ADMINISTERING POLYETHYLENE GLYCOL ELECTROLYTE SOLUTION VIA A NASOGASTRIC TUBE: PULMONARY COMPLICATIONS

By Norma A. Metheny, RN, PhD, and Kathleen L. Meert, MD

Background Patients sometimes require insertion of a nasogastric tube for the administration of a large volume of a polyethylene glycol electrolyte solution. If the tube is malpositioned, the risk for direct instillation of the solution into the lung increases. The risk for aspiration also increases if the infusion rate exceeds gastrointestinal tolerance.

Purpose To review published cases of patients’ experiencing adverse pulmonary events after administration of polyethylene glycol electrolyte solution via a nasogastric tube and to offer suggestions to prevent these outcomes.

Methods A search of the literature from 1993 through 2014 was performed by using the PubMed, MEDLINE, Cumulative Index to Nursing and Allied Health Literature, and Scopus databases.

Results In the 12 case reports located, none of the patients had radiographs to verify tube location before infusion of polyethylene glycol electrolyte solution. After symptoms developed in 3 children (ages 8-11 years), radiographs showed their tubes incorrectly positioned in the bronchus, lung, or esophagus; ports of a fourth child’s tube were in the oropharynx. The remaining 8 patients (ages 5-86 years) never had radiographs to determine tube placement. Pulmonary complications from the infusions of polyethylene glycol electrolyte solution contributed to the death of 5 of the patients.

Conclusion Relatively simple maneuvers to reduce the likelihood of adverse pulmonary events following the administration of large volumes of polyethylene glycol electrolyte solution via a nasogastric tube are well worth the cost and effort to protect patients from potential serious injury. (American Journal of Critical Care. 2017; 26:e11-e17)
Patients of all ages may undergo bowel cleansing with a polyethylene glycol-electrolyte solution (PEG-ES) for reasons such as whole-bowel irrigation for toxic drug ingestion, relief of intractable constipation, and preparation for colonoscopy or colorectal surgery. Although still commonly used to prepare for colorectal surgery, this form of bowel cleansing is less favored now than in the past.1,2 When patients are unable or unwilling to consume a large volume of PEG-ES orally, it may be necessary to insert a nasogastric tube to administer the solution.

Administering PEG-ES via a nasogastric tube creates risk for direct instillation of the solution into the lung if the tube is inadvertently positioned in the respiratory tract. It also creates risk for aspiration of the solution if the tube is incorrectly positioned in the esophagus or even when the tube is correctly positioned in the stomach, if gastric emptying is slowed. Although adverse pulmonary events following large-volume bowel preparations are uncommon, they can result in serious and even fatal outcomes.3,4

The purpose of this study was to review cases reported in the literature in which patients experienced adverse pulmonary events following the administration of PEG-ES via a nasogastric tube and to offer suggestions to prevent these outcomes.

Methods

A search of the literature from 1993 through 2014 was performed with the PubMed, MEDLINE, Cumulative Index to Nursing and Allied Health Literature, and Scopus databases, using various combinations of the following key words: cathartics, adverse events; colonoscopy, adverse events; intubation, gastrointestinal; intubation, intratracheal; polyethylene glycols, administration and dosage; polyethylene glycols, adverse events; pneumonia, aspiration; respiratory aspiration, etiology; respiratory distress syndrome, chemically induced; and therapeutic irrigation, adverse events. A Google search was performed with the same key words.

Results

We found 12 case reports of patients who experienced adverse pulmonary events after the administration of PEG-ES via a nasogastric tube; none of the 12 patients had radiographs to document tube placement before the infusions. After the development of respiratory symptoms, the children described in cases 1 through 3 underwent radiography to check tube placement; the radiographs showed incorrect position of the nasogastric tubes (1 each in the right lung, left main bronchus, and esophagus; Table 1).4-6 The ports of a fourth child’s tube were found in the oropharynx (Table 1, method not described).7 Three of the children (cases 1, 2, and 4) required intubation and mechanical ventilation following their adverse pulmonary events; fortunately, all eventually recovered. The remaining 8 patients (cases 5-12; age 5-86 years) did not have radiographic evidence of the location of the nasogastric tube at any time.8-15 Pulmonary complications from the PEG-ES infusions contributed to the death of 5 of these patients (cases 6-10).

