Intraperitoneal Elemental Mercury Exposure from a Mercury-Weighted Bougie

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Abstract

Introduction Significant exposure to elemental mercury can occur if a mercury-weighted medical device is damaged during use. We report a case of an elemental mercury spill into the peritoneum of a patient undergoing laparoscopic gastric bypass surgery.

Case Report A 64-year-old man with multiple comorbidities underwent an elective Roux-en-Y gastric bypass procedure for the treatment of morbid obesity. A mercury-weighted esophageal bougie was inadvertently used during construction of the anastomosis. A suture placed through the distal tip of the device caused elemental mercury to leak into the peritoneum. Two days later, the patient underwent another surgical procedure for removal of the mercury. Intermittent air

measurements taken from the laparoscope exhaust showed a peak intraperitoneal mercury concentration of 98,169 ng/m³. Blood mercury levels peaked at 146 µg/L on day 22 after the exposure, and urine mercury concentrations peaked on day 43 at 227 µg/L. The patient had no evidence of acute toxicity, but he was found to have proteinuria on follow-up evaluation.

Discussion Patients can be exposed inadvertently to toxic amounts of elemental mercury when the integrity of medical devices is compromised. We encourage hospitals to discontinue the use of devices that contain mercury. Effective alternatives that do not pose exposure risks to patients or health care workers are readily available.

Keywords Mercury · Peritoneal exposure · Bougie

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Introduction

Elemental mercury causes significant toxicity when inhaled, but is poorly absorbed orally and rarely causes systemic toxicity when ingested [1]. When the gastrointestinal tract is compromised, significant absorption can occur [2]. Mercury enters the peritoneal space, where it is oxidized into the readily absorbed inorganic form [1]. This can lead to local effects such as obstruction and systemic manifestations, including renal dysfunction and nervous system toxicity [1].

Elemental mercury is used in medical devices including bougies to weigh them down. A bougie is a thin, cylindrical instrument with a tip for insertion into a body cavity to facilitate passage of endotracheal or gastric tubes [3]. The rupture of medical devices containing mercury is uncommon, but has been reported with Cantor tubes used for gastrointestinal decompression [2]. This report describes an elemental mercury spill into the peritoneum of a patient undergoing a laparoscopic Roux-en-Y gastric bypass procedure.

Case Report

A 64-year-old man with a history of diabetes mellitus, hypertension, atrial fibrillation, hypercholesterolemia, peripheral neuropathy, renal insufficiency, gout, and obstructive sleep apnea underwent an elective laparoscopic Roux-en-Y gastric bypass procedure to treat morbid obesity. To evaluate the integrity of the proximal anastomosis, insertion of an orogastric tube was attempted unsuccessfully. A second attempt was made using an esophageal bougie to facilitate tube passage. A stitch was placed through the tip of the bougie to secure its placement. The bougie removed when the operation was completed. Shortly thereafter, an operating room (OR) technician noticed silver beads in the sink and on the floor, which were traced back to the bougie tip. Further investigation revealed the tip contained elemental mercury; however, the volume of the spill was not quantified. The HazMat team was notified and the OR where the procedure was performed and three adjacent ORs were closed for decontamination for 24 h.

The patient was informed of the incident upon recovery from anesthesia. He underwent computed tomography (CT) of the abdomen and pelvis, which demonstrated mercury within the gastrointestinal tract and peritoneal cavity (Fig. 1). Two days later, laparoscopy with fluoroscopic assistance was undertaken to remove the mercury. Electrocautery and harmonic scalpel were avoided near areas of contamination to prevent aerosolizing the mercury. Some of the beads were removed, but others remained near the anastomosis and throughout the peritoneum and could not be recovered.

During the procedure, ambient air mercury measurements were obtained using a Lumex RA-915 Zeeman mercury spectrometer. The concentrations in the OR remained less than 200 ng/m³ throughout the procedure. The same spectrometer was used to measure mercury in the exhaust from the laparoscope, representing intraperitoneal mercury concentrations. The maximum reading, 98,169 ng/m³, was

Fig. 1 Computed tomography scan demonstrating intraperitoneal mercury

obtained 141 min into the procedure, when mercury was being suctioned out of the cavity (Fig. 2).

During the patient's hospital stay and subsequent outpatient evaluation, he exhibited no acute manifestations of mercury toxicity nor did he require chelation therapy. Serial blood and urine mercury concentrations were obtained. The blood level peaked at 146 µg/L on day 22 post-exposure; the urine concentration peaked on day 43 at 227 µg/L (Fig. 3). A brain CT scan performed on the day of surgery demonstrated cerebral atrophy and chronic microvascular ischemic changes.

Thirty-five days after the initial surgery, the patient had an outpatient neurologic evaluation. He reported no new symptoms related to the exposure. He had an essential tremor, involving his head and both hands, which was present for the past 4 years. He reported no sensory complaints and his gait improved because of a 50-lb weight loss. The neuropsychological evaluation found no evidence of cognitive impairment related to mercury exposure. Current perception thresholds were elevated for large and small myelinated and unmyelinated nerve fibers, likely secondary to diabetic neuropathy, which was present before the mercury exposure. His electrolyte concentrations and complete blood cell count were normal. The patient had an elevated but stable creatinine concentration of 1.6 mg/dL. Before surgery, the patient's total urinary protein concentration was 480 mg/24 h; 44 days after the exposure, the concentration was 535 mg/24 h and at 88 days, it was 2301 mg/24 h. The patient's hypertension and diabetes mellitus were well controlled following surgery; therefore, the increasing degree of proteinuria was attributed to the ongoing mercury exposure.

