



## Use of Polyethylene Glycol in Whole Bowel Irrigation and Comparing of Systemic Effects with Lactated Ringer's Solution

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### Abstract

**Aim:** Whole Bowel Irrigation (WBI) has been used for many different purposes, especially in before large bowel surgery and colonoscopy. Some studies have reported that the lactated Ringer's (RL) solution has choleric effect and the Polyethylene Glycol (PEG) solution may produce liver necrosis. The aim of this study is to show the systemic effects of PEG in WBI and comparing with RL solution to determine the most reliable one.

**Methods:** Forty patients who underwent WBI with PEG and RL were studied. Vital signs, electrolyte levels, liver function, hemorrhage parameters and blood table were checked before and after the procedure. Vomiting and unrest complaints were noted to tolerance reagent. The amount of solution, the duration and the efficacy of the procedure were identified.

**Results:** WBI completed at the same time in PEG and RL group under-7 years old children. Patients used PEG were found to be better for patient compliance in 7 years old and over group, and time was decreased to 4 hours. The amount of solution was  $3.2 \pm 0.11$  / L in PEG and  $8.4 \pm 0.02$  / L in RL, significant difference ( $p < 0.05$ ). RL solution caused to be increased Na and Cl blood level ( $p < 0.05$ ) and PEG solution caused to be decreased K blood level ( $p < 0.05$ ). For liver functional test there were no significantly differences between PEG and RL solutions.

**Conclusion:** Evaluating for tolerance, used amount and liver influence, PEG is more preferable solution compared with RL especially for 7 years old and over children.

**Keywords:** Whole bowel irrigation; Polyethylene glycol; Ringer lactate

### Introduction

When the whole bowel irrigation is used for the first time, its actual purpose is to prevent the complications that may occur due to the infections that may form after colectomy with mechanical intestinal cleansing [1]. However, today, its field of use has expanded greatly; for example, it is also used for the purpose of diagnosis and treatment in the evaluation of the absorption of elements, DNA screening with samples taken from WBI fluids, heavy metal poisoning, drug intoxication, etc [2-5]. Researchers have been interested in ensuring adequate bowel cleansing. For this purpose, it was aimed to develop the method by finding the solutions that are the easiest, the most reliable, the shortest, have the least side effects and can be tolerated by the patient [6,7]. Therefore, the method is developed by using different solutions. In one study, abundant bile duct contents were observed in cases with WBI with Ringer Lactate (RL) solution, and it was thought that this may be due to choleric effect [6]. In an experimental study on rats, WBI was performed with Polyethylene Glycol (PEG) and histopathological examination revealed liver necrosis and infarction [8]. In light of this information, in cases made with PEG with WBI, we aimed to determine the most reliable solution by displaying the effects of the relevant solution on the application period, biological data, electrolytes, blood table, liver function and comparing it with the RL solution, and to compare it with the recently used methods.

### Materials and Methods

In this study, WBI was performed preoperatively with PEG in 20 patients who were admitted to our pediatric surgery department with the plan of colorectal surgery or colonoscopy. For comparison, 20 cases in which WBI is made with RL were evaluated and the second group was

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**Table 1:** Ottawa Colon Preparation score scale.

Score	Description
0	No fluid, empty
1	Clean colon even without aspiration
2	Clean colon with aspiration
3	Clean colon both with irrigation and aspiration
4	The presence of solid feces

formed. A total of 40 cases were included in the study. The study was conducted in accordance with the Helsinki Declaration Principles and "informed consent" was obtained from the cases that participated in the study.

