Safety and Effectiveness of Large-Volume Enema Solutions

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The effectiveness and side effects of three types of enema solutions were compared in healthy subjects. Using a repeated-measures, double-blind design, the three different enemas (soapsuds, tap water, and polyethylene glycol-electrolyte solution) were given at 1-week intervals to 24 healthy volunteers. Soapsuds and tap water enemas produced significantly greater returns than polyethylene glycol electrolyte solution (PEG-ES) and were also more uncomfortable. Rectal biopsies showed surface epithelium loss after soapsuds and tap water but not after PEG-ES enemas. Before recommending changes in nursing practice, further research is needed to determine the mechanism for the surface epithelium damage and to determine if this damage produces a stronger defecation stimulus and discomfort.

ENEMA ADMINISTRATION is a common nursing procedure used to treat constipation and empty the colon before surgery and diagnostic testing. Because enemas were developed hundreds of years ago, long before the dawn of nursing and the development of the scientific method, their use is largely based on tradition and trial and error and not scientific investigation.

The most common enema solutions are sodium-phosphate, tap water, and soapsuds. The small-volume sodium-phosphate enema is the easiest to give but irritates colonic mucosa (Meisel, Bergman, Graney, & Rubin, 1977) and may cause serious electrolyte imbalance (Knobel & Petchenko, 1996). Tap water and soapsuds enemas have fewer reported complications. Fluid overload can occur after repeated tap water enemas (Chertow & Brady, 1994), but very large volumes are commonly given without complications (Pietilae, Kinnunen, & Linden, 1990). Major concerns with soapsuds enemas are colonic mucosa irritation and colitis (Orchard & Lawson, 1986).

Hypotonic and hypertonic solution instilled into the colon may cause systemic fluid and electrolyte changes, but isotonic solutions minimize such effects. Polyethylene glycol electrolyte solution (PEG-ES) is an isotonic oral lavage solution developed in the 1980s and later modified. Concentrations of PEG and other ions in PEG-ES are such that little or no fluid or electrolyte absorption occurs as the solution passes through the entire gastrointestinal tract (Fordtran, Santa Ana, & Cleveland, 1990). PEG-ES is available for oral use, but its performance as an enema has had limited assessment.

The ideal enema solution would not be absorbed from the colon and would effectively empty it without discomfort or damage to colonic mucosa. Large-volume enemas are widely used in practice, but there is no clear understanding of how well various solutions empty the colon, whether or not they alter rectal mucosa, or how much patient discomfort occurs. The aim of this study was to compare net output, mucosal irritation, and subjective discomfort when three large-volume enema solutions (tap water, soapsuds, and PEG-ES) were given to healthy subjects.

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> ***The most common enema solutions are sodium-phosphate, tap water, and soapsuds.***

BACKGROUND

There are almost no scientific studies of large-volume enemas. In a 1955 study, Page et al. used a repeated measures design to compare three large-volume solutions, (tap water, soapsuds, and normal saline) and one small-volume enema (sodium-phosphate) in 10 healthy volunteers. They visually evaluated cleanliness during proctoscopy. Sodium phosphate enemas tended to produce the cleanest rectum, followed by soapsuds, tap water, and sodium chloride, but the researchers did not report the statistical significance.

More recently, Schmelzer et al. (2000) randomly administered tap water (deionized water) and soapsuds (deionized water plus 6 g of liquid castile soap per liter) enemas to 25 patients during their preoperative preparation for liver transplants. The researchers used net output (weight of the returns minus the weight of enema infused) to measure the effectiveness of tap water and soapsuds enemas, reasoning that enemas that produced the largest returns would provide the best emptying and therefore the best removal of stool. They expected the returns to be larger than the amount of enema given because the returns would contain both the enema infused plus stool already in the colon. Surprisingly, the enema returns usually turned out to be smaller than the amount of enema infused. All but one member of the tap water enema group had solution remaining behind in the colon and 6 of the 13 who received soapsuds enemas had smaller returns than what was instilled.

