• *CLINICAL RESEARCH* •

Prospective randomized comparison of oral sodium phosphate and polyethylene glycol lavage for colonoscopy preparation

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Abstract

AIM: To compare the effectiveness, patient acceptability, and physical tolerability of two oral lavage solutions prior to colonoscopy in a Taiwanese population.

METHODS: Eighty consecutive patients were randomized to receive either standard 4 L of polyethylene glycol (PEG) or 90 mL of sodium phosphate (NaP) in a split regimen of two 45 mL doses separated by 12 h, prior to colonoscopic evaluation. The primary endpoint was the percent of subjects who had completed the preparation. Secondary endpoints included colonic cleansing evaluated with an overall assessment and segmental evaluation, the tolerance and acceptability assessed by a self-administered structured questionnaire, and a safety profile such as any unexpected adverse events, electrolyte tests, physical exams, vital signs, and body weights.

RESULTS: A significantly higher completion rate was found in the NaP group compared to the PEG group (84.2% *vs* 27.5%, *P*<0.001). The amount of fluid suctioned was significantly less in patients taking NaP *vs* PEG (50.13±54.8 cc *vs* 121.13±115.4 cc, *P*<0.001), even after controlling for completion of the oral solution (*P* = 0.031). The two groups showed a comparable overall assessment of bowel preparation with a rate of "good" or "excellent" in 78.9% of patients in the NaP group and 82.5% in PEG group (*P* = 0.778). Patients taking NaP tended to have significantly better colonic segmental cleansing relative to stool amount observed in the descending (94.7% *vs* 70%, *P* = 0.007) and transverse (94.6% *vs* 74.4%, *P* = 0.025) colon. Slightly more patients graded the taste of NaP as "good" or "very good" compared to the PEG patients (32.5% *vs* 12.5%; *P* = 0.059). Patients' willingness to take the same preparation in the future was 68.4% in the NaP compared to 75% in the PEG group (*P* = 0.617). There was a significant increase in serum sodium and a significant decrease in phosphate and chloride levels in NaP group on the day following the colonoscopy without any clinical sequelae. Prolonged (>24 h) hemodynamic changes were also observed in 20-35% subjects of either group.

CONCLUSION: Both bowel cleansing agents proved to be similar in safety and effectiveness, while NaP appeared to be more cost-effective. After identifying and excluding patients with potential risk factors, sodium phosphate should become an alternative preparation for patients undergoing elective colonoscopy in the Taiwanese population.

INTRODUCTION

Colonoscopy has become an essential procedure for the detection and treatment of colonic lesions; therefore, cleansing the bowel for adequate visualization of the colonic mucosa during colonoscopic examination is important. In the past two decades, various bowel preparation methods have been proposed including castor oil, anthroquinones, diphenylmethanes, phenolphthalein, and magnesium citrate, in combination with a low residue diet[1-5]. Along with these bowel-cleansing agents, cleansing enemas formed the "traditional" bowel preparation[6-10]. The introduction of polyethylene glycol (PEG) in 1980, an osmotically balanced solution, gradually replaced the

rigorous traditional 2 d preparation of enemas, a clear liquid diet, and laxatives in various combinations[11-15]. Although PEG provided safe and effective bowel cleansing, the patient was required to take 3-4 L of a salty tasting solution within a short period of time[16-19]. As reported, 5-15% of patients were unable to finish the prescribed dosage[8,16], potentially resulting in a poorly cleansed colon and inadequate colonoscopic assessment[17,19].