Two methods used for mechanical cleansing were recorded, taking vomiting and restlessness into consideration in order to determine case tolerance. Body Weight (BW) before and after the procedure, Hour (h), Respiratory Rate (RR), Pulse (P) and Blood Pressure (BP) measurements were performed to evaluate vital signs during the procedure. The levels of Na and K, Cl and Ca before and after the operation were checked to determine the effect of the solutions on the electrolyte levels, as it was stated in the investigations that the solutions cause Na and water loss. Total Protein (Tpro), Albumin (Alb), AST, ALT and GGT levels were also checked before and after the procedure to investigate the effects on liver function. For this, a blood sample was taken to 2 ml of the flat tube. To determine the effect of the solution on hemorrhage parameters, aPTT, pTINR pre-and post-procedure 3 ml blood was taken to the 9NC tube. In order to determine its effects on hematological values; 1 ml blood was taken to Sodium Ethylenediamine Tetra Acetic Acid (EDTA) tube for the control of Hemoglobin (Hb), White Blood Cell (WB), Hematocrit (Hct), Trombosit (Plt) levels.

The PEG solution used in WBI contains 125 mEq/L Na, 35 mEq/L Cl, 10 mEq/LK, 20 mEq/L bicarbonate (HCO<sub>3</sub>) and 80 mmol/L PEG. The osmolarity is 263 mOsm/kg. RL solution contains 130 mEq/L Na, 109 mEq/LCl, 4 mEq/LK, 3 mEq/L Ca, 28 mEq/L lactate. The osmolarity is 254 mOsm/kg.

## The Implementation of the Solution

25 to 30 ml/kg PEG solution was orally administered to twenty patients under nursing supervision. Based on the patient's adaptation, Nasogastric (NG) catheter was administered to the cases who have restlessness, vomiting and unwillingness to drink the solution and they were given 150 ml to 200 ml of solution in 15 minutes (min) of intervals. When the contents of the intestines were clean, the process was terminated. The process time and the amount of solution used were noted. The patient's compliance period has been added to the duration of the procedure. Metoclopramide HCl 0.1 mg/kg was administered to 20 patients 30 minutes before the procedure who underwent WBI with RL solution. The NG probe was attached. Bowel irrigation was performed with 90 ml/kg/s RL. When the bowel contents were clean, the process was terminated, and the amount of the used solution was determined and recorded.

The efficacy of the solutions used was assessed visually during the course of the bowel cleansing according to the Ottawa colon preparation score (Table 1) [9]. No protective antibiotics were used during the procedure. The cases were given preoperative Sulbactam-ampicillin, Netilmicin and Metronidazole intravenously, and continued during the postoperative treatment.

**Table 2:** Diagnosis and indication distribution of WBI treated cases.

Diagnosis	Indication	n(%)	PEG	RL
Rectal bleeding	Colonoscopy	11(27.2%)	7	4
Anorectal malformation	Perineoplasty	3 (7.5%)	1	2
Male pseudohermaphroditism	Vaginoplasty	3 (7.5%)	2	1
Congenital megacolon	Colostomy closure	8(20%)	3	5
Anorectal malformation	Colostomy closure	5(12.5%)	2	3
Anterior ectopic anus	ASARP	2(5%)	1	1
Posttraumatic urethral rupture	Repair of urethra	2(5%)	2	-
Rectum carcinoma	Mass Excision	2(5%)	2	-
Extrophivesicalis	Bladder augmentation	1(2.5%)	-	1
Intestinal obstruction	Colostomy closure	1(2.5%)	-	1
Esophagus Stricture	Colon Interposition	2(5%)	-	2
<b>Total</b>		<b>40(100%)</b>	<b>20</b>	<b>20</b>

## Statistical Evaluations

In our study, the statistical evaluation of the findings was performed with T-test (parametric test), paired test, unpaired test, One-sample Kolmogrov-Smirnov test (one-way test), Independent sample test (normal distribution fit test between independent groups), Chi-Square Test. When  $p < 0.05$ , the data were considered significant.

## Results

Twenty patients who underwent WBI were treated with PEG and 20 patients with RL. 16 (40%) of the 40 cases who were included in the study were female and 24 of them (60%) were male. Their age distributions were between 4-14 years ( $11.07 \pm 5.6$  y) for those who got WBI with PEG, and those who got WBI with RL were between 2-18 years ( $10.08 \pm 25.2$  y).

