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Position Paper: Whole Bowel Irrigation[#]

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ABSTRACT

Whole bowel irrigation (WBI) should not be used routinely in the management of the poisoned patient. Although some volunteer studies have shown substantial decreases in the bioavailability of ingested drugs, no controlled clinical trials have been performed and there is no conclusive evidence that WBI improves the outcome of the poisoned patient. Based on volunteer studies, WBI should be considered for potentially toxic ingestions of sustained-release or enteric-coated drugs particularly for those patients presenting greater than two hours after drug ingestion. WBI should be considered for patients who have ingested substantial amounts of iron as the morbidity is high and there is a lack of other options for gastrointestinal decontamination. The use of WBI for the removal of ingested packets of illicit drugs is also a potential indication. WBI is contraindicated in patients with bowel obstruction, perforation, ileus, and in patients with hemodynamic instability or compromised unprotected airways. WBI should be used cautiously in debilitated patients or in patients with medical conditions that may be further compromised by its use. The concurrent administration of activated charcoal and WBI may decrease the effectiveness of the charcoal. The clinical relevance of this interaction is uncertain. A review of the literature since the preparation of the 1997 Whole Bowel Irrigation Position Statement revealed no new evidence that would require a revision of the conclusions of the Statement.

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SUMMARY STATEMENT

Introduction

- Overall the mortality from acute poisoning is less than one percent. The challenge for clinicians managing poisoned patients is to identify promptly those who are most at risk for developing serious complications and who might potentially benefit, therefore, from gastrointestinal decontamination.

Rationale

- Whole bowel irrigation (WBI) cleanses the bowel by the enteral administration of large amounts of an osmotically balanced polyethylene glycol electrolyte solution (PEG-ES) which induces a liquid stool.
- WBI has the potential to reduce drug absorption by decontaminating the entire gastrointestinal tract by physically expelling intraluminal contents (1).
- The concentration of polyethylene glycol and electrolytes in PEG-ES causes no net absorption or secretion of ions, so no significant changes in water or electrolyte balance occur (2).

In Vitro Studies

- In vitro studies demonstrate that activated charcoal does not produce a significant alteration in the osmolality of WBI solution (3).
- PEG-ES may reduce the binding capacity of charcoal (3–6).
- However, in two other studies (7,8), the binding of drug (mexiletine, imipramine) to charcoal was greater in WBI solution than in a slurry of charcoal.

Animal Studies

- Two animal studies have been performed in dogs (9,10).
- One study demonstrated a benefit from WBI. The mean total body clearance of paraquat was increased ($p<0.05$) from 5.67 L/h to 13.2 L/h by WBI and this procedure removed 68.9% of the ingested dose (9).
- Another study with theophylline is difficult to interpret because it lacked a control (no treatment) group (10).

Volunteer Studies

- Ten volunteer studies have investigated the value of WBI in reducing the absorption of ingested drugs (11–19).
- Three studies involving dosing with ampicillin (11), delayed-release aspirin (12), and sustained-release lithium (13) showed significant reduction in bioavailability of 67%, 73%, and 67%, respectively (all $p<0.05$).
- In a study designed to evaluate whether WBI enhanced the excretion of drugs during the post-absorptive phase, WBI did not reduce the bioavailability of aspirin (14).
- Two studies (15,16) involving aspirin are difficult to interpret because one (15) lacked a control (no treatment) arm and, in both, the duration and total volume of WBI were less than in other studies.
- A study of WBI using coffee beans as a marker failed to demonstrate enhanced expulsion from the gastrointestinal tract (17).
- A study using delayed-release acetaminophen preparation along with a capsule containing radiopaque markers failed to demonstrate a significant reduction of acetaminophen absorption, although simultaneously ingested radiopaque markers progressed futher through the gut during whole bowel irrigation (18).
- A study using therapeutic doses of sustained-release carbamazepine, theophylline and verapamil designed to determine whether there was an additive effect of WBI upon charcoal failed to demonstrate such an effect and WBI significantly decreased the effect of charcoal upon one of these three drugs (carbamazepine). However, this study is difficult to interpret because of the small doses of the ingested drugs and because the duration and total volume of WBI were less than in other studies (19).

Clinical Studies

- No controlled clinical studies have been performed.
- Twenty-one reports of the use of WBI in 29 patients have been published (19–38). Nine patients ingested iron (20–24) and nineteen ingested other agents (sustained-release verapamil (25), almodipine (26) delayed-release fenfluramine (27), latex packets of cocaine (28,29) or heroin (30), zinc sulfate (31), lead

(37,38), arsenic (36), mercury (37,38) and sustained-release potassium (39).

Indications

- WBI should not be used routinely, but could have potential value in a limited number of toxic ingestions, based on experimental studies and anecdotal reports.
- WBI should be considered for potentially toxic ingestions of sustained-release or enteric-coated drugs (12,13).
- WBI should be considered in the management of patients who have ingested substantial amounts of iron because of the high morbidity and mortality of this poisoning and a lack of other options for gastrointestinal decontamination (20–24).
- WBI should be considered for the removal of ingested packets of illicit drugs (28–30).