Oral sodium phosphate (NaP), a highly osmotic cathartic containing monobasic and dibasic sodium phosphate, was first evaluated by Vanner *et al*[19]. in 1990 by comparing it with PEG solutions. The mechanism of NaP is through the osmotic effect of phosphate. This draws large amounts of water into the bowel, creating a flushing action and a laxative effect within 30 min after ingestion and lasting an average of 2-3 h[19,20]. Several studies have been conducted to compare both NaP and PEG solutions, the majority of which have suggested a superiority or equivalence of NaP for adequate mechanical bowel preparation and safety[16-18,21,22]. Moreover, NaP was proven more cost-effective and has since been used worldwide[18,21,23]. With few studies being conducted in Singapore and Hong Kong[24-26], the effectiveness and safety of NaP for bowel preparation has not been prospectively assessed within the confines of a trial in the Taiwanese population. Due to the National Health Insurance (NHI) policy in Taiwan, only one bottle of magnesium citrate solution (MagVac, Pfizer Inc., USA) combined with six tablets of Bisacodyl (Durolax®, Boehringer-ingelheim GmbH, Ingelheim, Germany) are covered by NHI for bowel preparation; however, the results of bowel cleansing are often unsatisfactory. Other agents such as Klean Prep (Helsinn Birex Pharmaceuticals Ltd, UK), a PEG solution, and Fleet® Phospho-soda® (C.B. Fleet Company, Inc., Lynchburg, VA, USA), a NaP solution licensed after this trial, may be available at patients' own expense, if the hospitals carry such products. Most of the elective colonoscopic evaluations were performed at outpatient practice in Taiwan. Patients were scheduled for the examination on the day of consent, and bowel preparation agents were dispensed off on the same day along with both written and oral instructions. Patients were advised to start the preparation at home on the evening before the day of colonoscopy and only clear liquids were allowed after the procedure. The price of regular use of Klean Prep is NT\$800 (about US\$25) for four sachets (to be diluted to 4 L solution for use), while a 90 mL Fleet® Phospho-soda® costs NT\$380 (about US\$12). Since Fleet® Phospho-soda® had not been licensed by the Department of Health (DOH), Taiwan, until the results of this bridging study were available, and most of the doctors here do not have much experience with it, it becomes essential to provide effectiveness and safety data in this population along with cost-effective concerns. This study was undertaken to prospectively compare the effectiveness, patients' acceptability, and physical tolerability between the NaP and PEG in the Taiwanese population.

MATERIALS AND METHODS

Patients and methods

From August 2003 to December 2003, 80 consecutive patients who underwent elective colonoscopy were enrolled in this study. Eligible patients who had given written informed consent were randomized to receive either the standard 4 L of PEG (Klean Prep solution; Helsinn Birex Pharmaceuticals Ltd, UK) or 90 mL of NaP (Fleet® Phospho-soda®; C.B. Fleet Company, Inc., USA), in a split regimen of two 45 mL doses separated by 12 h, prior to the colonoscopic evaluation. Colonoscopy was scheduled after 8:00 a.m. for all the subjects, and study subjects were asked to report to the endoscopy room by 8:00 a.m. on the day of examination. Both groups were instructed to start the preparation around 6:00-7:00 p.m. the day before the colonoscopy. One sachet of Klean Prep should be diluted in 1 L of water (repeat for all four sachets) and one glassful (250 mL) of the solution would be taken every 10-15 min until the entire solution was consumed. The first 45 mL dose of Fleet® Phospho-soda® (diluted with a cold clear liquid or water by 1:16) was taken at 6:00-7:00 p.m. on the previous evening, and the second dose was taken at 6:00-7:00 a.m. on the day of the colonoscopy. A clear liquid diet was allowed during the bowel preparation. This study was approved by both the Health Department of Taiwan and the Institutional Review Board of ChangHua Christian Hospital, Taiwan. Exclusion criteria included symptomatic congestive heart failure, myocardial infarction, serum creatinine greater than 1.5 mg/dL, abnormal liver function defined as glutamic-oxaloacetic transaminase (GOT)/glutamic-pyruvic transaminase (GPT) greater than 120 U/L, ascites, electrolyte abnormalities, gastrointestinal obstruction, gastric retention, bowel perforation, obstructive or paralytic ileus, uncontrolled hypertension, unstable angina pectoris, pregnancy or breast feeding, and severe chronic constipation.

Demographic characteristics such as age, gender, prior bowel preparation experience, indication for colonoscopy, and medical history were obtained for all the patients. Laboratory assessment including blood urea nitrogen (BUN), GOT, GPT, sodium (Na), potassium (K), chloride (Cl), calcium (Ca), and phosphate (P), were done for all patients at baseline (the day of screening and consent, within 15 d prior to colonoscopy) and on the day following colonoscopy. In addition, a pregnancy test was performed on all the female patients and an electrocardiogram was performed on all the patients if no data were available within the prior 6 mo, during the initial screening visit. Body weight and routine vital signs, including pulse rate, blood pressure, and temperature were obtained at baseline, on the day of colonoscopy, and on the following day. Blood pressure and pulse rate were measured with the patient in both the supine (after resting for 5 min) and standing (after standing for 1 min) positions.