Diagnosis and indication distribution of cases; 11 cases (27.5%) to investigate the etiology of rectal hemorrhage planned to undergo colonoscopy, 3(7.5%) cases with diagnosis of opere anorectal malformation planned to perineoplasty, 3 cases (7.5%) with diagnosis of opere male pseudohermaphroditis planned for vaginoplasty, 8(20%) cases diagnosed with opere congenital megacolon planned to close the colostomy, 5 cases (12,5%) diagnosed with rectal anorectal malformation planned for colostomy, 2(5%) cases diagnosed with anterior ectopic anus for planned Anterior Sagittal Anorectoplasty (ASARP), 2(5%) cases diagnosed with rectal cancer planned for mass excision, 2(5%) cases diagnosed with posttraumatic urethral rupture planned for repair of the urethra, 1 case (2.5%) diagnosed with opereextroflexvesica planned for bladder augmentation, 1(2.5%) case diagnosed with opere intestinal obstruction planned to close colostomy, 2(5%) cases with diagnosis of developed stricture after corrosive substance ingestion in esophagus planned for colonic interposition (Table 2).

Body weight, BP, P and RR (Table 3) were measured before and after the procedure and evaluated in cases which are applied WBI with RL and PEG and no statistically significant difference was found. The mean values and standard deviations of serum electrolytes before and after treatment are given in Table 3. A statistically significant increase was found in the levels of Na ( $z=1.73$ ,  $p=0.01$ ;  $p < 0.05$ ) and Cl ( $z=1.67$ ,  $p=0.005$ ,  $p < 0.05$ ) when the changes at the level of electrolyte were statistically evaluated, and no significant change was detected in the level of K. In the cases that are made WBI with PEG solution, there was no significant increase in Na and Cl levels, but a significant

**Table 3:** Statistical evaluation of the cases that are applied WBI with PEG and RL.

	Mean (St. Deviation)				P<0.05	
	PEG		RL		PEG	RL
	Before	After	Before	After		
<b>BW (kg)</b>	33.0 ± 16.4	33.1 ± 16.2	26.4 ± 15.1	27.1 ± 15.7	-	-
<b>BP Systolic (mmHg)</b>	105.5 ± 6.6	106 ± 8.8	103.5 ± 9.8	107.7 ± 8.3	-	-
<b>BP Diastolic (mmHg)</b>	66.5 ± 6.7	68.5 ± 5.6	68 ± 6.1	66.2 ± 8.7	-	-
<b>P (min)</b>	103.6 ± 19.5	99.0 ± 18.5	106.4 ± 21.2	108.5 ± 15.5	-	-
<b>RR(min)</b>	24.6 ± 2.9	25.7 ± 2.9	25.6 ± 1.7	25.6 ± 2.4	-	-
<b>NA (mEq/L)</b>	140.1 ± 3.2	140.6 ± 3.6	139.9 ± 3.1	142.1 ± 3.4	-	<b>P = 0.01</b>
<b>K (mEq/L)</b>	4.2 ± 0.4	3.7 ± 0.5	4.2 ± 0.4	3.9 ± 0.5	<b>P = 0.02</b>	-
<b>Cl (mEq / L)</b>	108.3 ± 4.1	107.5 ± 3.9	106 ± 3.4	108.6 ± 3.8	-	<b>P =0.005</b>
<b>Ca (mEq/L)</b>	9.7 ± 0.4	9.1 ± 0.5	9.8 ± 0.5	9.3 ± 0.6	-	-
<b>ALT (IU/L)</b>	17.0 ± 7.6	14.3 ± 6.3	16.1 ± 6.6	16.2 ± 7.0	-	-
<b>AST (IU/L)</b>	29.8 ± 10.1	27.8 ± 7	28.5 ± 5.7	28 ± 7.2	-	-
<b>GGT (IU/L)</b>	11.7 ± 4.5	10.8 ± 4.4	12.9 ± 5.3	11 ± 4.6	-	<b>p=0.007</b>
<b>ALP (IU/L)</b>	332.2 ± 119.2	288.7 ± 145.9	437.7 ± 190.3	360.2 ± 146.5	-	-
<b>Alb (%gr)</b>	4.4 ± 0.3	4.0 ± 0.3	4.3 ± 0.3	3.7 ± 0.3	-	-
<b>T.Prot(%gr)</b>	7.2 ± 0.8	6.4 ± 0.6	7.0 ± 1.4	6.1 ± 0.6	-	<b>p=0.001</b>
<b>Hb (%gr)</b>	12.0 ± 1.0	12.7 ± 1.4	11.6 ± 1.2	11.1 ± 1.2	-	-
<b>Htc (%)</b>	35.4 ± 2.5	34.8 ± 3.3	34.8 ± 3.2	33.49 ± 4.1	-	-
<b>Plt (mm<sup>3</sup>)</b>	337.9 ± 96.6	334.4 ± 87.1	339.2 ± 125.7	308.7 ± 87.6	-	-
<b>WB (mm<sup>3</sup>)</b>	8.5 ± 3.0	8.8 ± 4.8	9.0 ± 5.6	9.8 ± 5.2	-	-
<b>aPTT (min)</b>	28.0 ± 3.7	28.5 ± 4.2	30.0 ± 3.8	29.7 ± 1.5	-	-