Because fluid overload is a complication of tap water enemas, Schmelzer et al. (2000) anticipated that some enema solution might be absorbed. They added 2 g of a nonabsorbable marker, PEG 3350, to each liter of solution and later measured the amount of PEG 3350 in the enema returns. An increased concentration of PEG in the returns would provide evidence of absorption of the enema solution. The researchers discovered that PEG 3350 was diluted by the contents of the colon and only partially excreted. They suggested that a poorly absorbed isotonic solution might produce larger net outputs than the hypotonic tap water and soapsuds solutions.

Schmelzer et al. (2000) found that soapsuds produced significantly larger net outputs than tap water did ($t = 3.04$, $df = 17$, $p = .007$). Unfortunately, soapsuds enemas are reputed to cause mucosal irritation and colitis and are therefore shunned as bowel preparations before diagnostic procedures. The evidence is anecdotal, however, and describes situations in which individuals received harsh solutions (Kim, Cho, & Levinsohn, 1980) or several repeated enemas (Orchard & Lawson, 1986). Despite these reports, soapsuds enemas are still being used to treat constipation (Potter & Perry, 2001; Taylor, Lillis, & LeMone, 2001), and there has been no systematic examination of the rectal mucosa after treatment with a known concentration of soapsuds solution.

One would expect an irritating enema solution to be more uncomfortable than a nonirritating one, but Schmelzer et al. (2000) found that soapsuds enemas produced no more discomfort than tap water enemas. Perhaps the questionnaire used to measure discomfort was not sensitive enough to detect differences. Subjective discomfort was measured by asking subjects whether or not they had experienced any of 11 types of discomfort (e.g., abdominal cramping, abdominal pain, nausea), and marking either yes or no next to each one. Asking subjects to record the intensity of discomfort on a Likert scale would provide more precise measurements that could make potential differences in discomfort more evident.

The current study was an extension of earlier work by Schmelzer et al. (2000). An isotonic solution with poorly absorbable osmotic agents (PEG-ES) was compared with tap water and soapsuds solutions. Biopsies were obtained after each enema to microscopically examine the rectal mucosa. Finally, a more sensitive questionnaire was used to measure subjective discomfort. The hypothesis was that there are differences between tap water, soapsuds, and PEG-ES enema solutions in (1) net output, (2) rectal mucosal irritation, and (3) subjective discomfort.

METHODS

Because colon function varies widely among individuals and is influenced by disease and medications, a repeated-measures design was chosen and only healthy subjects were recruited. Institutional Review Boards for the Protection of Human Subjects approved the study. Each volunteer received one enema per week for 3 weeks. Each enema was followed by proctoscopy and biopsies. To control for treatment order effects, volunteers were randomly assigned to one of six possible treatment groups (four subjects per group) and were given enemas in the order indicated for that group. Subjects were paid for participating because they were receiving enemas and proctoscopies, procedures that could be embarrassing, uncomfortable, and time consuming.

Sample

A convenience sample of 12 men and 12 women was recruited through referrals from university faculty, students, and hospital employees. Subjects were admitted into the study if they met the following criteria: healthy, mentally alert, and at least 18 years old. They completed an 18-item questionnaire to determine if they had conditions that would worsen with enemas or interfere with the experiment. People were excluded from participation if they had bleeding disorders, colostomies or ileostomies, diabetes, neurologic disease, heart disease, renal disease, inflammatory bowel disease, bowel motility or absorption irregularities, cancer of the digestive tract, or sores or fissures on the anus. Because biopsies were planned, subjects were asked about excessive bleeding from dental procedures or minor trauma to screen for occult bleeding. They were instructed to avoid aspirin for 10 days and nonsteroidal anti-inflammatory drugs for 4 days before the study began and during the time they participated in the study. No dietary restrictions were given but subjects were asked to maintain the same general diet during the 3 weeks of the study.

Setting

The study took place in a gastrointestinal (GI) laboratory in a large metropolitan hospital. The enemas were given in an examining room with an adjacent bathroom. The proctoscopy room was immediately across the hall. The study was conducted on Saturdays when the GI laboratory was not otherwise in use. Data were collected for 8 months.