Discussion

Elemental mercury has been used since the 1940s to weight medical devices. In theory, the risk of toxicity would be low in the event of a spill, because the gastrointestinal tract does not absorb elemental mercury well [1, 2]. However,

Fig. 2 Intraperitoneal mercury concentrations measured during surgery

Fig. 3 Blood and urine mercury concentrations following exposure

mercury-weighted devices may be used in situations where the integrity of the gastrointestinal tract is compromised and instrument failure can lead to significant exposure. Patients with intestinal inflammation or ischemia are at risk due to the increased potential for perforation [2].

Complications secondary to intraperitoneal exposure to mercury, primarily from orogastric tubes, have been reported [2, 4–7]. Enterocutaneous and rectal fistulas formed following intraperitoneal mercury exposure. The fistulas did not heal until the mercury was removed, suggesting mercury causes chronic inflammation of the surrounding tissue, promoting fistula formation [4, 5]. Mercury contamination of the peritoneum has been associated with granuloma formation and intestinal obstruction [2, 6]. In some cases, the mercury became encapsulated in fibrous tissue and did not induce systemic toxicity [4–6]. If the leak occurs at the level of the esophagus, mercury can enter the mediastinum. Systemic toxicity following peritoneal contamination with mercury has been documented [2, 7]. The central nervous system (CNS) is particularly susceptible to mercury poisoning: elemental mercury in the peritoneum is oxidized and absorbed. It crosses the blood–brain barrier and accumulates in the CNS, leading to memory loss, behavioral changes, tremors, weakness, and impaired coordination and gait. Mercury is also toxic to peripheral nerves [1, 2, 7]. The kidneys, skin, and gastrointestinal tract can be affected by elemental mercury.

Treatment of peritoneal elemental mercury exposure can be complex and multifaceted. Whole bowel irrigation (WBI) can be considered if a significant amount of mercury is present in the gastrointestinal tract. When WBI is contraindicated or if the contamination occurred outside the gut lumen, surgical removal might be warranted [4–6]. Mercury can become loculated in scar tissue, making removal difficult, and, sometimes, impossible [2]. Chelation therapy with dimercaptosuccinate has been used to treat patients with peritoneal mercury exposure, but with limited success because of residual mercury deposits [2].

The patient did not develop acute mercury toxicity, but his increasing proteinuria could have been a consequence of the ongoing exposure. The significance of the elevated mercury level in the air measurements is unclear as these measurements are not routinely obtained. Elevated levels of mercury in ambient air pose a threat to employees, because elemental mercury is toxic when exposure occurs via inhalation [1]. To protect workers, the U.S. Occupational Safety and Health Administration set a permissible exposure limit for mercury at 0.1 mg/m^3 as an 8-h time-weighted average (TWA) [8]. The highest mercury concentration that was measured in the laparoscope exhaust was $98,169 \text{ ng/m}^3$ (0.098 mg/m^3), which was just below the TWA.

There are several medical devices that contain mercury; however, their use has largely fallen out of favor. Mercury thermometers were banned in 2003 and most sphygmomanometers have been replaced with aneroid and electronic devices [9, 10]. Mercury has been removed from the majority of tracheal intubation devices. Conversely, intestinal tubes continue to be used and often contain more elemental mercury (approximately 450 g) than other devices. Viable alternatives to mercury-weighted esophageal tubes are available, including air, water, and tungsten-weighted tubes, some of which are radiopaque [10]. In addition to the concern for toxicity, there are significant costs associated with decontamination after a mercury spill. One institution reported \$26,000 in clean-up expenses due to sphygmomanometer spills over a 2-year period [9].

Widespread efforts have been undertaken in the USA to remove mercury from hospitals. In 1998, the American Hospital Association, in conjunction with the Environmental Protection Agency (EPA), developed a memorandum of understanding (MOU) calling for the removal of mercury-containing waste from the hospitals by 2005 [9, 10]. The primary motivation for the MOU was environmental preservation, not patient safety. Between 1991 and 2000, the U.S. Food and Drug Administration received reports of 58 gastrointestinal device failures that resulted in mercury exposures. In 2002, the EPA issued best practice guidelines for the management of mercury waste in healthcare facilities, but they are not legally enforceable [10]. Professional organizations such as the American Academy of Pediatrics have formally recommended against the use of mercury-containing medical devices [9]. Despite these recommendations, mercury-containing medical devices continue to be used both intentionally, and as in this case, inadvertently [9, 10].

Conclusion

The patient described in this report experienced intraperitoneal exposure to elemental mercury from iatrogenic damage to a mercury-weighted bougie. Although elevated mercury

levels were documented in the patient's blood, urine, and intra-abdominal air, he did not suffer acute toxicity, but demonstrated worsening proteinuria. The patient required an additional surgical procedure to remove the mercury, which is not without risk. We encourage hospitals to abandon the use of instruments that contain mercury, in the interest of patient and worker safety, as viable, less toxic alternatives are available.

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Conflicts of Interest None.

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