A self-administered structured questionnaire was completed by the patients to assess the tolerance, acceptability, and palatability of the bowel preparation

Table 1 Grades of bowel cleansing

Score	Stool amount	Stool consistency	Percent wall visualized	Overall assessment
0	None	None	≥90%	
1	Small	Clear lavage	75-89%	Excellent (small volume of clear liquid)
2	Moderate	Liquid stool	50-74%	Good (large volume of clear liquid)
3	Large	Particulate stool	≤49%	Fair (some semi-solid stool that could be suctioned or washed away)
4		Semi-solid stool		Poor (semi-solid stool that could not be suctioned or washed away)
5		Solid stool		

Table 2 Demographic characteristics and prior bowel preparation experience

Variables	NaP (n = 40)		PEG (n = 40)		P^1
	N	%	N	%	
Gender					0.178
Male	18	45.0	25	62.5	
Female	22	55.0	15	37.5	
Age					0.948
Mean±SD^2	52.2±13.6		52.4±12.6		
Median (range)	51.9 (25.6-75.6)		54.2 (23.1-77.3)		
Frame size					0.571
Small (BMI<21)	6	15.0	6	15.0	
Medium (BMI:21–24)	30	75.0	26	65.0	
Large (BMI>24)	4	10.0	8	20.0	
Concomitant edication	4	10.0	5	12.5	1.000
Anti-hypertensive	1	2.5	4	10.0	
Others	3	7.5	4	10.0	
Previous bowel preparation					1.000
	13	32.5	14	35.0	

[1]Fisher's exact test or 2-sample Student's t-test, when appropriate. [2]SD: standard deviation.

method. The taste of the oral solutions was graded as very poor, poor, fair, good, and excellent. The ease of taking or swallowing, convenience, and the entire preparation process were graded as very difficult, difficult, tolerable, easy, and very easy. The occurrence and severity of several adverse events commonly associated with bowel preparation, the percentage of the solution ingested, and willingness to repeat the assigned preparation in the future were also addressed in the questionnaire. Patients were instructed to complete and return the questionnaire prior to the colonoscopy.

A single surgeon who was blinded to the type of preparation performed all of the colonoscopies. The time to reach the cecum, the scope of insertion and removal time, the volume of fluid irrigated and suctioned, and the level of the colon reached were recorded. Colonic cleansing was evaluated as to the amount and consistency of stool and the estimated percentage of the bowel wall visualized at the level of the rectum, descending colon, transverse colon, ascending colon, and cecum, as well as the overall assessment rated by the colonoscopist and scored according to the scale shown in Table 1.

Table 3 Consumption rate of oral solution

Variables	NaP (n = 38)		PEG (n = 40)		P^1
	N	%	N	%	
Consumption rate (%)					
100%	32	84.2	11	27.5	<0.001
75-99%	6	15.8	15	37.5	
<75%	0	0	14	35.0	
Mean±SD^2	97.2±6.9		73.4±21.1		<0.001
Median (range)	100 (75–100)		75 (25–100)		

[1]Mantel–Haenszel χ^2 test and t-test when appropriate. [2]SD: standard deviation.

Statistical analysis

The Mantel-Haenszel χ^2 test and Fisher's exact test were used to compare the ordinal scores of the global and segmental assessment of bowel cleansing and patient index of experience, preference, and acceptability between the two groups. The Cochran-Mantel-Haenszel χ^2 was used to compare these categorical variables between the two groups, controlling for the completion of oral solution. General linear regression analysis was conducted by SAS Proc GLM procedure (SAS v.8.12, SAS Institute Inc., Cary, NC, USA) for the comparison of continuous variables between the two groups, controlling for the completion of oral solution. Changes from baseline of the laboratory tests and vital signs were analyzed across the treatment groups by the paired t-test. With a one-sided test, type I error rate of 0.05, power of 80% and a drop out rate of 7.5%, 40 patients for each group are needed to distinguish the difference of completion rate between a 62% for Klean Prep and 87% for Fleet® Phospho-soda® Solution.