Dosage Regimens

- WBI fluid is best administered through a nasogastric tube.
- There are no dose-response studies upon which to base dosing. However, a recommended dosing schedule for WBI is (1):
  - Children 9 months to 6 years: 500 mL/h
  - Children 6–12 years: 1000 mL/h
  - Adolescents and adults: 1500–2000 mL/h
- WBI should be continued at least until the rectal effluent is clear although the duration of treatment may be extended based on corroborative evidence (e.g., radiographs or ongoing elimination of toxins) of continued presence of toxins in the gastrointestinal tract.

Contraindications

- Bowel perforation
- Bowel obstruction
- Clinically significant gastrointestinal hemorrhage
- Ileus
- Unprotected or compromised airway
- Hemodynamic instability
- Uncontrollable intractable vomiting

Complications

Nausea, vomiting, abdominal cramps, and bloating have been described when WBI was used in preparation for colonoscopy and barium enema (40).

There are insufficient clinical data to describe accurately the types and incidences of complications associated with the use of WBI for the treatment of potentially toxic ingestions.

Nausea and vomiting may complicate the use of WBI (11). Vomiting is more likely to occur if the patient has been treated recently with ipecac (41) or if the patient has ingested an agent that produces vomiting.

Patients with compromised and unprotected airways are at risk for pulmonary aspiration during WBI.

SUPPORTING DOCUMENTATION

Introduction

Whole bowel irrigation (WBI) for the management of poisoning is the enteral administration of large volumes of PEG-ES by nasogastric tube at rapid rates at least until the rectal effluent takes on the physical appearance of the infusate (1). The duration of treatment may be extended based on corroborative evidence (e.g., radiographs or ongoing elimination of toxins) of continued presence of toxins in the gastrointestinal tract.

PEG-ES is preferred for WBI because there is no clinically significant absorption or secretion of fluid or electrolyte across the gut epithelium when PEG-ES is used as the irrigation solution (2). The gastroenterology, surgery, and radiology literatures contain many reports of its safety and efficacy in patients ranging from infancy to seniors.

Rationale

The rationale for this procedure is that it prevents the absorption of toxic substances by physically expelling the intraluminal contents of the gastrointestinal tract.

IN VITRO STUDIES

In vitro studies have been conducted to determine the potential for binding of the polyethylene glycol by activated charcoal and whether such binding alters the osmotic properties of the irrigating solution or the absorptive capacity of the charcoal.

Salicylic Acid

Kirshenbaum et al. (3) tested clinically relevant ratios of PEG-ES to charcoal of 0.6:1, 1.2:1, and 2.4:1 and found that PEG-ES adsorption was 38%, 32%, and

16%, respectively. Osmolality changes were insignificant. Salicylic acid (500 mg/L) was used as a marker substance to test whether PEG-ES interfered with charcoal binding of drugs. A series of six clinically relevant ratios of volumes of WBI solution and charcoal were tested (20:1 to 1:1). There were small, clinically unimportant changes (predicted vs. measured osmolality) in solution osmolality of 17 mOsm/kg over the entire range of ratios tested. Salicylate binding by activated charcoal decreased with increasing amounts of WBI solution from 100% binding of salicylate and charcoal alone to 68% at the clinically relevant ratio of 8:1.

Theophylline

Hoffman et al. (4) evaluated the influence of WBI solution upon drug adsorption by charcoal using theophylline as a marker. Theophylline was agitated with activated charcoal (1:4 charcoal to water slurry) in charcoal: theophylline ratios of 1:1, 3:1, and 10:1. The mean percent of theophylline adsorbed by activated charcoal was 16±4%, 67±5%, and 97±3%, respectively. PEG-ES added to the same charcoal theophylline mixtures resulted in 17±5%, 37±3%, and 62±2% adsorption by charcoal. All data were statistically significant ($p<0.03$) at the 3:1 and 10:1 activated charcoal to theophylline ratios. Greater interference of drug adsorption occurred when WBI solution and charcoal were premixed (62±2% vs. 74±1%).

Cocaine

Makosiej et al. (5) evaluated the influence of WBI solution upon drug adsorption by charcoal using cocaine as a marker. They found a statistically significant decrease ($p<0.05$) in the mean percentage drug adsorption to charcoal: 17.8±1.3% to 4.2±1.1% (1:1 ratio of charcoal to cocaine), 51.0±2.1% to 39.4±2.6% (3:1 ratio), 80.5±0.3% to 28.3±3.9% (5:1 ratio), 95.4±1.0% to 35.9±1.5% (7:1 ratio), and 99.7±0.1% to 43.8±4.5% (10:1 ratio). Statistically greater interference occurred if WBI solution and charcoal were mixed prior to incubation with cocaine. In these circumstances, adsorption to charcoal was reduced from 39.4±2.6% to 7.1±1.0% (3:1 ratio of charcoal to cocaine), 28.3±3.9% to 7.3±0.3% (5:1 ratio), 35.9±1.5% to 11.5±1.6% (7:1 ratio), and 43.8±4.5% to 14.8±0.9% (10:1 ratio).