Intervention

The tap water enema contained 2 g of PEG 3350 per liter of deionized water. The soapsuds enema contained 6 g of castile soap and 2 g of PEG per liter of deionized water. The PEG-ES enema contained 105 g of PEG, 65 mEq of Na^+, 53 mEq of Cl^-, and 17 mEq of HCO_3^- per liter of deionized water. The deionized water/PEG mixture used for the tap water and soapsuds solutions was prepared in advance in a GI research laboratory. The principal investigator added the castile soap for the soapsuds solution and prepared the PEG-ES according to package directions. She put the appropriate solution for each subject in a beaker labeled with the subject's name. One registered nurse (RN) later weighed out 1100 g of the solution from the beaker, warmed it to 102°F, and added it to the enema bag. A second RN gave all the enemas according to a standard procedure developed by Schmelzer and Wright (1996). Both nurses were blinded to solution used.

Variables and Their Measurement

The variables included net enema output, PEG recovery, musocal irritation, and subjective discomfort. Demographic information was also collected.

Net enema output. Net enema output was calculated by subtracting the weight of enema solution infused from the weight of the enema returns. The following formulas were used: (1) weight of leakage = absorption pad weight after the enema − absorption pad weight before the enema, (2) weight of solution infused = weight of the initial enema solution − weight of solution remaining in the bag − weight of leakage, and (3) net output = weight of enema returns − weight of solution infused.

Both volume and weight are valid measures of stool output. Weight was chosen for this study for measurement accuracy and because leakage could be estimated by weighing the absorption pad under the patient before and after the enema was given. The manufacturer specified that the balance selected (Model EW-3000G; A&D Company, Limited, Tokyo, Japan) was accurate to 1 g and had a capacity of 3,000 g. Before data collection, the measurement method was found to be precise to ±0.44 g, indicating negligible measurement error.

The balance was calibrated before each set of measurements.

PEG recovery. All three solutions contained a known concentration of PEG 3350 that was used to estimate the enema recovery. Personnel in the GI research laboratory measured PEG 3350 concentration in the enema returns using turbidometric procedures developed by Hyden (1956). The percentage of PEG recovery was calculated using the following formula:

$$\text{PEG recovery } (\%) = \frac{(\text{PEG}) \text{ in enema returns} \times \text{Weight of enema returns}}{(\text{PEG}) \text{ in original enema solution} \times \text{Weight of enema solution}} \times 100$$

Higher–molecular-weight PEG has been used as a poorly absorbable marker for intestinal perfusion studies for 30 years. The GI Research Laboratory that measured the PEG 3350 concentrations in the enema returns had extensive experience measuring and analyzing PEG 3350 stool concentrations.

Mucosal irritation. Mucosal irritation was measured by evaluating biopsies. The physician coinvestigator and four GI fellows, trained in proctoscopy by the coinvestigator, performed a proctoscopy immediately after the subjects defecated the enema and obtained two biopsies from the valves of Houston. The physicians were blinded as to type of enema given.

Biopsies were immediately placed in a 10% formalin solution and sent to the laboratory where they were embedded in paraffin. Histologic sections were prepared and stained with hematoxylin and eosin. Slides were prepared soon after biopsies were obtained and were read when data collection was completed. One pathologist examined all slides microscopically for degeneration and loss of the surface epithelium and for signs of inflammation in the lamina propria. The pathologist was blinded to subject ID, solution used, and sequence of biopsies.

Subject discomfort. Subject discomfort during the enema was measured by using a visual analog scale listing nine types of discomfort including embarrassment, nausea, vomiting, abdominal cramping, abdominal pain, rectal itching, rectal burning, dizziness, and faintness. Content validity of the scale is supported by documentation in the literature (Schmelzer & Wright, 1996; Schmelzer, Case, Chappell, & Wright, 2000).

Subjects indicated the intensity of discomfort experienced by placing a mark through the 10-cm line ranging from no discomfort to severe discomfort. The scale was scored by measuring the distance from the left end point to the mark on the line for each type of discomfort. The nine discomfort items were added to get a total score.