RESULTS

Among the 80 patients who were prospectively randomized and completed the study, two NaP subjects were excluded from effectiveness analysis due to invalid laboratory tests at screening visit. The demographic characteristics and prior bowel preparation experience of all the 80 patients are summarized in Table 2. No significant differences in any of these variables were observed between the two groups. The major indications for colonoscopic evaluation were change in bowel habits (34/80; 42.5%), history of polyps (11/80; 13.8%), bleeding (11/80; 13.8%), family history of colorectal cancer (10/80; 12.5%), and cancer surveillance (9/80; 11.3%). There were four patients (three from NaP, and one from PEG group) in whom the cecum was not reached due to a surgical history of colorectal cancer. None of the baseline variables for the laboratory assessment/vital sign measurements were significantly different between the two groups. However, the NaP group had a significantly higher preparation completion rate than the PEG group (84.2% vs 27.5%, respectively; $P<0.001$) (Table 3).

Assessment of bowel cleansing

The amount of fluid suctioned was significantly less in patients taking NaP than those taking PEG (50.13±

Table 4 Overall assessment of preparation by the colonoscopist and stratified by completion of solution

Group	Excellent (%)	Good (%)	Fair (%)	Poor (%)	$\chi^2_{M\text{-}H}$ P	Good/excellent (%)	P
Overall							
NaP (*n* = 38)	22 (57.9)	8 (21.1)	8 (21.1)	0 (0.0)	0.648	30 (78.9)	0.778[1]
PEG (*n* = 40)	22 (55.0)	11 (27.5)	3 (7.5)	4 (10.0)		33 (82.5)	
Complete	100				0.584[2]		0.321[2]
NaP (*n* = 32)	19 (59.4)	7 (21.9)	6 (18.8)	0 (0.0)		26 (81.3)	
PEG (*n* = 11)	8 (72.7)	2 (18.2)	1 (9.1)	0 (0.0)		10 (90.9)	
Incomplete	0-99						
NaP (*n* = 6)	3 (50.0)	1 (16.7)	2 (33.3)	0 (0.0)		4 (66.7)	
PEG (*n* = 29)	14 (48.3)	9 (31.0)	2 (6.9)	4 (13.8)		23 (79.3)	

[1]Fisher's exact test. [2]Cochran-Mantel-Haenszel χ^2 test controlling for completion of oral solution.

Table 5 Colonic segmental assessment of preparation

	Stool amount (none/small) N (%)			Stool consistency (none/clear lavage) N (%)			% Colonic wall visualized (≥75%) N (%)		
	NaP (N = 38)	PEG (N = 40)	P	NaP (N = 38)	PEG (N = 40)	P	NaP (N = 38)	PEG (N = 40)	P
Rectum	37 (97.4)	33 (82.5)	0.057	31 (81.6)	32 (80.0)	1.000	37 (97.4)	37 (92.5)	0.616
Descending	36 (94.7)	28 (70.0)	0.007	32 (84.2)	33 (82.5)	1.000	38 (100)	35 (87.5)	0.055
Transverse[1]	35 (94.6)	29 (74.4)	0.025	31 (83.8)	34 (87.2)	0.752	37 (100)	37 (94.9)	0.494
Ascending[2]	35 (100)	35 (89.7)	0.117	24 (68.6)	31 (79.5)	0.302	35 (100)	38 (97.4)	1.000
Cecum[2]	35 (100)	35 (89.7)	0.117	23 (65.7)	31 (79.5)	0.202	35 (100)	37 (94.9)	0.495

[1]One patient in NaP group and 1 in PEG group did not have this data. [2]Three patients in NaP group and 1 in PEG group did not have this data.