Atta-Politou et al. (6) investigated in vitro the effect of polyethylene glycol and polyethylene glycol-electrolyte lavage solution, on the adsorption of fluoxetine activated charcoal in simulated gastric (pH 1.2) and intestinal (pH 7.2) fluid environment. They demonstrated that the absorption of fluoxetine to activated charcoal was decreased at gastric (69.4% when activated charcoal is unsaturated by fluoxetine; 46% when saturated) and intestinal pH (48.8 and 37.7% in the same conditions, respectively) by the presence of polyethylene glycol or polyethylene glycol-electrolyte lavage solution added concurrently to activated charcoal When polyethylene glycol or polyethylene glycol-electrolyte lavage solution is added sequentially simulating clinical practice, the reduction of fluoxetine adsorption on activated charcoal was less pronounced both at gastric (59.5% when activated charcoal is unsaturated by fluoxetine; 43.6% when saturated) and intestinal pH (53.5 and 36.6% in the same conditions, respectively). These data support both decreased adsorption to charcoal and enhanced desorption from charcoal when PEG-ES is present due to competition between PEG and fluoxetine for available activated charcoal binding sites.

Mexiletine

Arimori et al. (7) studied the binding of mexiletine in PEG-ES by charcoal. Adsorption of mexiletine by charcoal was higher in WBI solution than in a control solution (328 mg vs. 284 mg/g charcoal, respectively). Because PEG-ES has a pH of 8.5 and mexiletine has a pka of 9.1, a higher proportion of mexiletine is unionized (non-ionized) which favors charcoal binding.

Imipramine

Arimori et al. (8) studied the binding of imipramine by charcoal in the presence of PEG-ES. Adsorption of imipramine to charcoal was greater in WBI solution than in a control solution (610 mg vs. 372 mg/g charcoal, respectively).

These studies (3–6) support that there is competition between polyethylene glycol and ingested drugs for charcoal binding sites. It is difficult to determine the relevance of these in vitro data to clinical practice. In most situations there would not be a need for the concurrent use of these two interventions. The most likely indication would be the ingestion of two substances each requiring one of these treatments. If the clinician elected to employ both of them, then there is the potential for decreased effectiveness of charcoal.

ANIMAL STUDIES

Paraquat

Mizutani et al. (9) evaluated WBI in six paraquat-poisoned and six control dogs. The weights of the dogs

ranged from 7–12 kg and they were given paraquat dichloride 250 mg/kg as a 25% solution in normal saline via a jejunal tube to eliminate the influence of gastric absorption. WBI with PEG-ES 50 mL/kg/h was begun 1 hour after paraquat administration and continued for 5 hours. Rectal effluent was collected and paraquat was measured. Mean percentage of recovered paraquat dose was 68.9% with a range of 30.7–95.3%. Plasma paraquat concentrations at 2, 3, and 5 hours after the initiation of bowel irrigation to the end of the study were significantly lower in the bowel irrigation group compared with the control group. The 5-hour mean ± SEM WBI and control plasma paraquat concentrations were 5.6 ± 1.8 and 33.0 ± 10.2 mg/L, respectively ($p<0.05$). The mean total body clearance of paraquat was significantly greater ($p<0.05$) in the bowel irrigation group (13.2 ± 1.26 L/h) compared with control (5.67 ± 1.82 L/h). Clinical outcome was not assessed as the animals were sacrificed after the completion of specimen collection.

Sustained-Release Theophylline

Burkhart et al. (10) evaluated WBI as an adjunct to multiple-dose charcoal therapy in a randomized crossover study of eight dogs poisoned with sustained-release theophylline 75 mg/kg. The multiple-dose charcoal regimen was charcoal 1.0 g/kg along with sorbitol (70%) 1.0 mL/kg at 2 hours followed by doses of charcoal 0.5 g/kg in water at 5 and 8 hours. WBI consisted of four doses of irrigation solution 25 mL/kg every 45 minutes for four doses beginning at 2 hours after drug administration. There were no significant differences between the AUCs for multiple-dose charcoal therapy, WBI followed by multiple-dose charcoal, and WBI during multiple-dose charcoal therapy. It is unknown if any of the interventions in this model were effective because this study lacked a control (no treatment) group.

VOLUNTEER STUDIES

Ampicillin

Tenenbein et al. (11) evaluated WBI by utilizing a randomized two-limb crossover design in nine adults. Each subject ingested ampicillin 5 g and was subjected to WBI 2 L/H beginning 1 hour and continued until the rectal effluent was clear or 5 hours had elapsed. Ten specimens of blood for ampicillin concentration were collected during the 12 hours after ampicillin ingestion. The mean ± SEM AUC0-12 h for the WBI and control limbs were 22.0 ± 2.6 and 65.7 ± 7.9 g/h/mL, respectively. This represents a decreased ampicillin absorption of 67% for WBI ($p<0.001$).