Subjects completed the discomfort scale immediately after defecating the enema and again 15 minutes later to establish test-retest reliability. Pearson correlations were 0.93 on the discomfort scale after the soapsuds enema and 0.91 on discomfort scales after the other two solutions. All correlations were significant at $p < .001$ (two-tailed).

Demographic questionnaire. Before receiving the first enema, subjects completed a demographic questionnaire containing questions about age, race, gender, usual bowel movement frequency, and previous laxative or enema use.

Procedure

When contacted by potential subjects, the PI described the study including criteria for participation, gave them a copy of the consent form to read, and made an appointment for the first day of data collection. When the individual arrived at the laboratory, the PI answered any questions, ensured that the subject met the study criteria, and obtained informed consent. An RN measured the subject's vital signs and gave the enema. She asked subjects to hold the enema as long as possible or a maximum of 10 minutes. Subjects then went to the bathroom where they eliminated the enema into a collection pan inserted in the toilet. After completing defecation, subjects completed the discomfort scale and then had the proctoscopy with biopsies. Fifteen minutes after the proctoscopy finished, the RN measured vital signs and released subjects after ensuring they felt fine. Enema returns were weighed and sent to the laboratory for PEG analysis.

DATA ANALYSIS

Descriptive statistics were used to tabulate demographic information. Normality of the dependent variables was examined using Kolmogorov-Smirnov statistics, histograms, and normal Q-Q plots. A repeated measures analysis of variance was used to test net output, PEG recovery, and discomfort ($\alpha = 0.05$). When a significant differ-

Table 1. Comparison of Net Output, Surface Epithelium Loss, and Discomfort

	Net Output* (g) (24 in Each Group)	Surface Epithelium Loss† (21 in Each Group)‡	Discomfort§ (24 in Each Group)
Soapsuds	*M:* −7.50	*M:* 3.29	*M:* 11.0
	SD: 179.16	*SD:* 1.01	*SD:* 8.0589
	Range: −40 to +293	Range: 1 to 4	Range: 0 to 27.5
Tap water	*M:* −24.50	*M:* 2.29	*M:* 8.3
	SD: 158.52	*SD:* 1.42	*SD:* 6.5374
	Range: −332 to +358	Range: 0 to 4	Range: 0 to 28.0
PEG-ES	*M:* −278.54	*M:* 0.24	*M:* 3.9
	SD: 202.97	*SD:* 0.44	*SD:* 4.0825
	Range: −762 to +138	Range: 0 to 1	Range: 0 to 15.5
Statistical significance (α = .05)	One-Way repeated measures ANOVA	Friedman (nonparametric)	One-way repeated measures ANOVA
	Wilk's λ = 0.527	Chi-square: 29.8	Wilk's λ = 0.389
	df = 2,22	*df:* 2	*df* = 2,22
	p = .001	*p* < .001	*p* < .001
Post hoc testsλ‖	Soapsuds > PEG-ES (*p* = .001)	Soapsuds > tap water (*p* = .012)	Soapsuds > PEG-ES (*p* < .001)
	Tap water > PEG-ES (*p* = .001)	Soapsuds > PEG-ES (*p* < .001)	Tap water > PEG-ES (*p* = .005)
		Tap water > PEG-ES (*p* < .001)	

*Weight of enema returns minus weight of enema instilled.
†Measured on a scale ranging from no injury (0) to complete surface epithelium loss (4).
‡Three subjects did not have biopsies.
§Maximum total score is for each item is 10 for a total maximum score of 90.
‖Post hoc tests for ANOVA include adjustment for multiple comparisons: Bonferroni.

ence was observed, pair-wise comparisons were performed using Bonferroni tests.

The nonparametric Friedman test was used to examine differences in biopsy findings (α =0.05). When a significant difference was observed, the Wilcoxon signed-rank test, a nonparametric post hoc test for related samples, was used to identify the solutions that accounted for the difference. Because no procedures correct for inflation of the type I error when performing nonparametric post hoc tests, the level of significance was adjusted using the Bonferoni correction. Alpha was set at 0.0167 (0.05 ÷ 3) for each nonparametric post hoc test.