54.8 cm^3 *vs* 121.13±115.4 cm^3, respectively; $P < 0.001$), even after controlling for the completion of oral solution ($P = 0.031$). The two groups showed a comparable overall assessment of bowel preparation with a grade of "good" or "excellent" in 78.9% in the NaP and 82.5% in the PEG group ($P = 0.778$) (Table 4). Patients taking NaP tended to have significantly better colonic segmental cleansing as assessed by the colonoscopist in the amount of stool observed in the descending ($P = 0.007$) and transverse ($P = 0.025$) colon, even after controlling for the completion of oral solution ($P = 0.006$ for descending and $P = 0.048$ for transverse colon). Twenty-two (57.9%) patients in the NaP group had the stool amount graded as "none" for the descending and 22 (59.5%) for the transverse colon, while only 11 (27.5%) and 16 (41%) patients in the PEG group had perfect visibility in the descending and transverse colon, respectively. Furthermore, more patients in the NaP group had a grade of "none" in terms of stool consistency and ≥90% of the colonic wall visualized throughout the entire colon, although this difference was not statistically significant. A slightly better grade in the rectum ($P = 0.057$) relative to stool amount and in the descending colon for percent of wall visualized ($P = 0.055$) was also observed in the NaP group (Table 5).

Patient acceptability and preference
When assessing for the taste of the bowel preparation, four patients disliked the NaP and did not wish to have this preparation again, while slightly more patients enjoyed the taste and rated it as "good" or "very good" compared to patients taking PEG (13/40, 32.5% *vs* 5/40, 12.5%,

respectively; $P = 0.059$). No differences were observed relative to ease of taking or swallowing, convenience, and ease of the entire preparation process, although slightly more patients in our study taking PEG rated these variables as "good/easy" or "very good/easy". When asked whether the patient would take the same preparation in the future, 26 (68.4%) in the NaP group and 30 (75%) in the PEG group replied "yes" ($P = 0.617$). Among the patients who had previous experience with bowel preparation, 8 (66.7%) of the 12 receiving NaP and 11 (78.6%) of the 14 receiving PEG would have the same preparation in the future ($P = 0.665$).

Adverse events
A total of 33 patients had 117 adverse events in the NaP group and 33 had 91 adverse events in the PEG group. These are summarized in Table 6. Although patients who received NaP had a slightly higher incidence than those who received PEG, no significant differences between the two groups were observed. One 32-year-old female patient in the NaP group who had a history of allergies to seafood was taking Lorazepan (Ativan, Wyeth, USA) for insomnia during the study period. Consequently, the patient experienced severe nausea, dizziness, and chills after taking the entire NaP solution. The patient's follow-up electrolytes were normal and all the symptoms subsided on the day following the colonoscopy.

Serum electrolyte changes
Comparison of baseline and post colonoscopy laboratory assessment revealed a significantly elevated Na, while Cl

Table 6 Occurrence and severity of anticipated adverse events

	NaP (n = 40)				PEG (n = 40)				P^2
	Mild	Moderate	Severe	Occurrence (%)[1]	Mild	Moderate	Severe	Occurrence (%)[1]	
Nausea	17	0	1	18 (45)	14	4	0	18 (45)	1.000
Vomiting	9	1	0	10 (25)	5	4	0	9 (22.5)	1.000
Abdominal bloating	16	2	0	18 (45)	12	0	0	12 (30)	0.248
Abdominal pain	14	1	1	16 (40)	11	0	0	11 (27.5)	0.344
Anal irritation	13	3	0	16 (40)	10	1	1	12 (30)	0.482
Dizziness	13	2	1	16 (40)	10	1	0	11 (27.5)	0.344
Chills	3	0	1	4 (10)	3	0	0	3 (7.5)	1.000
Hunger pains	7	0	0	7 (17.5)	7	0	0	7 (17.5)	1.000
Headache	6	1	0	7 (17.5)	6	0	0	6 (15)	1.000
Insomnia[3]	4	1	0	5 (12.8)	2	0	0	2 (5)	0.263
Total	11	4	117	11	80	10	1	91	

[1]Occurrence rate was calculated by "frequency of occurrence/total number of subject". [2]Fisher's exact test for occurrence frequency of adverse events. [3]One patient in NaP group was taking Lorazepan (Ativan, Wyeth, USA) for insomnia during the bowel preparation, therefore this event was not assessable for this patient.

