to the impossibility of evaluating the segment due to the presence of abundant stools that were not possible to suck. The BC was considered successful if the total score was between 3 and 6 points (2 to 4 in the group of 6 months), and not successful if the score was between 7 and 12 points (5 to 8 in the Group of 6 months). It was defined as BC failure when the examination should have been interrupted due to inadequate preparation.

Adherence evaluation and adverse effects

Parents and/or patients were interviewed on the same day of the procedure using a questionnaire to record demographic data, previous bowel habits and test's indications, adherence and adverse effects during preparation.

The adherence to the preparation was classified according to the amount of the prescribed solution that was actually ingested by the patient. It was arbitrarily defined as good adherence when the patient swallowed 2/3 or more of the prescribed solution; regular adherence when patient swallowed 1/3 to 2/3 of the solution and bad adherence when patient swallowed 1/3 or less of the solution prepared. The adverse effects evaluated were nausea, vomiting, abdominal pain, bloating and anal irritation.

Statistical analysis

Descriptive statistics were performed, expressing the categorical variables according to their frequencies and the continuous variables as medians and interquartile range (IQR) due to their non-normal distribution. Chi-square test (or Fisher when appropriate) was used for categorical comparisons and continuous

variables were compared by non-parametric test using EpiInfo® 7 software (CDC, Atlanta).

Results

159 patients were enrolled, 87 males (55%), median age of 4 years and 2 months (IKR 1-10 years). Table 2 shows the distribution of patients according to age and treatment scheme, with their main demographic and clinical characteristics. The proportion of males in the 4-9 years and 11 months group was significantly higher, and in the 10 to 18 age group it was significantly lower than the total group. The most frequent indication for colonoscopy was low digestive hemorrhage, followed by suspected food allergy and chronic diarrhea.

The 13% of the patients had constipation before starting with BC protocol, and this proportion was significantly higher in the 4-9 and 11 months group (29%; $p = 0.00025$).

Table 3 shows the effectiveness, adherence and adverse effects in each group of patients.

BC was successful in 78% of patients. When analyzing all patients, the highest proportion of effectiveness was achieved in the group of children younger than 6 months of age, who were prepared with glycerin suppositories and enrolled to left colonoscopy only. According to patients who were enrolled to a complete colonoscopy, the group previously prepared with PEG 3.350 with electrolytes (10 to 18 years old) had the highest proportion of successful BC (91%), which is in agreement with their higher percentage of liquid depositions after the protocol (82%), and contrasts with its significantly lower adherence to the solution administrated (71%).

Patient groups receiving PEG 3,350 without electrolytes had a lower proportion of a successful BC, regardless of the use of bisacodyl (67% and 69% for the none and with bisacodyl group, respectively).

Patients with a history of constipation had a significantly lower proportion of success compared to normal bowel transit or diarrhea (55% and 78%, respectively, $p = 0.016$). The proportion of failures due preparation was generally low and only occurred in the PEG groups without electrolytes. 70% of patients achieved fluid deposition at the end of the BC protocol. This proportion is lower in the 6 months to 3 year and 11 months (61%) group and higher in the 10 to 18 years group (82%), which agrees with their BC success rates (Table 3).

Although the proportion of good adherence was high in all groups (87%), it was significantly lower in the group of 10 to 18 years old (71%), who received PEG 3.350 with electrolytes. This lower rate of adhe-

Table 2. Demographic and clinical characteristics of 159 pediatric patients undergoing colonoscopy according to age group and intestinal cleaning protocol