Although subjects were randomly assigned to groups to control for the effects of the order of enema administration, univariate procedures were used to verify whether order had an effect on net output, PEG recovery, discomfort, and surface epithelium loss (α =0.05). (Surface epithelium loss was the only abnormal finding noted on the biopsies.) The Bonferroni post hoc test was used when variances were equal, and the Tamhane post hoc test was used when they were unequal. Findings were verified using the Kruskal-Wallis Test, a nonparametric test for independent groups. When significant differences occurred, the Dunn procedure was used for post hoc testing (Zar, 1999). When data were not normally distributed, nonparametric tests were performed to verify parametric test findings. Order had no effect and all nonparametric results were found to be similar to parametric results.

RESULTS

Twelve men and 12 women, ages 20 to 65, participated in the study. Seventeen were white, four were Hispanic, and three were black. Fifteen had never had an enema before. Subjects reported bowel movement frequency ranging from 3 weekly to 3 daily, and 20 reported having at least a daily bowel movement.

Almost everyone was able to retain over 1,000 mL of enema solution. One person took the entire soapsuds enema but took only 381 mL of tap water and 654 mL of PEG-ES. A second person took the entire soapsuds and tap water solutions but 974 mL of the PEG-ES.

Mean net outputs were −7.5 g after a soapsuds enema, −24.5 g after a water enema, and −278.5 g after a PEG-ES enema (Table 1). The type of enema solution had a significant effect on net output (Wilk's Lamda = 0.527, $F[2,22] = 9.857$, p = .001). The observed power was 0.968. Post hoc

Table 2. Frequencies of Loss of Surface Epithelium After Each Enema Solution

Enema Solutions	Surface Epithelium Loss					
	0 none	1 >0 but <25%	2 >25 but <50%	3 >50 but <75%	4 >75%	Total
Soapsuds	0	2	2	5	12	21
Tap water	2	7	0	7	5	21
PEG-ES	16	5	0	0	0	21

tests revealed no significant differences in net output between soapsuds and tap water, but both had significantly more net output then PEG-ES ($p = .001$).

In many cases, the weight of solution infused was greater than the weight of the returns (stool plus enema solution). Twenty-three subjects had negative net outputs after the PEG-ES compared with 15 with negative outputs after a tap water enema and 12 with negative outputs after the soapsuds enema.

The only abnormal finding on biopsies was a loss of surface epithelium, and there were significant differences in surface epithelium loss after the three enemas. Three subjects were omitted from data analysis, two because excessive stool in the rectum prevented the biopsies, and the third one because the biopsy was mucus instead of tissue. Therefore, the biopsy results are based on 21 of the 24 subjects.

Biopsies after the PEG-ES enemas appeared normal, with little or no loss of surface epithelium (Table 2). Everyone had at least some loss of surface epithelium after the soapsuds enema and 17 subjects had 50% or more loss. There was a great deal of variability after tap water enemas with nine subjects experiencing little or no loss and 12 experiencing greater than 50% loss.

Figure 1 shows a normal-appearing biopsy with intact surface epithelium that was obtained after a PEG-ES enema. The rectal mucosa is covered with a layer of columnar epithelium composed of absorptive cells and lighter-colored, mucin-secreting goblet cells. Crypts are interspersed throughout the mucosa and contain the newly forming epithelial cells. The lamina propria, the area lying directly beneath the surface epithelium and between the crypts, appears normal with no signs of inflammation.

In contrast, Figure 2 shows a biopsy that was obtained after a tap water enema. Again, the lamina propria appears normal, but the surface epithelium is gone. Some biopsies showed intermediate damage to the surface epithelium with flattened or absent columnar cells, irregular nuclei, and goblet cells that had lost their mucous.