Delayed-Release Aspirin

Kirshenbaum et al. (12) studied WBI vs. activated charcoal and sorbitol after the ingestion of delayed-release aspirin by utilizing a randomized three-limb crossover design in 10 adults. Each subject ingested enteric-coated salicylate 2.9 g, and either WBI or activated charcoal 50 g in sorbitol (70%) was administered 4 hours later. The rate of WBI was 1.52.0 L/h. Treatment was terminated when the rectal effluent was visibly similar to the infusate with a minimum of 3 hours and a maximum of 5 hours of infusion. The mean duration of WBI was 4 hours. Ten specimens of blood for salicylate concentration were collected at 11 intervals over 14 hours after drug ingestion. The $AUC_{0-14\ h}$ for WBI and activated charcoal in sorbitol both showed a significant ($p<0.01$) decrease in drug absorption of 73% and 57%, respectively, compared to control. WBI was superior to activated charcoal in sorbitol ($p<0.05$).

Sustained-Release Lithium

Smith et al. (13) evaluated WBI as a treatment for sustained-release lithium ingestion using a two-limb crossover design in 10 adult volunteers. Each subject ingested lithium 0.80 mg/kg and WBI was begun 1 hour later at a rate of 2 L/h for 5 hours. The mean serum lithium concentration was significantly decreased ($p=0.03$) within one hour of beginning WBI. Mean ± SD AUCs for WBI vs. control were 5.93 ± 2.50 mM h/L and 18.26 ± 5.83 mM h/L, respectively ($p<0.0005$). This equals a reduction in bioavailability of 67 ± 11% due to WBI.

Aspirin

Mayer et al. (14) studied whether multiple-dose activated charcoal or WBI would enhance the excretion of previously absorbed salicylate. There were no statistical differences in AUC after salicylate alone (2320 ± 501 mg/L h) compared with either activated charcoal (2040 ± 454 mg/L h) or WBI (2093 ± 418 mg/L h). Additionally, there were no differences between and among various study limbs for percent salicylate excretion, peak salicylate acid concentrations, and the time to peak concentration. These data do not support the use of WBI to enhance the excretion of previously absorbed salicylates.

Olsen et al. (15) compared low volume WBI with ipecac plus activated charcoal in sorbitol in six adults

in a randomized two-limb crossover study. All treatments began 30 minutes after the ingestion of acetylsalicylic acid 3.25 g. WBI consisted of the administration of irrigation solution 3 L over 100 minutes. The ipecac charcoal limb consisted of syrup of ipecac 30 mL followed by activated charcoal 50 g with sorbitol 96 g after emesis had ceased. Urine was collected for 24 hours for salicylate analysis. The mean SD urine recoveries of salicylate after WBI and ipecac-charcoal were 48.6 5.4% and 37.0 2.6%, respectively ($p<0.01$). The mean peak serum salicylate concentration in the WBI treated subjects (112.0±25.6 mg/L) was significantly higher ($p<0.01$) than that of the activated charcoal-ipecac group (7.4±21.6 mg/L). The AUCs were 1663.5±242.8 (WBI) and 951.8±393 (charcoal-ipecac) g/h/mL, respectively ($p<0.05$). Because this study lacked a control (no treatment) arm, the effectiveness of either intervention was not demonstrated. Duration and total volume of WBI were less than other studies.

Rosenberg et al. (16) compared WBI alone, activated charcoal combined with WBI, and activated charcoal alone in a four-limb crossover study in three adults who ingested acetylsalicylic acid 650 mg as two tablets. All treatments were begun 5 minutes after drug ingestion. WBI consisted of 4 L given over 40–60 minutes and activated charcoal 50 g in 250 mL of water. Salicylate excretion was quantified from 24-hour urine collection. The mean SD urinary salicylate excretion in the control group was 456±83 mg, in the WBI treated group was 354±31 mg, in the charcoal and WBI treated group was 321±99 mg, and in the charcoal alone group was 98±36 mg. Only charcoal alone was different from control ($p=0.011$). Charcoal was not compared with WBI but WBI alone was not different from control. This study has several limitations. The salicylate recovery was only 70% of the administered dose in the controls, the number of subjects was very small, the dose of aspirin was only 650 mg, and the duration of WBI was only 40–60 minutes considerably shorter than that of other studies (3,11).

Coffee Beans

Scharman et al. (17), using a controlled crossover experimental design, evaluated WBI with and without oral metoclopramide pretreatment for the clearing of coffee beans from the gastrointestinal tract. Eleven volunteers each ingested 10 coffee beans followed by metoclopramide or placebo 60 minutes later. They then waited another 30 minutes prior to WBI which was continued for 5 hours at a rate of 2.0 L/h. For WBI with and without metoclopramide, a mean of 2.3 beans were passed at the time of clear rectal effluent, 2.9 and 3.1 hours, respectively. At 5 hours, the mean±SD number of beans passed were 3.8±2.5 and 3.5±1.9 in the metoclopramide and placebo groups, respectively.

