

A Call to Action: What Physicians Need to Know about Water Beads

Water beads are sold under a variety of brand names. Originally used for industrial purposes, recently water beads have been heavily marketed as a “non-toxic” sensory toy for children and as ammunition for water bead guns. The beads are often imported and sold as both an agricultural soil conditioner and as a sensory toy for children, without the chemical ingredients and composition listed on the product’s label. Water beads/ Super absorbent polymer balls are designed to absorb water, expand in size and volume, and are most often made of polyacrylamide-polyacrylate (Han et al., 2021).

Polyacrylamide is considered non-toxic, however it is made from the polymerization of neurotoxic acrylamide. According to the Albert Einstein College of Medicine, polymerized acrylamide gels should be treated with the same caution as acrylamide monomers themselves to avoid repeated accidental exposure to neurotoxic acrylamide monomers (Environmental health & safety: Acrylamide, n.d.). Polyacrylamide solid gels, water beads, may contain residual and extremely toxic acrylamide monomers in concentrations of 10-30% (Chen, 1979). Although water bead toys meet current CPSIA standards for heavy metal and phthalate levels, each bag/batch of beads is not required to be pre-tested for monomer concentration levels before being placed in commerce.

While acrylamide polymers are too large to be absorbed, acrylamide monomers are easily absorbed into an organism's circulatory system from dermal exposure, inhalation, and ingestion. Polyacrylamide for agricultural purposes is legally permitted to contain a residual level of acrylamide thousands of times greater in concentration than polyacrylamide used in cosmetic formulations and water treatment for drinking water; 500 ppm for agricultural purposes, 0.1 to 0.5ppm for cosmetics, and the residual acrylamide limit for water suppliers by the EPA is less than 0.5 ppb. (Chalker-Scott, 2007)(Center for Science in the Public Interest, 2003). Manufacturers are not required to disclose the initial concentration of acrylamide monomer used to create polyacrylamide or the amount of residual acrylamide monomer remaining after polymerization in all toys containing polyacrylamide-copolymer.

When ingestion of water beads is suspected a high degree of suspicion is necessary. The beads do not behave as traditional foreign bodies due to their size and chemical composition. The chemical composition of the beads is generally unknown to physicians at the point of care and consumers at the point of purchase. Consumption and aspiration of water beads pose a public health risk, and the public should be informed of the dangers (Faytrouni, et al., 2021). Although acrylamide loses some toxicity after polymerization, it can still cause chemical corrosion of the nasal mucosa and can enter the digestive and respiratory tracts, where it is absorbed, entering the systemic circulation and causing toxic reactions (Han et al., 2021). “Increased oral exposure to acrylamide impairs gastric emptying, intestinal motility, mucus secretion and compromises digestive and absorptive functions of the small intestines, especially the duodenum. These observations may be ascribed to acrylamide-induced impaired neuronal signaling, autonomic neuropathy, oxidative stress, inflammation and cell necrosis” (Ige et al., 2021). Additionally, the reduction in gastric protective factors caused by acrylamide exposure contributes to the dose-dependent degeneration of gastric mucosal integrity, putting the patient's mucosa at risk for erosions and lesions (Ige et al., 2019)

Water beads are banned in Italy and Malaysia because they are a safety hazard. Water beads should not be marketed to children and their families as toys, sensory toys, or therapeutic aids. Because "non-toxic" is not a regulated term, "non-toxic" claims on a product's label or online listing should not be solely relied upon to eliminate poisoning or chemical exposure from the initial diagnostic assessment or the formation of differential diagnoses.