The type of enema solution had a significant effect on surface epithelium loss ($\chi^2 = 29.8$, $df = 2$, $p < .001$), and the Kendall coefficient of concordance was 0.709. Biopsies after soapsuds enemas showed significantly greater loss of surface epithelium than biopsies after tap water enemas ($p = .012$), and biopsies after tap water enemas showed significantly more loss of surface epithelium than biopsies after PEG-ES ($p < .001$).

The mean discomfort score after the soapsuds enemas was 11.0, after tap water was 8.3 and after PEG-ES was 3.9. Subjects experienced significantly different amounts of discomfort following the three solutions (Wilks' Lambda = .389, $F[2,22] = 17.3$, $p < .001$). Observed power was 0.999. Post hoc tests with the Bonferoni correction found that subjects experienced significantly more discomfort after soapsuds enemas than PEG-ES enemas ($p < .001$) and also after tap water than PEG-ES enemas ($p = .005$). There were no significant differences in discomfort experienced when comparing soapsuds enemas to tap water enemas.

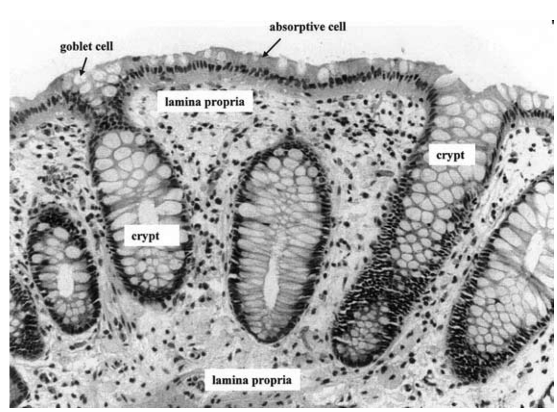

Figure 1. Normal biopsy with intact surface epithelium (goblet and absorptive cells).

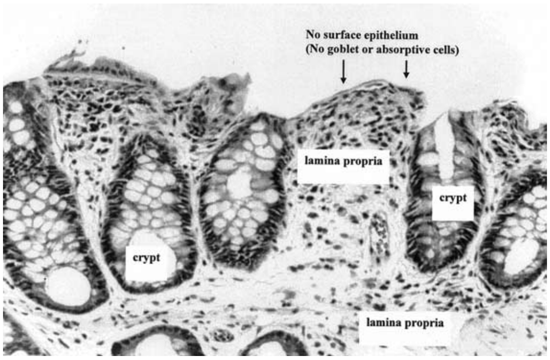

Figure 2. Abnormal biopsy showing absence of surface epithelium (no absorptive or goblet cells on the surface).

Embarrassment, abdominal cramping, and abdominal pain were the most frequent and most severe types of discomfort reported. Embarrassment ratings were similar across groups. Abdominal cramping received a rating greater than or equal to 5 from 13 subjects after a soapsuds enema, from seven subjects after a tap water enema, and from two subjects after a PEG-ES enema. Abdominal pain received a rating greater than or equal to five from seven subjects who received a soapsuds enema, from five subjects who received a tap water enema, and from one person who received a PEG-ES enema. Reports of rectal itching and rectal burning were almost nonexistent. Faintness was rated greater than one in three cases, dizziness was greater than one in five cases, and nausea was greater than one in nine cases. No one vomited.

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There were no significant differences in the percentage of PEG recovered after the three enema solutions. One subject actually had more than 100% recovery of PEG in her enema returns after the soapsuds enema. Because she had the PEG-ES enema the week before, some of the PEG probably remained in her colon and was eliminated with the soapsuds solution.

DISCUSSION

The findings raise the following questions: (1) How does the type of enema solution influence net output? (2) How does the damage to surface epithelium occur? (3) Why did tap water's effects on surface epithelium vary so much? (4) Why was there no inflammation? and (5) How much discomfort occurred?

How Does the Type of Enema Solution Influence Net Output?