Discussion

Although 12 cases in 21 years is a small number, it is likely that many others have occurred, because adverse events are often not reported in the literature. For this reason, it is helpful to review the circumstances of the case reports to identify possible strategies to prevent future adverse pulmonary events after the administration of PEG-ES via a nasogastric tube. A common factor in all 12 cases was the absence of radiographic confirmation of correct tube placement before the initiation of the PEG-ES infusion.

In cases 1 through 3, radiographs were obtained after respiratory symptoms occurred (usually after several hundred milliliters of the PEG-ES had been administered). No information was provided about bedside tests used to determine placement of the tubes later found to be positioned in the left main bronchus (case 1), esophagus (case 2), or oropharynx (case 4). The auscultatory method failed to detect tube misplacement in the right lung in case 3. Other...
### Table 1
Case reports of adverse events associated with the administration of a polyethylene glycol bowel-cleansing solution via a nasogastric tube

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Reference</th>
<th>Radiographic confirmation of tube location</th>
<th>Bedside placement testing method(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Narsinghani et al⁴</td>
<td>No radiography when nasogastric tube inserted. After symptoms, radiograph showed tube in left main bronchus</td>
<td>Not described</td>
</tr>
<tr>
<td>2</td>
<td>Liangthanasarn et al⁵</td>
<td>No radiography when nasogastric tube inserted. After symptoms, radiograph showed tube in esophagus</td>
<td>Not described</td>
</tr>
<tr>
<td>3</td>
<td>Mosquera et al⁶</td>
<td>No radiography when nasogastric tube inserted. After symptoms, radiograph showed tube in right lung</td>
<td>Auscultation for air injected via tube</td>
</tr>
<tr>
<td>4</td>
<td>Givens and Gabrysch⁷</td>
<td>No radiography when nasogastric tube inserted. After infusion started, chest radiograph showed tube in &quot;good position&quot; and right lower lobe infiltrate. Tube placement checked 14 h after bupropion ingestion, and proximal ports were found in oropharynx (unclear if this was by radiography or bedside assessment)</td>
<td>Auscultation for air injected via tube at time of insertion</td>
</tr>
<tr>
<td>5</td>
<td>Argent et al⁸</td>
<td>No radiograph of tube location at any time</td>
<td>Auscultation for air injected via tube. Aspiration of fluid from tube</td>
</tr>
<tr>
<td>6</td>
<td>De Graaf et al⁹</td>
<td>No radiograph of tube location at any time</td>
<td>None described</td>
</tr>
<tr>
<td>7</td>
<td>Gabel and Muller¹⁰</td>
<td>No radiograph of tube location at any time</td>
<td>Auscultation for air injected via tube. Aspiration of &quot;acid&quot; gastric liquid</td>
</tr>
<tr>
<td>8</td>
<td>Hasan and Brown¹¹</td>
<td>No radiograph of tube location at any time</td>
<td>Not described</td>
</tr>
<tr>
<td>9</td>
<td>Lutz and Mason¹²</td>
<td>No radiograph of tube location at any time</td>
<td>Not described</td>
</tr>
<tr>
<td>10</td>
<td>Marschall and Bartels¹³</td>
<td>No radiograph of tube location at any time</td>
<td>Not described</td>
</tr>
<tr>
<td>11</td>
<td>Paap and Ehrlich¹⁴</td>
<td>No radiograph of tube location at any time</td>
<td>&quot;Placement documented several times by nurse&quot; (methods used not described)</td>
</tr>
<tr>
<td>12</td>
<td>Wong and Briars¹⁵</td>
<td>No radiograph of tube location at any time</td>
<td>Auscultation for air injected via tube. Litmus test (findings not described)</td>
</tr>
</tbody>
</table>