decrease was found in the level of K ( $z=1.69$ ,  $p=0.02$ ,  $p>0.05$ ).

To assess the effect of the cases on liver function, blood levels of AST, ALT, GGT, ALP, Tpro and Alb were measured before and after the procedure. The effect of PEG and RL solutions on liver function was compared (Table 3). Whereas PEG solution was found to have no significant effect on liver function, it was seen that the RL solution caused a decrease in GGT ( $z=1.68$ ,  $p=0.007$ ;  $p<0.05$ ) and Tpro levels ( $z=2.21$ ,  $p=0.001$ ;  $p<0.05$ ).

Hb, Htc, WB, Plt, aPTT and pTINR levels were measured (Table 3) to determine the effect of PEG and RL solutions on blood and hemorrhage parameters, it was found that there was no significant effect on the statistical evaluation.

In 20 cases that are made WBI with PEG, the treatment time was 4-11h ( $9.02 \pm 2.89$ h) and the amount of solution used was  $3.2 \pm 0.11$ L. Especially in 11 cases (55%) in the 4-7 age groups, the dissatisfaction with the taste of the solution caused the prolongation of the duration of the resistance to drink. In these cases, PEG solution was applied by attaching NG probe. It was seen that the cases of 7 years and above ( $n=9$ , 45%) were better adapted to the procedure and the duration of the procedure shortened to 4 hours. We detected vomiting in 5(25%) cases and restlessness in 10(50%) cases. In 20 cases made WBI with RL, the treatment time was 6-10s ( $8.40 \pm 1.87$ s) and the amount of solution used was  $8.4 \pm 0.08$ L. All cases of RL were given NG probe. We observed vomiting in four of these cases (20%) and restlessness in 14(70%) cases. PEG and RL solutions were statistically compared with respect to the duration of the treatment, no significant difference was observed. PEG solution was evaluated by adding the compliance time of the cases to the process time of the cases. It was determined

**Table 4:** Evaluation of WBI process.

	PEG (n)	RL (n)	Statistic Evaluations
<b>Score</b>			
<b>1</b>	14	16	NS*
<b>2</b>	2	2	NS*
<b>3</b>	2	2	NS*
<b>4</b>	2	-	NS*
<b>Success</b>	18	20	<b>p&gt;0.05</b>
<b>The given quantity (L)</b>	$3.2 \pm 0.1$	$8.4 \pm 0.1$	<b>P&lt;0.05</b>

NS \*: There is no statistically significant difference

that there was a significant difference in terms of the amount of solution used ( $p=0.009$ ;  $p<0.05$ ). When vomiting, restlessness, patient compliance and the amount of solution used were evaluated, it was determined that the PEG solution was more acceptable by the cases.