Intestinal cleaning protocol	Total	< 6 m	6 m - 3 y and 11 m	4 y - 9 y and 11 m	10 y - 18 y
		Glycerine suppository	PEG 3350 without electrolytes	PEG 3350 without electrolytes + bysacodyle	PEG 3350 with electrolytes
<i>N° of patients</i>	159	28	48	49	34
<i>N° of male (%)</i>	87 (55)	13 (46)	28 (58)	33 (67)*	13 (38)**
<i>Median age, months (IQR)</i>	50 (12-126)	4 (2-5)	24 (12-35)	74 (58-93)	147 (130-165)
<i>Indication of colonoscopy, n (%)</i>					
Lower gastrointestinal bleeding	76 (48)	16 (57)	16 (33)**	30 (61)*	14 (41)
Food allergy workout	34 (21)	11 (39)*	15 (31)*	7 (14)**	1 (3)**
Chronic Diarrhea	20 (13)	0	8 (17)	8 (16)	4 (12)
Chronic abdominal pain	14 (9)	0	3 (6)	4 (8)	7 (21)
Inflammatory bowel disease workout	9 (6)	0	1 (2)	0	8 (24)*
Abdominal distension	2 (1)	1 (4)	1 (2)	0	0
Undernutrition	4 (3)	0	4 (8)	0	0
<i>Stool consistency before intestinal cleaning protocol</i>					
Normal	111 (70)	21 (75)	37 (77)	27 (55)	26 (76)
Constipation	21 (13)	5 (18)	1 (2)	14 (29)*	1 (3)
Diarrhea	27 (17)	2 (7)	10 (21)	8 (16)	7 (21)

PEG: polyethylen glycol; IQR: inter quartile range. *Rate significantly higher than total group of patients ($p < 0.05$). **Rate significantly lower than total group of patients ($p < 0.05$).

Table 3. Effectivity, adherence y adverse effects of the intestinal cleaning (IC) protocols in 159 children undergoing colonoscopy according to age group and intestinal preparation protocol

Intestinal cleaning protocol	Total	< 6 m	6 m - 3 y and 11 m	4 y - 9 y and 11 m	10 y - 18 y
		Glycerine suppository	PEG 3350 without electrolytes	PEG 3350 without electrolytes + bysacodyle	PEG 3350 with electrolytes
<i>N° of patients</i>	159	28	48	49	34
<i>Effectivity</i>					
<i>N° of patients with successful IC (%)</i>	124 (78)	27 (96)	32 (67)**	34 (69)**	31 (91)
<i>Failure of IC</i>	3 (2%)	0	1	2	0
<i>Stool consistency after the protocol</i>					
Solid-Soft	6 (4%)	1 (4%)	2 (4%)	1 (2%)	2 (6%)
Loose-soft	41 (26%)	7 (25%)	17 (35%)	13 (27%)	4 (12%)
Liquid	112 (70%)	20 (71%)	29 (61%)**	35 (71%)	28 (82%)*
<i>Adherence</i>					
<i>N° of patients with good adherence (%)</i>	139 (87)	28 (100)	45 (94)	42 (86)	24 (71)**
<i>N° of patients with adverse effects (%)</i>					
Total (%)	54 (34)	0	7 (15)	17 (35)	30 (88)*
Abdominal pain (%)	38 (24)	0	5 (10)	15 (31)	18 (53)*
Nausea (%)	23 (14)	0	0	1 (2)	22 (65)*
Bloating (%)	18 (11)	0	4 (8)	7 (14)	7 (21)
Vomits (%)	12 (8)	0	1 (2)	2 (4)	9 (26)
Anal irritation (%)	10 (6)	0	2 (4)	2 (4)	6 (18)

PEG: polyethylen glycol. *Rate significantly higher than total group of patients ($p < 0.05$). **Rate significantly lower than total group of patients ($p < 0.05$).

rence in this group was related with a significantly higher frequency of adverse effects (Table 3).

Regarding adverse effects, they were observed in 34% of patients. They were mild and their presence did not determine the suspension of the prescribed solution by the doctor. The high frequency of nausea and abdominal pain in the group of 10 to 18 years (PEG 3.350 with electrolytes) was highlighted, showing a type of relationship between a higher frequency of adverse effects and less adherence to the scheme.

Discussion

According to the results of the present study, approximately 4 out of 5 children enrolled to BC protocols had an adequate colonoscopic vision. Significant differences were evidenced between the analyzed age groups, which is probably due to differences in the solutions administered for each age group and also due to the presence or absence of previous constipation. Pall et al recently described in a study, based on surveys of pediatric gastroenterologists in the United States, that the practice of indicating differential BC protocols according to patient age is widely diffused⁴. This is considering the fact that the adherence and risks are different for each BC scheme and age group.