Delayed-Release Acetaminophen and Radiopaque Markers

Ly et al. (18) performed a 2-armed, prospective, randomized, crossover volunteer study in 10 subjects. In the experimental phase, subjects were administered a delayed-release acetaminophen preparation (75 mg/kg) along with a capsule containing radiopaque markers. However, it is important to note that the pharmacokinetic profile resembles that of a conventional rather than a delayed release pharmaceutical. In the control phase, WBI was not performed. In the treatment phase, WBI was initiated at 30 minutes after ingestion and continued until the rectal effluent was clear. Serum acetaminophen concentrations were measured at baseline and from 0.5 to 8 hours. Abdominal radiographs were obtained at the completion of WBI or after 24 hours in the control phase. Only non significant reductions were observed in C_{max}, T_{max} and AUC (8.1%, 13.2% and 11.5%, respectively) of the acetaminophen concentration versus time curve. The majority of the effect on AUC occurred after the 2-hour in the WBI phase. Radiographs obtained at the end of whole bowel irrigation revealed progression of radiopaque markers in the right hemicolon in 8 of 10 subjects, while markers were randomly dispersed throughout the small and large intestines on radiographs obtained 24 hours in the control arm. The clinical significance of this mechanical effect of WBI is not clear, since it is not associated with a significant reduction of the drug absorption.

Effect of WBI on Activated Charcoal Efficacy

Lapatto-Reiniluoto et al. (19) have examined whether whole-bowel irrigation affects the efficacy of charcoal (25 g) on the prevention of the absorption of therapeutic doses of carbamazepine, theophylline and verapamil given one hour earlier as sustained-release tablets in 9 healthy subjects in a randomized crossover study. Whole-bowel irrigation did not increase significantly the effect of charcoal on any absorption parameters [area under the plasma drug concentration-time curve from time zero to 24 hours AUC(0–24), peak plasma concentration (C_{max}), C_{max} minus the plasma concentration at 1 hour ($C\Delta$), time to peak (t_{max})] of the 3 drugs studied. On the contrary, whole-bowel irrigation significantly ($P<.01$) decreased the efficacy of charcoal with respect to carbamazepine.

This study was performed with therapeutic drug doses only, low doses of activated charcoal were administered, and the volumes of fluid used for the WBI procedure were low and the duration of PEG-ES administration was short. Thus the results are difficult to extrapolate to clinical practice.

CLINICAL STUDIES

Clinical studies of WBI consist only of a case series and case reports.

Iron

Tenenbein (20) described six patients aged 2–19 years who ingested a mean of 84 mg/kg of elemental iron (26, 65, 72, 88, 120, and 133 mg/kg). The ingestion was confirmed radiologically in five (the sixth had ingested a pediatric multivitamin plus iron preparation). Two patients were treated with ipecac and gastric lavage, and two with ipecac alone; however, these interventions were negligibly effective by radiologic assessment. All were treated with WBI by nasogastric tube at a rate of 0.5 L/h for the toddlers and 2.0 L/h for the teenagers. During WBI, physical evidence of the ingestant was seen in the effluent of all six patients. WBI was stopped when the rectal effluent became clear (6–12 hours). All patients were followed with serial serum iron concentrations during the first 14 hours and the individual peak serum iron values were 2.58 mg/L, 3.19 mg/L, 3.58 mg/L, 4.37 mg/L, 4.42 mg/L, and 4.59 mg/L. (Note: 2.58 mg/L=258 μg/dL=46.23 mol/L.) Four of the six patients received deferoxamine, and colored urine was seen in only one of the four. The clinical courses were unremarkable.

Mann et al. (21) described a 16.5 kg 2.5-year-old male who was brought to the emergency department (ED) 75 minutes after having ingested elemental iron 130 mg/kg. A large amount of iron was demonstrated in a radiograph of the abdomen, but ipecac-induced emesis produced no tablets or fragments. Gastric lavage was also performed. Eight hours later, WBI 0.5 L/h for 10 hours and deferoxamine therapy were instituted. The urine did not change color and the highest serum iron concentration was 2.9 mg/L which was prior to WBI. Iron sediment was seen in the rectal effluent. The patient's course was uneventful.

Everson et al. (22) reported an 11-month-old infant who ingested prenatal iron supplements. An abdominal X ray on admission to the ED showed 23 to 26 tablets equivalent to elemental iron 130–150 mg/kg. Two doses of ipecac and two gastric lavages resulted in the retrieval of eight tablets and assorted tablet fragments. The patient was treated intravenously with deferoxamine 15 mg/kg/h from 3–12 hours after ingestion and had orange urine. His highest serum iron concentration was 2.65 mg/L at 2 hours after ingestion. At 14 hours after ingestion an abdominal X ray showed a large radiopaque mass of tablet material. He was then treated with a WBI 1450 mL over 8 hours and iron tablet fragments were seen in the rectal effluent. The clinical course was unremarkable.

A 33-month-old boy who ingested at least 160 mg/kg of elemental iron (estimated from an abdominal radiograph taken at presentation to hospital some 15 hours after ingestion) was described by Kaczorowski and Wax (23). The child had normal vital signs and serum iron concentration was 3.67 mg/L. Gastric lavage yielded no iron tablets or fragments. WBI with PEG-ES at 500 mL/h and deferoxamine infusion were initiated. The deferoxamine was stopped 24 hours later and the urine never changed color. WBI was continued for 121 hours total because of the continual presence of iron tablets in abdominal radiographs and the intermittent passage of iron tablets in the effluent. The total volume administered was 44.3 L of PEG-ELS (2,953 ml/kg). The rectal effluent was clear after 2 days. Serum electrolytes remained normal throughout the entire WBI. Serum iron concentration never increased and fell to 0.86 mg/L on the day of discharge when two iron tablets were still present radiographically. No adverse effects resulted from the large volume or duration of the PEG-ELS therapy.