Table 7 Electrolytes

	NaP (n = 40)			PEG (n = 40)			Overall			2-Sample
	Baseline	Follow-up	Change[1]	Baseline	Follow-up	Change[1]	Baseline	Follow-up	Change[1]	t-test
	Mean±SD[2]	Mean±SD[2]	Mean±SD[2]	Mean±SD[2]	Mean±SD[2]	Mean±SD[2]	Mean±SD[2]	Mean±SD[2]	Mean±SD[2]	P^3
Na (meq/L)	138.83±2.15	140.40±2.42	1.58±2.57[b]	138.85±2.15	140.88±2.37	2.03±1.83[b]	138.84±2.14	140.64±2.39	1.80±2.23[b]	0.370
K (meq/L)	3.99±0.34	3.86±0.39	-0.13±0.43	4.02±0.40	4.10±0.50	0.09±0.40	4.00±0.37	3.98±0.46	-0.02±0.43	0.022[a]
Cl (meq/L)	104.93±2.75	101.48±2.77	-3.45±2.84[b]	105.20±2.85	101.43±2.38	-3.78±2.71[b]	105.06±2.78	101.45±2.57	-3.61±2.76[b]	0.602
Ca (mg/dL)	9.17±0.35	9.17±0.39	-0.01±0.49	9.14±0.36	9.29±0.34	0.15±0.40[a]	9.16±0.35	9.23±0.37	0.07±0.46	0.129
P (mg/dL)	3.42±0.83	2.71±0.50	-0.71±0.76[b]	3.25±0.57	3.10±0.51	-0.16±0.57	3.34±0.71	2.90±0.54	-0.43±0.73[b]	<0.001[b]

[a]$P<0.05$; [b]$P<0.01$. [1]Change: value obtained at follow-up visit – value obtained at baseline visit. [2]SD: standard deviation. [3]The change from baseline (change) was compared between the two groups by independent 2-sample t-test.

Table 8 Hemodynamic profile

	Baseline		Day of colonoscopy change[1] from baseline		Follow-up visit change[1] from baseline	
	NaP	PEG	NaP	PEG	NaP	PEG
Pulse (beats/min) mean±SD[2]	76.4±11.2	72.9±12.4	5.4±13.6	6.7±12.6	1.7±10.9	0.6±13.0
Elevation in pulse rate ±10 beats/min (n %)			13 (32.5%)	13 (32.5%)	8 (20%)	9 (22.5%)
Elevation in pulse rate ±20 beats/min (n %)			5 (12.5%)	4 (10%)	3 (7.5%)	3 (7.5%)
SBP[3] (mmHg) mean±SD[2]	128.0±16.4	130.4±16.0	-6.8±12.5	-1.7±10.8	-4.3±10.7	-1.4±13.6
Drop in SBP ≥10 mmHg (n %)			13 (32.5%)	11 (27.5%)	14 (35%)	7 (17.5%)
Drop in SBP ≥20 mmHg (n %)			3 (7.5%)	0 (0.0%)	2 (5%)	4 (10%)

[1]Change: value obtained at the visit – value obtained at baseline visit. [2]SD: standard deviation. [3]SBP: systolic blood pressure.

and P were decreased in both groups ($P<0.001$; Table 7). The changes from baseline for both K and P were significantly different ($P<0.05$), while the changes of Na, Cl, and Ca were comparable between the two groups. Most of the laboratory values remained within the normal range and none of the patients complained of any discomfort during the follow-up period.

Hemodynamic profile and body weight
Hemodynamic profile is summarized in Table 8. Change from baseline in pulse rate (≥10 beats/min) and systolic blood pressure (SBP≥10 mmHg) were observed in 27.5-32.5% subjects from each group on the day of colonoscopy after the preparation, and were seen in 17.5-35% subjects on the day following the colonoscopic evaluation, though only <10% of the subjects had a change of >20 beats/min (mmHg) at the follow-up visit. Following the colonoscopy, after rest and resumption of a normal diet, most of the average values of vital signs, including body temperature, body weight, and pulse rate returned to baseline level except blood pressure (change from baseline of SBP for all subjects: -2.8±12.3, $P = 0.042$; diastolic BP: -3.5±7.9, $P<0.001$). None of these hemodynamic fluctuations were clinically significant