The intestinal cleansing of the cases which are applied WBI with PEG and RL were evaluated visually during the operation. In 2 cases (10%) that were applied WBI with PEG, bowel cleansing score was given 4 and colonoscopy was canceled. In 2 cases (10%), colon cleansing score was detected as 3, and the surgery was continued. In 2 cases (10%) that were applied WBI with RL, colon cleansing score was accepted as 3, and the surgery was continued. There was no statistically significant difference between the two solutions in terms of visual sufficiency of intestinal cleaning (Table 4).

No protective antibiotics were used during WBI. The cases were given preoperative Sulbactam-ampicillin, Netilmicin and Metronidazole intravenously, and continued during the postoperative

treatment. During the treatment, enterocolitis findings were not observed in the cases and they were discharged upon healing.

## Discussion

WBI that was first identified and used in 1973 has been in a short time a common method used especially before colorectal surgery and colonoscopy [10]. It is well known that inadequate bowel cleansing increases anastomotic leaks, wound infection and postoperative sepsis [1,10]. For this reason, a new solution has been described by Davis et al. [11] PEG is an iso-osmolar solution that is used orally, not absorbed by the intestine, and does not cause water and salt loss. In clinical trials, it has been stated that the cases adapt well to this new solution [1,8]. Although WBI is not widely used in young children, it has been shown to be safe and effective in children 10 years of age and above [12,13]. The reason that WBI is not recommended in children is vomiting, colicky pain and increased distension experienced during the procedure [12,13].

In our study, the duration of treatment was detected as 4-11h ( $9.02 \pm 2.89$  h) in cases that are applied WBI with PEG. Particularly in the 4-7 years age group (n=11; 55%), the adaptation problem in children and distaste of the solution caused prolonged drinking time. In these cases, the solution was applied by attaching NG probe. It was seen that the cases of 7 years and above (n=9, 45%) were better adapted to the procedure and the duration of the procedure shortened to 4 hr. Vomiting was observed in 5 cases (25%), uneasiness was observed in 10 cases (50%), there was no colic pain and no increased distension. In the cases that are made WBI with RL, the duration of the procedure was 7 hr to 9 hr ( $8.40 \pm 1.87$  h), vomiting was observed in 4 patients (20%) and unrest was observed in 14 patients (70%). When we compared the WBI application with respect to PEG and RL solutions, PEG was thought to be a preferable solution, especially in children in the age of 7 and above since there is no need to attach NG probe, patient adaptation is good, and there are no additional complications other than vomiting and restlessness in those children.

Studies show that the salt-based electrolyte solutions provide rapid bowel cleansing [7,14]. However, the amount of solution required is 7 L to 10 L, and there is a need for NG tube insertion, and it must be implemented by a nurse and requires close monitoring [14]. The most important effect is that it is rapidly absorbed and causes intravascular volume increase. Therefore, it is not used in cases of heart and kidney failure [14,16]. In our study, intestinal cleansing was performed with an average of  $3.2 \pm 0.11$  L PEG solution. There was no statistically significant difference in the pre- and post-procedure BW scores of the cases. There was no any complication in BP, P, and RR. In cases that are made WBI with RL solution, the average solution used was  $8.4 \pm 0.08$ L. There was no statistically significant difference in the pre- and post-procedure BW of the cases. When the amount of PEG and RL solutions were compared, the amount of PEG solution used was found to be less ( $p=0.04$ ,  $p>0.05$ ). It was in accordance with the findings in the literature that the PEG solution did not cause an increase in BW and the amount of solution used was low.