A 21-year-old patient in week 26 of her fourth gestation ingested approximately 3.9 g elemental iron with suicidal intent (24). A serum iron concentration some 2 hours later was 5.07 mg/L. Deferoxamine 1517.9 mg/kg/h was administered intravenously for 14 hours (total dose 10.2 g) and WBI was undertaken. PEG-ES was given at 2 L/h for 12 hours, by which time the rectal effluent had become clear. The patient delivered a healthy infant at 39.5 weeks gestation. After cessation of WBI and deferoxamine, the serum iron concentration was 0.53 mg/L.

Sustained-Release Verapamil

Buckley et al. (25) reported a 23-year-old female who ingested sustained-release verapamil 4.8 g. At 2 hours post-ingestion, she was asymptomatic. She was treated with gastric lavage, activated charcoal 100 g, and WBI 3.5 L. Within 2 hours she passed a conglomerate of tablets about 23 cm in diameter consistent with the tablets taken. The clinical course was unremarkable. In the same report a 44-year-old female ingested slow-release verapamil 1520 g. She

presented for medical care 24 hours later after collapsing. She was hypotensive and bradycardic. Activated charcoal and PEG-ES were administered but not retained due to episodic emesis. The patient expired 39 hours postingestion.

Almodipine

Stanek et al. (26) report the case of a 42-year-old woman who ingested amlodipine besylate 50–100 mg and beer in a suicide attempt. This overdose was associated with sustained hypotension and sinus tachycardia as well as transient pulmonary edema following relatively low-volume fluid replacement with saline. Decontamination consisted of administration of activated charcoal and two 500 ml doses of PEG-ES. Whole bowel irrigation was not performed. The patient was discharged on day 2 in good condition.

Delayed-Release Fenfluramine

Melandri et al. (27) described a 26-year-old female who ingested delayed-release fenfluramine 1.8 g. She was treated with gastric lavage followed by WBI 5 L from 610 hours after overdose. The endpoint was a clear rectal effluent. Her course was unremarkable.

Body Packing: Cocaine or Heroin

A 39-year-old male who had ingested 80 latex packets of cocaine, 10 g each, for the purpose of illicit drug smuggling was described by Hoffman et al. (28). Prior to presentation at the hospital, the patient had passed 61 of these spontaneously. WBI at 2 L/h was begun and continued over 10.5 hours (total 16 L PEG-ES). Ten packets were passed within 1.5 hours. Eight more packets were passed over the next 9 hours. The final packet remained in the stomach and was endoscopically removed. The clinical course was unremarkable.

Olmedo et al. (29) described an asymptomatic 30-year-old woman who presented 2 days after the ingestion of 40 packets of cocaine in an attempt of illicit drug smuggling. She had not been able to pass any of them. An abdominal roentgenogram revealed multiple packets within the bowel without any signs of obstruction. Initial management included one dose of activated charcoal (1 g/kg) and WBI with PEG-ES 2 L/hr. Despite continuous WBI for 3 days, she passed only 25 packets. Abdominal computed tomography (CT) with oral and IV contrast identified an undetermined number remaining in the sigmoid colon. Several hours later, the patient developed precipitous hypotension and coma. She was resuscitated and underwent immediate laparotomy and 29 packets (including 3 ruptured packets) were removed from the transverse colon. A repeat abdominal CT performed postoperatively to exclude an intra-abdominal abscess because of had persistent tachycardia and fever for 4 days, located 2 additional packets in the sigmoid colon, that were removed by colonoscopy and appeared to be intact. The total number of cocaine packets removed was 56, substantially more than the patient initially reported ingesting. Subsequently, the patient's hospital course was complicated by wound dehiscence and cellulitis which was treated with antibiotics. The patient was discharged 3 weeks postoperatively with some residual memory deficits.

The use of WBI has also been reported in body packing (with heroin packets by Traub et al. (30) in two pediatric patients. A 16-year-old boy, presented with findings consistent with opioid intoxication after arriving in the US on a transcontinental flight. His mental status improved after he received naloxone hydrochloride, and he subsequently confessed to body packing heroin. He was treated with a naloxone infusion and aggressive gastrointestinal decontamination. He ultimately passed 53 packets of heroin, one of which had ruptured. He recovered uneventfully. The other child was a 12-year-old boy who presented to the emergency department with rectal bleeding. He had recently arrived in the US from Europe, and confessed to body packing of heroin. He was treated with WBI and activated charcoal, and subsequently passed 84 packets. He also recovered uneventfully. The rate of administration and the duration of WBI were not documented for either patient.

Zinc Sulfate

Burkhart et al. (31) described a 16-year-old male in whom an abdominal X-ray demonstrated approximately 50 zinc sulfate tablets despite previous spontaneous emesis and gastric lavage. Within 1 hour of the initiation of WBI 1 L/h, he began passing pill fragments. The procedure was stopped at 4 hours at which time a repeat radiograph demonstrated a marked decrease in the number of tablets present (quantity not specified). His clinical course was unremarkable.