Abbreviations: ICU, intensive care unit; PEG-ES, polyethylene glycol-electrolyte solution.
Case description

An 11-year-old girl with chronic constipation was admitted for bowel cleansing. Episodic coughing and gagging were noted during placement of a nasogastric tube. Significant respiratory distress occurred 1 hour after the PEG-ES infusion was started at 200 mL/h. The infusion was stopped and a radiograph showed that the tube’s tip was in the left main bronchus. Approximately 200 mL of the solution was removed from the lung at the time of intubation and initiation of mechanical ventilation. The child subsequently recovered in several days.

An 8-year-old girl was admitted for bowel cleansing for an elective colonoscopy. A nasogastric tube was inserted and a PEG-ES infusion was started at 200 mL/h. Vomiting occurred several times. Respiratory distress occurred 2 hours after the infusion was started and became progressively worse during the next few hours. A chest radiograph showed bilateral pulmonary infiltrates and location of the nasogastric tube’s tip in the mid-esophagus. Following bronchial lavage, mechanical ventilation was required for 16 hours. The child subsequently recovered in 4 weeks.

PEG-ES was administered via a nasogastric tube to a 9-year-old boy in preparation for surgery. After 283 mL of fluid had infused, coughing and gagging with a small emesis of clear fluid was noted. The infusion was stopped and a radiograph showed that the nasogastric tube was in the right lung. The child subsequently recovered after treatment for right lower lobe pneumonia.

A 3-year-old boy ingested bupropion and had seizures. On arrival in a pediatric emergency department, about 5 hours after ingestion, he was mildly sleepy but had appropriate motor and verbal responses and was determined to be able to protect his airway. Following the insertion of a nasogastric tube and placement check by auscultation, PEG-ES solution was infused at a rate of 150 mL/h. Additional seizures occurred 6 hours after the drug ingestion. Breathing was impaired and a nasal trumpet was inserted (it was removed when the child became more awake). Lorazepam was administered for seizure prophylaxis every 4 to 6 hours. The child was described as somnolent but arousable and able to protect his airway after the seizures. A chest radiograph revealed a right lower lobe infiltrate that may have represented aspiration; the film also showed “good placement” of the naso-gastric tube. Oxygen was administered via face mask. The child was admitted to the pediatric ICU 8 hours after the ingestion. About 14 hours after the ingestion, ICU nurses noted abdominal distention and increased work of breathing. Nasopharyngeal suction of the esophagus returned about 400 mL of PEG-ES. Nasogastric tube placement was checked and proximal ports of the tube were noted in the oropharynx. The authors hypothesized that the tube was dislocated during transfer from the emergency department to the ICU. Intubation was performed 15 hours after the ingestion when the child became obtunded with no gag reflex. A chest radiograph revealed progression of the right lower lobe infiltrate. Acute respiratory distress syndrome was diagnosed and required maximal ventilator support. After an extended treatment period, the child improved and was discharged on hospital day 30.

Three hours after starting a PEG-ES infusion (100 mL/h) via a nasogastric tube to treat constipation in a 5-year-old boy, the child was found stuporous, tachypneic, and cyanotic. The tube was removed and the patient was moved to an ICU. Outcome of this case was not described.

An 86-year-old man was unable to drink a large volume of fluid, so a nasogastric tube was inserted to administer a PEG-ES infusion in preparation for a colonoscopy. Nausea developed after 2 L of the solution had been delivered in 3 hours. Vomiting subsequently occurred and the tube was removed. Respiratory distress was noted 2 hours later; a chest radiograph showed massive consolidation in both lungs. Worsening of his respiratory status necessitated intubation and mechanical ventilation. The patient ultimately died of acute respiratory distress syndrome and multiorgan failure.