DISCUSSION

A "clean" colon is essential in colonoscopic examination for the early diagnosis of colonic neoplasia. A higher compliance rate for a bowel preparation agent will help to achieve this goal. In this study, 84% of the patients who received NaP completed the entire bowel preparation regimen compared with only 27.5% of the PEG group (*P*<0.001). All four patients in the PEG group who reported a "poor" grade for overall assessment were associated with poor compliance. Consistently more patients in the NaP group had perfect cleanliness in terms of the stool amount, stool consistency, and percent of colonic wall visualized in the majority of the colonic segments compared to those patients in the PEG group. In our study, although significantly better performance was found in some of the colonic segmental evaluations, NaP did not demonstrate a dramatic superiority over PEG in terms of the overall assessment. Our results differ from those of previous studies that have reported a 10-40% difference in favor of NaP[16,17,19,21,22]. In addition to these studies, two Asian studies conducted in Singapore and Hong Kong[24,25] also indicated a significantly higher proportion of patients reporting good or excellent grades with the NaP compared to the PEG solutions (22% and 20% difference, respectively for each study; *P*<0.05). However, this study did not demonstrate any statistically significant difference between patients receiving PEG who were graded as "good" or "excellent" in terms of overall assessment by the physician, compared to those who took NaP (82.5% *vs* 78.9%, respectively; *P* = 0.78). Although some of the studies used less amount, *i.e.*, 3 or 2 L, instead of 4 L for PEG preparation[18,27-29], most of the trials adopted a standard amount of 4 L recommended by the manufacturer for a better cleansing result. The Hintertux study group even demonstrated that the 4 L PEG group was significantly superior to the 3 L PEG group[28]. However, a remarkably low completion rate of PEG solution (27.5%) was observed in this study. Using 75% as the cut-off for the completion rate, *i.e.*, 3 L of PEG solution, there were still 14 (35%) subjects who failed to complete the PEG preparation in this study, which indicated a cultural difference in terms of the practice of bowel preparation. Instead of getting admitted to the hospital the day prior to the colonoscopic evaluation as did in some other trials[19,30], all of our subjects initiated the preparation at home without assistance. With the large amount (4 L) of the solution, some subjects tended to stop drinking PEG when they felt that they were already clean. Others stated that they were afraid of having the needs to go to the restroom on a bus or a train to the hospital and therefore stopped taking the rest of the solution after going to bed in the night before the colonoscopy. This kind of stress and inconvenience are less likely to happen to inpatients, subjects who have their own vehicles or those who live close to the hospital. Contrary to the results reported by Cohen *et al*[17]. in which significantly more fluid was suctioned from the colon after NaP, while more irrigation was necessary to cleanse the bowel after PEG, our data show that significantly more fluid was suctioned in patients who took PEG than those taking NaP, while the amount of irrigation did not differ between the two groups. More fluid in the colon may result in missed colonic lesions or tumors while the use of suction may cause more mucosal injury.

There were four patients who disliked the NaP and did not wish to have this preparation again. The same situation was mentioned by some studies[22,24,31], although some patients reported discomfort with the NaP solution due to its salty and unpalatable taste, still found it easier to complete than the PEG solution due to the smaller volumes. Although the 4 L required for the PEG solution is much greater than that required for NaP, none of the patients in the PEG group complained about taking or swallowing the large amount of solution. Furthermore, none of them rated the convenience of taking or ease of the entire preparation as "very poor", though the completion rate was also much lower than expected. In contrast to most of the other studies, slightly more patients in our study taking PEG rated the ease of taking or swallowing, convenience of taking, and ease of the preparation as "good/easy" or "very good/easy", and answered "yes" to the question "would you take the same preparation in the future" compared with the NaP group, although these differences were not statistically significant. The majority of our patient population lived in rural areas and tended to unquestionably follow physician's instructions more than their urban counterparts, which may explain the high satisfaction rates with the PEG preparation.