The maximum proportion of a successful BC was achieved in infants younger than 6 months, prepared with glycerin suppositories and enrolled to left colonoscopy. Although this group is not comparable with the rest of the series (since the examination was limited to a small segment of the colon) we decided to include it, because there are few articles and studies in this group and there is almost no evidence regarding which is the best system of bowel solutions and preparations. Since the results were optimal with the protocol used, this reinforces the premise that this group of patients requires minimal amount of solution, at least for performing a left colonoscopy.

The group that followed in success (rating 91%) was the group that received PEG with electrolytes (10 to 18 years), which is in agreement with previously described in other series^{4,22}. It is noteworthy that this high success rate was achieved even though the proportion of good adherence was significantly lower than in the other groups (71%), probably due to the greater frequency of adverse effects (88%), or because the patients considered that they had reached the administered solutions' goal (liquid stools) before taking the full volume of solution, stopping their intake. The latter suggests that, with lower volumes, satisfactory results could be achieved as well. This type of solution is poorly tolerated by children because of its taste and also because of the large volume of liquids that must be taken in a short time, so it has frequently been re-

quired to be administered through a nasogastric tube with consequent discomfort and additional costs²⁷. For this reason, the use of protocols with reduced volumes of PEG with electrolytes associated to bisacodyl and/or ascorbic acid has been evaluated in order to improve the effectiveness and tolerance respectively²². The results have been satisfactory, reinforcing what our data suggests.

The groups of patients who received PEG without electrolytes had a lower effectiveness, regardless of the use of bisacodyl and despite having a high proportion of good adherence. This contrasts with the high success rates described by the Pashankar and Safder groups using the same PEG doses (1.5 g/kg/d) of this study^{18,31}. These differences could be due to the higher frequency of constipation in patients of our study (29% in the PEG group without electrolytes + bisacodyl). Although constipation has been considered as a potential risk factor for BC failure, the results in clinical trials have been inconsistent so far^{20,22}. Our findings propose that constipation may decrease the effectiveness of BC protocols, which suggests that these patients may require more aggressive protocols. Phatak et al evaluated a 2-day preparation scheme with 2 g/kg/day of PEG 3.350 without electrolytes with a maximum of 136 g per day associated with bisacodyl¹⁷. This preparation scheme had an excellent or good effectiveness of 92% and an excellent tolerance in 95% of the patients, with a shorter duration than other schemes without bisacodyl¹⁷. It would be necessary to determine in a new prospective protocol if the increase in doses in patients of the age groups considered in this study, as well as constipated patients, is related to more effectiveness.

The proportion of patients with adverse events was relatively high (1 in 3 patients). However, most of these effects were mild and did not signify the suspension of the medication or colonoscopy by the doctor. This supports what has been reported in other series regarding the safety of the protocols used^{4,22}.

Within the limitations of this study we must consider its descriptive design, the use of a validated scale of effectiveness in adults (although it has been previously used in children) and the arbitrary classification of schemes by age group. However, according to the scarce Latin American literature in this area, we believe that this prospective series is a more streamlined approach of BC, considering the age of the patients. It would be fascinating for these schemes to be validated against a control group in the future.

We consider that the results obtained in patients of 10 to 18 years are acceptable, although it would be enticing to improve the profile of adverse effects. However, in children under 10 years old, the results are insufficient in terms of effectiveness and require new adjustments in order to generate recommendations.

Conclusions

Protocols devised by age groups proposed in this serie showed an acceptable effect, obtaining successful BC in 4 out of 5 patients. However, these results should be optimized, especially in the group of 6 months to 10 years in terms of effectiveness, and in the group of 10 to 18 years regarding adverse effects. The results differed between groups, which were probably related to the previous bowel habit and the protocol used. It would be necessary to make further progress with controlled studies in order to determine the best BC protocol adapted to the patient's age and Bowel habits.

Ethical Responsibilities

Human Beings and animals protection: Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World

Medical Association regarding human experimentation developed for the medical community.

Data confidentiality: The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

Rights to privacy and informed consent: The authors have obtained the informed consent of the patients and/or subjects referred to in the article. This document is in the possession of the correspondence author.

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Conflicts of Interest

Authors state that any conflict of interest exists regards the present study.

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