In preparation for a colonoscopy, a nasogastric tube was inserted to administer a PEG-ES to a 79-year-old woman who was uncooperative and refused to drink the required amount of liquid. Sedation was administered before the tube insertion. The PEG-ES was administered at a rate of 500 mL/h with the patient in a half-sitting position. Respiratory distress developed after 150 mL of the solution had been administered. Intubation was performed; no evidence was found of the nasogastric tube being positioned in the airway. The patient remained unconscious and died as result of a stroke associated with prolonged hypoxemia.

In preparation for a colonoscopy, a 60-year-old man had a nasogastric tube inserted to administer a PEG-ES because nausea prevented him from consuming the fluid orally. After 4 L had been administered, the patient pulled out the nasogastric tube. Shortly thereafter, respiratory failure developed and radiographic evidence of aspiration was noted. Although intubation and mechanical ventilation were implemented, he died the next day.

A 65-year-old woman was admitted for evaluation of rectal bleeding. PEG-ES was initiated via a nasogastric tube at a rate of 20-30 mL/min. Approximately 1 hour later, respiratory distress occurred that necessitated intubation and mechanical ventilation. More than 500 mL of clear fluid was suctioned from the endotracheal tube (presumably PEG-ES aspirated during the infusion). The patient’s condition deteriorated with worsening infiltrates and acute respiratory distress syndrome was diagnosed. Death occurred on the 26th day after admission.

A 78-year-old woman was scheduled for surgery for rectal cancer. The day before surgery, 11 L of a PEG-ES was administered via a nasogastric tube until rectal effluent was clear of solid material. Vomiting occurred during removal of the nasogastric tube, and immediate dyspnea was noted. Death occurred 2 weeks later and was associated with severe pneumonia and acute respiratory distress syndrome.

An 8-year-old girl was admitted for bowel cleansing for an elective colonoscopy. A nasogastric tube was inserted and a PEG-ES infusion was started at a rate of 200 mL/h. During the infusion, the child experienced discomfort and vomited twice. The infusion rate was decreased to 150 mL/h for a short time and then returned to 200 mL/h. A liter of solution was administered in 5 hours and the nasogastric tube was removed. Two hours later, vomiting and respiratory distress occurred. A radiograph showed bilateral infiltrates and a distended stomach. Intubation and mechanical ventilation were required. At the time of intubation, 50 mL of clear fluid drained from the endotracheal tube and continued to drain at a rate of about 30 mL/h for the next 6 hours (consistent with aspiration-induced pulmonary edema). Following treatment, the child eventually recovered.

A PEG-ES infusion was started at a rate of 15 mL/kg per hour via a nasogastric tube to treat a fecal impaction in a 7-year-old boy. He dozed occasionally during the infusion and started coughing and vomited 150 mL of frothy fluid about 3 hours later. The infusion was stopped and the nasogastric tube removed after respiratory distress developed. A chest radiograph showed extensive alveolar shadowing throughout both lung fields. After treatment, the child made a full recovery.
Table 2
Recommendations to prevent pulmonary complications associated with PEG-ES infusion via a nasogastric tube