The patients in our study reported a consistently higher incidence of several anticipated adverse events than cited by other studies[17,18,24,25], although there was no significant difference between the two groups. Nevertheless, the NaP group had a slightly higher overall occurrence of these symptoms than did the PEG group. The majority of the adverse events were graded as mild-to-moderate and had subsided by the day following the colonoscopy. One patient in the NaP group who suffered from severe nausea, dizziness, and chills was taking Lorazepan (Ativan, Wyeth, USA) for insomnia during the bowel preparation. This observation might be just a coincidence or a result from multiple factors, *i.e.*, the concomitant use of NaP and Lorazepan along with the patient's history of allergy, which will need further investigations. A transient hypophosphatemia was observed in the NaP group the day following the colonoscopy, compared to baseline. Hyperphosphatemia is a recognized consequence of sodium phosphate. According to the reports by Kolts *et al*[22]. and Huynh *et al*[30]. serum phosphate rose significantly 2 h after NaP consumption, but subsequently returned to normal within 26 h. Since the preparation was done at the subjects' residence, instead of continuous monitoring the electrolytes during the preparation, only the value on the day after the colonoscopy was obtained to compare the baseline level, and therefore we failed to observe the elevation phase of serum phosphate but observed only the decrease phase at more than 24 h after the preparation. The same pattern was also observed by Vanner *et al*[19]. in which serum phosphate of seven patients in NaP group elevated from 3.7±0.2 mg/dL on the day of admission to 7.2±0.6 mg/dL at 8:00 a.m. on the

day of colonoscopy, then dropped to 3.7±0.3 mg/dL at 4:00 p.m. in the evening and to 3.1±0.3 mg/dL at 8:00 a.m. on the following day. Consistent with known effect of oral sodium phosphate solution, serum sodium levels remained higher and potassium levels were lower than baseline on the day following the colonoscopy. Although different from baseline, most of the values were still within normal ranges and none of the subjects developed any clinically relevant adverse events that accompanied these metabolic changes after the cessation of the preparation.

Contraindications to the use of NaP have been emphasized, and serious electrolyte disturbances have been reported in individual patients taking oral sodium phosphate[20,32,33]. Some studies have indicated that NaP should not be used in women who are pregnant or breast-feeding, or patients with renal failure, congestive heart failure, ascites, or congenital megacolon[34,35]. Furthermore, hypokalemia resulting from the ingestion of NaP can increase the risk of cardiac arrhythmias in patients who are taking diuretics or digitalis[30,36]. The proportion of subjects (27.5-32.5%) with a hemodynamic change greater than 10 beats/min in pulse rate or 10 mmHg in systolic blood pressure on the morning of colonoscopy compared to baseline levels are slightly higher than reported studies, i.e., 14-28% of oral sodium phosphate solution recipients with decreases in SBP >1.33 Kpa and 15-30% with changes in postural pulse ≥10 beats/min from baseline[19,30,34]. Without taking any solid food since the previous afternoon, suffering from the preparation process and insufficient sleep, along with an early commute to the hospital (some had a commute longer than 30 min), most of the subjects appeared weak on arrival at the endoscopic station. It might explain why the outpatient subjects had a larger hemodynamic change on the day of colonoscopy compared with those who were admitted to the hospital on the previous day[19]. One study reported that 12% NaP patients had changes in SBP>20 mmHg[34], which was higher than what we observed (7.5%). Hemodynamic changes suggest that intravascular volume decreases during the bowel preparation, and it is considered to be transient unless contraindications are encountered. Patients in both the groups were instructed to take adequate amounts of fluid during the preparation, therefore, no significant body weight changes were observed in either group.

CONCLUSION

Both bowel cleansing agents were found to be equally safe and effective for bowel preparation prior to colonoscopy. Although NaP was more effective in some of the colonic segmental cleansing, both solutions were found to be equally acceptable and had the same overall assessment. However, the high completion rate related to NaP may prevent inadequate bowel preparation and facilitate colonoscopic evaluation. Taking its more affordable price into consideration (about half price of PEG), NaP demonstrates its cost effectiveness. Severe adverse events were observed in only one patient who was taking medication for insomnia during the NaP preparation, which implies that caution should be taken relative to concomitant medications. Although not clinically significant, some hemodynamic and electrolyte changes were prolonged more than 24 h. After identifying and excluding patients with potential risk factors, NaP should become an alternative bowel preparation for patients undergoing colonoscopy in the Taiwanese population.

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