Information and research

- Ingestion of water beads requires prompt medical attention and evaluation. Diagnosis is made more complicated due to imaging difficulties. (Faytrouni et al., 2021) (Caré et al., 2021)
- Prompt endoscopic removal should be attempted for all patients with no signs of obstruction whenever the gel beads might be in the upper GI tract. (Faytrouni et al., 2021)
- Case management should not conform to standard protocols of foreign body removal, and early removal whenever possible should be attempted to prevent complications such as obstruction, lung injuries, nasal cavity injuries, hearing loss, seizures, brain injury such as cytotoxic edema, encephalopathy, and exposure to toxic chemicals specifically, extremely neurotoxic acrylamide. (Faytrouni et al., 2021) (Han et al., 2021)
- A high degree of suspicion is necessary for prompt diagnosis due to imaging difficulties, beads may mimic duplicated cysts versus presenting as a traditional foreign body. (Mullens et al., 2021)
- Duplicate cysts are congenital GI tract alignment abnormalities. Duplicate cyst structure can be divided into cystic or tubular on the basis of their structure. Research indicates identification of duplicated cysts is best assessed using ultrasound (Sangüesa Nebot et al., 2018) (Di Serafino et al., 2015)
- Due to the ability of water bead material to mimic duplicated cysts, imaging utilized to identify duplicate cyst lesion pathology, ultrasound, should be utilized during assessment for potential water bead ingestions. Medical professionals should be aware ultrasound may underestimate the number of water beads when compared to endoscopic evaluation (Kim et al., 2020)
- Water beads can collect, forming a bezoar, asymptotically in the GI tract without belly distention or traditional GI symptoms of distress. (Faytrouni et al., 2021) (Alharbi, & Dabbour., 2020)
- Surgical management with complete removal of hydrogel granules from the gastrointestinal tract is required, when the child presents to a hospital with intestinal obstruction symptoms and surgeons must be aware the beads have the ability to collect lower in the GI tract and form a new mass if all beads are not removed. Surgeons should also be aware ultrasound can miss beads lower in the digestive tract (Shangareeva et al., 2019).
- Pediatric patients who are young or non-verbal cannot be relied upon to effectively and consistently communicate pain. Furthermore, "Pediatric patients are not reliable historians and events are not typically witnessed" (Sterling et al., 2016)
- Symptoms of pain / distress may be less obvious to those outside the immediate household and include increased night wakings, increased fussiness and irritability.

Cases presenting with a dermatitis rash on the mouth and/or hands should be handled very carefully. The presence of a dermatitis rash should alert clinicians to the possibility the patient has suffered a higher level acrylamide dose exposure. Patients, especially ones with the rash should be monitored for follow up care and closely monitored for any signs of regression or neurological involvement. Referral to the developmental pediatrician, neurology, and ECI may be needed. A patient's clinical history is often the cornerstone of diagnosis in neurotoxicology. Tests to identify exposure to acrylamide are not readily and widely available to clinicians: laboratory studies are unhelpful, evidence of peripheral neuropathy on nerve conduction studies supports the diagnosis of acrylamide neurotoxicity, normal studies do not exclude the diagnosis. (*Acrylamide - health effects, n.d.*) (Acrylamide (PIM 652). n.d.). (*Public health statement acrylamide - agency for toxic..., 2012*). (*Acrylamide EHC 49, 1985*)

Toxicity symptoms in pediatric patients particularly when the water bead ingestion timeframe is unknown include:

- Dermatitis rash
- Patient may have rhinorrhoea
- Projectile vomiting and other traditional obvious obstruction symptoms appear after the rash and can be delayed for long periods after initial ingestion due to beads not consistently traveling through the digestive tract
- Seizures
- GI symptoms such as constipation and/or diarrhea
- The patient is likely to be very clingy to caregivers
- Increased need to nurse
- Weight loss with normal appetite
- Signs and symptoms of motor and sensory peripheral neuropathy
- Cytotoxic edema (EEG may be abnormal when beads are in patient according to one case study [not enough evidence to definitively say if all cases will present this way], CT scan and MRI are normal; according to radiopaedia MRI with diffuse weighted imaging is able to identify cytotoxic edema (Goel & Bell, 2013)
- Toxic Brain Encephalopathy

Water beads should not be marketed as toys, sensory toys, or therapeutic aids to children and their families. Because "non-toxic" is not a regulated term, "non-toxic" claims on a product's label or online listing should not be relied on solely to exclude poisoning or chemical exposure from initial diagnostic assessment or differential diagnosis formation. Water bead ingestion, insertions, toxicity, and other water bead injuries should be reported to the Consumer Product Safety Commission (CPSC) and poison control centers. Do not hesitate to seek guidance from specialists associated with the Pediatric Environmental Health Specialty Units.

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