Lead

Roberge and Martin (32) described an 89-year-old male who ingested approximately 100 mL of ceramic glaze with a 30% lead oxide content. Gastric lavage

was carried out within 1 hour of ingestion and a subsequent abdominal radiograph demonstrated lead throughout the small intestine. At 5 hours post-ingestion, dimercaprol 250 mg was given and WBI was initiated. Eight liters of solution were infused over 6 hours at which time the rectal effluent was clear. A repeat abdominal radiograph demonstrated near total clearing. The initial blood lead concentration was 18 μg/dL with subsequent values of 39 μg/dL at 16 hours and 42 μg/dL at 24 hours.

Clifton et al. (33) reported the case of a 21-month-old girl who was examined in an ED 12 hours after ingestion of an unknown amount of lead BB pellets. The past medical history was significant for a routine blood lead level of 12 μg/dL. An abdominal X ray showed two 0.4 cm rounded densities in the duodenal bulb. A WBI with nasogastric polyethylene glycol electrolyte solution at 250 mL/h, which the patient tolerated with some difficulty. Patient's blood lead level on admission was 47 μg/dL. Twenty-four hours after admission,a repeat abdominal X-ray revealed the presence of two pellets in the cecal region and chelation therapy with succimer was initiated. Twenty-four hours after initiation of chelator, the blood lead level was 48 μg/dL and he position of the pellets remained unchanged on the radiograph. The girl was transferred for colonoscopic removal of the pellets. Immediately after colonoscopy, the blood lead level was 25 μg/dL. The remainder of the patient's hospitalization was uneventful.

Gordon et al. (34) reported the case of a 3-year-old child who developed massive lead poisoning (550 μg/dL) from environmental exposure to lead paint at home. The child was treated with WBI and triple chelation therapy with British anti-Lewisite, EDTA, and oral succimer. The rate of administration of PEG-ES was 20 ml/kg/hr and the duration of WBI was three days with the endpoint of clearing the gut of opacities as assessed by abdominal radiograph. This treatment was well-tolerated and seemed effective.

McKinney (35) reported the case of a 5 1/2-year-old girl who vomited and complained of abdominal pain after eating multiple 1.4 mm diameter lead pellets from an ankle weight. Abdominal radiographs showed thousands (OK it right!) of small, round, metallic density objects in the stomach. Whole-bowel irrigation was begun and she passed over 11 stools with pellets as well as other foreign bodies (erasers, bead, etc.) in the first 24 hours. She received PEG-ES 4100 ml over 24 hours which was less than the recommended dose. Her pediatrician elected to discontinue the WBI at 24 hours despite the presence of numerous pellets in the abdominal radiograph. She received a high-fiber diet and bisacodyl tablets. Blood lead on admission drawn 13 hours after ingestion was 57 μg/dL and peaked at 79 μg/dL approximately 36 hours after ingestion. Chelation was begun with oral 2,3-dimercaptosuccinic acid for two weeks. She did not develop any apparent signs of lead poisoning.

Arsenic

Lee et al. (36) described two cases of acute arsenic ingestion treated with WBI. A 41-year-old man ingested an arsenic-containing herbicide. At 2 hours he had several bouts of emesis and diffuse abdominal pain. At 4 hours, an abdominal radiograph showed radiopaque material in the small bowel. WBI 2 L over 3 hours, resulted in rectal effluent with the characteristic garlic odor of arsenic and a clear radiograph. He also received dimercaprol (3 mg/kg intramuscular every 6 hours for 4 days), then penicillamine (25 mg/kg oral every 6 hours for 10 fays). His stools retained the garlic odor for two more days. His clinical course was unremarkable. The second patient was a 29-year-old male who ingested an arsenic-containing insecticide. He was asymptomatic several hours later when he presented for medical care. An abdominal X-ray showed large amounts of radiopaque material. He was treated with WBI 1 L/h for 24 hours at which time a subsequent radiograph was normal. He was also treated with dimercaprol. His course was unremarkable.

Mercury

Satar et al. (37) reported the case of a 23-year old woman who presented to an emergency department complaining epigastric pain after intentional ingestion of 100 grams of pure mercury obtained from her dentist's laboratory. Chest and abdominal radiographs confirmed the presence of a radiopaque substance scattered throughout the GI tract. She was treated with gastric lavage and activated charcoal. Then whole bowel irrigation was performed with a PEG-ES solution. This was done over five days but the dose and rate were not specified. On day two, some mercury was in the rectum and an enema was administered. Despite ongoing whole bowel irrigation, mercury particles persisted in the cecum and disappeared on day eight after a fibrous diet was given. No adverse event was observed and the laboratory values remained in the normal range.

Ly et al. (38) reported of mercuric oxide (HgO) (H_2O_3??? HgO seems right) powder ingestion. A 31-year-old man presented to an emergency department after ingestion of approximately 40 g of HgO. Soon

after ingestion, he developed nausea, vomiting, and abdominal cramping. Abdominal radiograph revealed radiopaque material in the stomach. He was treated with a dose (how much? no details in the paper) of activated charcoal. Whole-bowel irrigation with PEG-ES was begun and he received 23 liters over 32 hours. At this point only trace amounts of radiopaque material remained along the greater curvature of the stomach. He was also chelated with British anti-Lewisite for 5 days, followed by succimer for 10 days. He had markedly elevated urine and blood mercury levels after ingestion, but except for a mildly depressed serum bicarbonate (19 mEq/L), the chemistry results remained normal and the patient did not develop the end-organ toxicity typical of inorganic mercury poisoning.