Enemas are given to stimulate defecation and empty the colon. No one knows exactly how enemas work, but two theories have been proposed: the volume theory and the chemical irritation theory. According to the volume theory, the large volume of the enema stretches the intestinal lumen to produce a strong defecation urge. The resulting defecation pushes enema solution and feces from the bowel (Potter & Perry, 2001). However, volume alone cannot explain the enema's effects because the soapsuds and tap water enemas produced significantly more output than PEG-ES enemas, although they were given in equal volumes.

According to the chemical irritation theory, enemas stimulate defecation by irritation of the colonic mucosa. When the sensory neurons in the colon detect chemical changes from foreign antigens, toxins, or chemicals, the endocrine cells start a secretory response to dilute the irritant and then create powerful propulsive forces to eject it from the body (Wood, 1994). Hence, the strong defecation response after certain enema solutions may be the body's way of protecting itself from irritating substances.

The irritating effects of soapsuds might stimulate defecation to produce a larger net output. An earlier study found significantly larger net outputs when soap, an irritant, was added to the water solution (Schmelzer, 2000). However, chemical irritation does not explain the findings in this study. First, soapsuds enemas did not produce significantly larger net outputs than plain water enemas. And second, tap water enemas produced significantly larger net outputs than PEG-ES enemas, although neither solution contained a chemical irritant.

A more likely explanation is that the enemas stimulated defecation by damaging the colon's surface epithelium. Researchers have found surface epithelium loss from the colonic mucosa after other substances given to empty the colon. These include Fleets Phospho-soda enemas (CB Fleets, Inc., Lynchburg, VA) (Meisel et al., 1977; Sugimura et al., 1990), glycerine enemas (Sugimura et al., 1990), bisacodyl suppositories (Meisel et al., 1977), bisacodyl enemas (Meisel et al., 1977; Saunders, Haggitt, Kimmey, & Silverstein, 1990), and an oral solution containing 240 mL of magnesium citrate and X-Prep senna derivative (Pockros & Foroozan, 1985).

Trends noted in the current study further support a relationship between surface epithelium loss and emptying of the colon. The soapsuds enema produced the greatest destruction of surface epithelium and the largest net output (although net output was not significantly greater than for tap water), the tap water enema produced the next greatest loss of surface epithelium and the next largest net output, and the PEG-ES produced little or no loss of surface epithelium and the smallest net output.

How Does the Damage to Surface Epithelium Occur?

Chemical damage to the surface epithelium could explain soapsuds effects, but tap water contains no chemicals. Perhaps surface epithelium loss is caused by the hypotonicity of the enema solution. The tap water solution contained 2 g of PEG 3350 per liter of deionized water for an osmolality of 0 mosmol/L. The addition of 6 g of castile soap to the distilled water/PEG 3350 solution gave the soapsuds solution an osmolality of 8 mosmol/L. Both solutions have much lower osmolality than the normally isotonic contents of the colon.

The colon's major function is water reabsorption. Its lumen is lined with highly absorptive epithelial cells that absorb water from the feces moving slowly through the colon. Because the contents of the colon are normally isotonic, perhaps the colon cannot tolerate a large hypotonic load. Cell lysis could occur from osmotic movement of water from hypotonic enemas into the epithelial cells.

If hypotonicity is responsible for the loss of surface epithelium, the epithelium should be intact after isotonic solutions like PEG-ES and normal saline. Indeed, all subjects in the study had normal rectal mucosa biopsies after the PEG-ES, an isotonic solution. Furthermore, other studies have found normal biopsies after PEG-ES (Pockros & Foroozan, 1985) and normal saline infusions (Meisel et al., 1977; Sugimura et al., 1990).

To isolate the effects of tonicity and chemical irritation, the study should be repeated using four enema solutions: (1) water, (2) water with soap, (3) isotonic solution, and (4) isotonic solution with soap. Distilled water should be used for the tap water solution because the contents of tap water vary from city to city. The isotonic solution could be either PEG-ES or normal saline. A repeated-measures design is recommended because it controls for variability in the subjects and produced a large effect size in this study despite a relatively small sample.