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Comments</th>
</tr>
</thead>
</table>
| **Confirm placement of nasogastric tube by radiograph before infusion**      | Risk factors for aspiration during PEG-ES infusion:  
Neurological disorders (e.g., stroke, head injury, Parkinson disease, muscular dystrophy, cerebral palsy, amyotrophic lateral sclerosis)  
Confusion  
Delayed gastric emptying  
Antecedent symptoms of nausea and vomiting  
Incompetent gastroesophageal junction  
Unprotected or compromised airway                              |
| **Assess competency of airway before starting infusion and during infusion** | Clear, coherent speech and ability to swallow secretions are indicators of a protected airway, whereas pooling secretions and inability to swallow indicate need for intubation.  
A score ≤8 on the Glasgow Coma Scale is a useful guideline for the prediction of intubation; however, it should be used in conjunction with other clinical data.    |
| **Maintain upright position during infusion**                                | If possible during whole-bowel irrigation, position patient on commode in sitting position; if bedfast, elevate head of bed to at least 45º. Placing the patient in an upright position allows the infused solution to settle in the distal portion of the stomach, thereby decreasing the likelihood of vomiting. |
| **Consider typical flow rates for infusion according to age**                | A dosing schedule for toxic ingestions described in a 2004 position paper on whole-bowel irrigation is as follows:  
Children age 9 months to 6 years: 500 mL/h  
Children age 6-12 years: 1000 mL/h  
Adolescents and adults: 1500-2000 mL/h  
Bowel preparation regimens for colonoscopy vary widely. In children, the dosage may be prescribed per body weight (e.g., 20-40 mL/kg). Volumes in adults may be from 2 to 4 L, although the volume varies depending on the specific protocol. |
| **Monitor patient closely for signs of pulmonary distress during infusion**  | Observations to be made at least every 15 minutes include  
Pulse and respiratory rates  
Lung sounds  
Continuous pulse oximetry readings  
Coughing and gagging                                                                 |
| **Monitor for emesis**                                                        | If emesis occurs despite the use of a prokinetic agent and upright positioning of the upper half of the patient’s body, slowing the infusion rate by 50% for 30-60 minutes may be necessary (and then return to original rate). Adjunctive use of a prokinetic agent may increase tolerance to the PEG-ES infusion. |
| **Measure GRV if abdominal distention noted**                                | Although controversy remains about the value of GRV measurement, it may prove helpful in detecting failure of the stomach to empty adequately during rapid infusion of a large volume of PEG-ES. For example, is the recovered volume more than twice the hourly flow rate of the infusion? For bedfast patients, it may be helpful to turn them to their right side (while still elevated to at least 45º) before GRV measurement. |
| **Continue to monitor nasogastric tube position throughout the infusion**    | If vomiting occurs, recheck tube position by radiography (important because retching and vomiting can lead to tube misplacement). Observe for a change in length of the external portion of the nasogastric tube (if not adequately secured, the nasogastric tube may become dislocated upon patient repositioning during care). |

Abbreviations: GRV, gastric residual volume; PEG-ES, polyethylene glycol–electrolyte solution.

Authors have reported cases in which the auscultatory method failed to detect malpositioned nasogastric tubes, for example, it failed to detect nasogastric tubes inadvertently positioned in the respiratory tracts of 7 acutely or critically ill children. In cases 5 through 12, radiographic confirmation of tube location was never obtained, so it is impossible to know where the tubes were actually located. When the nasogastric tube was inserted, auscultation was used to test tube placement in
cases 4, 7, and 12. Testing of fluid withdrawn from the tubes with litmus paper was reported in cases 7 and 12; however, pH values of the fluid were not provided. Fluid withdrawn from the nasogastric tube in case 7 was described as "acidic." Although an aspirate with a low pH most likely rules out respiratory placement, it cannot rule out esophageal placement, given that fluid withdrawn from the esophagus could be refluxed acidic gastric contents.16,19

Signs of gastrointestinal intolerance were observed in multiple cases; for example, vomiting occurred in 6 patients (cases 2, 3, 6, 10, 11, and 12) before development of respiratory symptoms. Impaired ability to protect the airway was observed in case 4 and possibly in case 7 (due to sedation). It is noteworthy that the 5 deaths (cases 6-10) occurred in older patients (age 60-86 years).

Recommendations to prevent pulmonary complications associated with the infusion of PEG-ES via a nasogastric tube are provided in Table 2.

Conclusion

Although the infusion of PEG-ES via a nasogastric tube seems like an innocuous procedure, it is associated with significant risk for injury. Relatively simple maneuvers can be implemented to reduce the likelihood of adverse pulmonary events when administering large volumes of PEG-ES via a nasogastric tube.

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REFERENCES


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