Potassium

Su et al. (39) describe the use of whole-bowel irrigation in two patients who ingested sustained-release potassium preparations. A 50-year-old woman ingested 100 tablets (each containing KCl 750 mg or 10 mEq potassium) in a suicide attempt 1 hour prior to presenting to the emergency department with abdominal cramping. Her peak serum potassium level was 9.7 mEq/L and she developed transient, potentially life-threatening electrocardiographic changes. Tablets persisted in the stomach on abdominal radiographs despite orogastric lavage and sodium polystyrene sulfonate administration. WBI was started 13 hours after admission at a rate of 30 ml/hr. The duration of WBI was unclear and there were no pill fragments seen in her abdominal radiograph taken at 35 hours after admission. The other patient described by Su et al. was a 17-year-old man ingested 20 to 30 tablets (same potassium content) in a suicide attempt 10 hours prior to presentation. Abdominal radiographs showed multiple radiopaque densities in the upper gastrointestinal tract. WBI with PEG-ES was initiated at a rate of 2.0 L/hr. After six hours of WBI, a repeat radiograph showed no tablets. His peak serum potassium was 6.1mEq/L and he did not develop ECG changes. The clinical course was uneventful.

INDICATIONS

WBI should not be used routinely. There are no established indications for the use of WBI since no conclusive evidence from controlled clinical trials demonstrates that WBI improves the outcome of poisoned patients. Based on volunteer studies and anecdotal reports, WBI should be considered for potentially toxic ingestions of sustained-release or enteric-coated drugs. WBI should be considered for patients who have ingested substantial amounts of iron as the morbidity is high and there is a lack of other options for gastrointestinal decontamination. The use of WBI for the removal of ingested packets of illicit drugs should also be considered.

CONTRAINDICATIONS

WBI is contraindicated in the presence of ileus, bowel obstruction, bowel perforation, clinically significant gastrointestinal hemorrhage, hemody-namic instability, uncontrollable intractable vomiting, and an unprotected compromised airway.

COMPLICATIONS

There are few clinical data to describe accurately the types and incidences of complications associated with the use of WBI for the treatment of potentially toxic ingestions.

Ernstoff et al. (40) have reported nausea, vomiting, abdominal cramps, and bloating following the use of WBI as preparation for colonoscopy and barium enema. Reported complications of WBI in volunteer studies include nausea and vomiting (1,13,15,17,20,24) which was controlled in one study (12) by decreasing the administration rate from 2.0 to 1.5 L/h. Vomiting is more likely to occur if the patient has been treated recently with ipecac (41) or if the patient has ingested an agent that produces vomiting such as theophylline or aspirin.

There were no complications attributable to WBI described in any of the case reports. Patients with compromised and unprotected airways are at risk for pulmonary aspiration during WBI.

APPENDIX: TECHNIQUE FOR PERFORMING WBI

The required equipment and materials include a small bore (12 F) nasogastric tube, a feeding bag used for nasogastric tube feedings, an intravenous pole, a supply of polyethylene glycol electrolyte solution, and a commode. This procedure does not require a specialized location or setting and can be performed wherever acutely poisoned patients are managed.

A 12 French nasogastric tube is passed into the stomach. A nasogastric tube is required because

patients will not drink the PEG-ES at the required rate. Only a small bore tube is needed and gastric location is ensured by auscultation during air injection. It is preferable to confirm radiologically that the tip of the tube is in the midportion of the stomach as this position increases the likelihood of anterograde propulsion of the ingestant. Attach the tube to a reservoir bag of irrigation solution which is hung from an elevated site.

The patient should be seated or the head of the bed elevated to at least 45. Placing the patient in an upright position promotes the settling of the ingestant into the distal portion of the stomach, decreases the likelihood of vomiting, and establishes a dependent relationship of the intestines to the stomach.

A recommended dosing schedule is:

- Children 9 months to 6 years—500 mL/h
- Children 6–12 years—1000 mL/h
- Adolescents and adults—1500–2000 mL/h

A commode or similar receptacle is useful to collect the effluent.

If emesis occurs, it is usually a consequence of the ingestant or prior administration of ipecac. Ingestant-induced emesis is best managed by the parenteral administration of an antiemetic which does not impair consciousness. Metoclopramide has both antiemetic and gastric emptying properties. The likelihood of emesis is also decreased by keeping the patient's upper half of the body upright. If emesis occurs despite the above measures, decrease the infusion rate by 50% for 30–60 minutes and then return to the original rate.

Monitoring of WBI requires no more nursing supervision than is needed for intravenous therapy. There is no need to monitor the patient's fluid or electrolyte status during the procedure. WBI should be continued at least until the rectal effluent is clear (which takes many hours) although the duration of treatment may be extended based on corroborative evidence (e.g., radiographs or ongoing elimination of toxins) of continued presence of toxins in the gastrointestinal tract. After completion of WBI, additional liquid bowel movements will occur.

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