Patients are encouraged to hold enemas as long as possible, even if they feel a strong urge. Nursing textbooks recommend that patients hold enemas 5 to 15 minutes (Taylor, Lillis, & LeMone, 2001) or as long as possible (Potter & Perry, 2001). In this study, subjects were asked to retain each enema for 10 minutes. Perhaps the loss of surface epithelium would be decreased by allowing subjects to defecate immediately or as soon as they feel a strong urge. Different concentrations or types of soap might also provide a strong defecation urge with less damage to the surface epithelium.

Why Did Tap Water's Effects on Surface Epithelium Vary So Much?

Although a majority of the biopsies (12 of 21) showed epithelium damage after water enemas, it is puzzling that nine biopsies showed little or no damage. One possibility is that the amount of stool present when the enema was given changed the enemas' effects. Sugimura et al. (1990) found that rats with feces retained in the rectum had greater injury from enemas.

The amount of stool in the rectum could be better controlled in future studies if certain precautions were taken. Variations in colon stool content could be decreased by including only subjects who have at least a daily bowel movement and by asking subjects to fast the night before. Subjects would be allowed clear liquids, which have no effect on stool content. Future studies could also examine the effects of individual physical characteristics on a person's response to different enema solutions.

Why Was There No Inflammation?

Even when surface epithelium was missing, biopsies showed no inflammatory changes. This is not surprising since biopsies were obtained within 30 minutes of the enema, and the inflammatory response occurs up to 3 hours after tissue injury (Saunders, Haggitt, Kimmey, & Silverstein, 1990). Waiting at least 3 hours after the enema before obtaining biopsies would provide better information about an enema's inflammatory effects.

How Much Discomfort Occurred?

Although the enemas were uncomfortable, the major types of discomfort (embarrassment, abdominal cramping and abdominal pain) are fairly common even without enemas. People in western culture often find defecation embarrassing, and normal bowel elimination is preceded by an uncomfortable abdominal or rectal sensation that is relieved by defecation. Abdominal cramping and abdominal pain are characteristics of the strong defecation urge that occurs with diarrhea or after the ingestion of large amounts of dietary fiber.

IMPLICATIONS FOR PRACTICE AND RECOMMENDATIONS FOR FURTHER STUDY

Further studies are needed before recommending any changes in nursing practice. Findings of surface epithelium loss after soapsuds and tap water enemas must be considered in context. Both enema solutions have been used for centuries and are commonly used today. Despite widespread enema use, reports of complications are rare. Both surface epithelium loss and discomfort are temporary.

Further investigation is also needed to determine the role of tonicity and irritants in stimulating defecation and damaging the colon's surface epithelium. We recommend using the current study's methodology, with the following modifications:

1. Use a repeated measures design to administer four different enema solutions to isolate the effects of a soap irritant and tonicity: (1) plain water, (2) plain water with soap, (3) isotonic solution, and (4) isotonic solution with soap.
2. Limit subjects to those who have at least a daily bowel movement to control effects of varying colonic transit time.
3. Limit intake to clear liquids for at least 8 hours before the enema to decrease the amount of stool in the colon.
4. Examine the colon using a flexible sigmoidoscope because it allows a more extensive examination and is more comfortable than proctoscopy.
5. Arrange for one skilled endoscopist to perform all flexible sigmoidoscopies and biopsies to decrease variability in measurements.
6. Obtain a second set of biopsies at least 3 hours after the enema to measure inflammatory effects of the enema solution.
7. Ask subjects to defecate immediately or within 5 minutes after the enema to decrease the amount of time the enema solution is in contact with the surface epithelium.
8. Isolate stool from the liquid in the enema returns to measure the contribution of stool to net output.

CONCLUSION

The study findings suggest that (1) enemas stimulate defecation by damaging the colon's surface epithelium and (2) hypotonicity contributes to the damage. In addition, PEG-ES is not recommended for enemas because it did not stimulate defecation. Further research is needed (1) to separate the osmotic and chemical effects of enemas because both could potentially account for surface epithelium destruction, (2) to explain the wide variations in epithelium loss after tap water enemas, and (3) to determine optimal retention time for enemas.

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