The salt in the PEG solution described by Davis et al. [11] is mainly formed by sodium sulfate and PEG is not absorbed by the intestines, thereby it is an iso-osmolar solution which does not cause any water or salt loss. However, when WBI is done with a salt solution, Na is absorbed, Cl and K are lost into the intestine [11,14]. In our study, while a significant increase in cases that are applied WBI with RL was detected in Na and Cl levels ( $p=0.01$ ,  $p=0.005$ ,  $p<0.05$ ), no significant

change was found in the level of K. This result was found compatible with published studies. In the cases that are made WBI with PEG solution, there was no significant increase in Na and Cl levels, but a significant decrease was found in the level of K ( $p=0.02$ ,  $p>0.05$ ). It was seen that PEG did not cause Na and Cl absorption but caused K to be lost into the intestine. It has been reported in the literature that due to the hydrophilic and lipophilic properties of polyethylene glycol, a little amount of water shows-up as Na and Cl are being absorbed, resulting in the loss of K into the intestine in order to achieve osmotic equilibrium [11-13]. The change in potassium level did not cause an unwanted complication in 20 cases.

In the study, abundant bile duct contents were detected in the intestinal lumen of patients that were applied WBI with RL solution, and it was considered that there might be the cholesteric effect of RL solution [6,8]. In a study on rats, WBI was also performed using different solutions and it was thought that WBI treatment itself, without regard to solution variability, directly increase the bile secretion. In addition, liver necrosis was observed in the group used PEG [8]. In our study, RL solution was found to cause a significant increase in plasma GGT levels ( $p=0.007$ ;  $p<0.05$ ). This result was thought to be due to the cholesteric effect of the RL solution, whereas it was determined that the PEG solution did not have a significant effect on liver function. It was thought that liver necrosis and infection in the experimental study may be coincidental or may be due to another cause other than PEG.

In studies, PEG solution was described as a solution that did not cause water and salt loss, while aspiration of NG and PEG infusion in children was reported [17]. It was noted that the bronchoalveolar lavage and steroid administration are effective in the treatment of PEG aspiration [17,18]. Dehydration and alkalosis were seen in cases that were applied WBI with salt solution and an increase in the number of inflammatory cells was detected in the colon mucosa. For this reason, the use of erythromycin and neomycin in cases was proposed [19-21]. In our study, aspiration and enterocolitis findings were not observed in cases that were made WBI with PEG and RL solutions. Prophylactic antibiotics were not used during the procedure. The cases were given preoperative Sulbactam-ampicillin, Netilmicin and Metronidazole intravenously, and continued during the postoperative treatment, and they were discharged with recovery.

According to the previous studies, PEG solution is more effective and reliable among the solutions used in WBI [1,711]. In our study, the operation was canceled because 2 of the 20 patients (10%) had 4 scores of intestinal cleanliness. In two cases (10%), the intestinal cleansing score was found to be 3, and the level was found adequate for the operation. There was no statistically significant difference in terms of bowel cleansing when compared with RL solution. Our results were parallel to the information in the literature.

The use of WBI has expanded especially in diagnosis and treatment. Especially in chronic inflammatory bowel diseases and colon cancers, DNA studies from lavage fluid samples taken after WBI have been increased [3,15,22-24]. For the purpose of treatment, its use in heavy metal intoxications and acute encephalopathy has become widespread [5,24,25]. PEG solution in WBI remains a preferred solution in the literature and research continues to reduce the amount of solution used [26-28].

## Conclusion

In the WBI procedure, the PEG solution did not appear to have

a significant effect on liver function, suggesting that hepatic necrosis and infactancy are coincidental or may be due to the causes other than PEG. PEG solution is considered to be preferred because 7-year-old and the older group have better compatibility of the cases and the amount of solution used is less.

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