



Outcomes of ingested superabsorbent polymers (“water beads”): A poison center study

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ABSTRACT

Background: Superabsorbent polymers (SAPs) are hydrophilic polymers that expand many-fold from their original size after contact with water. Ingestions of “water beads” by young children have been reported to cause bowel obstruction however, the incidence of bowel obstructions is unknown.

Methods: We conducted a retrospective study analyzing ingestions reported to our regional poison center from January 1, 2002 to April 25, 2023. The primary outcome was development of bowel obstruction. Secondary outcomes included development of symptoms, imaging, interventions, disposition, and outcome.

Results: Of 256 cases reviewed, 217 met inclusion criteria, with 84 % of ingestions occurring in children under six years of age. Of the 217 analyzed cases, no patients developed bowel obstruction. No clinical effects were reported in 54.8 %, while 4.1 % had minor effects, and less than 1 % were coded with moderate effects. There were no cases coded with major effects or death. Fourteen patients underwent imaging which showed no abnormalities, and no patients were admitted to the hospital. Most patients (83.4 %) were monitored at home. Follow-up attempts were made in 53 % of cases, with an average of 45 h of follow-up time.

Discussion: None of the patients reported to our poison center had abnormal imaging, required admission, developed a bowel obstruction, or required a procedure for foreign body removal. Though cases of bowel obstruction have been reported in literature, the incidence appears to be rare.

Conclusion: In our study, no bowel obstructions, admissions, or severe or fatal outcomes were documented, indicating a generally favorable outcome from SAP ingestions. Given reports of serious outcomes in literature, clinicians should continue to use clinical judgement to evaluate patients on a case-by-case basis for potential complications.

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1. Introduction

Superabsorbent polymers (SAPs), derived from hydrophilic acrylic acid polymers, exhibit a remarkable expansion capacity of up to 230 times their dry size upon contact with water [1,2]. SAPs have gained renewed interest in agriculture, concrete engineering, sanitary products, and children's toys [1,2]. The popularity of SAP-based “water bead” toys for children has led to an increase in ingestions, with reported cases of bowel, nasal, aural, and pulmonary obstructions [3–6]. A review of SAP ingestions identified 43

cases of bowel obstruction in patients with ages ranging 6 to 36 months. All patients reported persistent vomiting with a reported mean bead diameter of 30 mm. Two cases underwent endoscopic removal, and 41 underwent surgical removal of the SAP with two fatal cases [6]. In contrast, a retrospective study by Texas Poison Centers, focusing exclusively on Orbeez™ ingestions over a 5.5-year period, showed that most patients were managed outside of healthcare settings without serious complications [7]. Managing patients with SAP-related ingestions can be difficult due to the unknown rate of serious outcomes. Understanding the risks associated with this ingestion can aid in the management and disposition of these patients in the emergency department. Our study aims to analyze outcomes of all SAP ingestions reported over a 21-year period to our regional poison center, which serves a population of approximately 3.4 million residents with an average of 27,000 human cases per year.

Abbreviations: SAP, superabsorbent polymer; AAPCC, American Association of Poison Control Centers.

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2. Methods

This was a retrospective cohort study conducted by chart review of electronic records of our regional poison center from January 1, 2002 to April 25, 2023. The electronic database Toxicall™ was searched for human exposures using verbatim terms such as “water bead”, “expanding beads”, “polymer water beads”, “super absorbent polymer”, “Orbeez”, “expanding water crystals” as specific AAPCC codes do not currently exist. Inclusion criteria were single acute human ingestions of superabsorbent polymers, of all ages, including suspected ingestion. Cases were excluded if there was an exposure to non-absorbent polymers and non-oral route of exposure. The primary outcome was the development of bowel obstruction. Secondary outcome measures included development of any symptoms, imaging, interventions, disposition, total follow-up time, and poison center outcome. Cases were divided between five abstractors, consisting of medical toxicologists or toxicology fellows, who analyzed the narratives of each case to assess inclusion criteria and outcomes.

3. Results

Our search resulted in 256 total cases who met inclusion criteria. Thirty-nine were excluded for other routes of exposure such as inhalational or dermal exposure, or ingestion of small fragments of pre-expanded beads. Therefore, 217 cases were analyzed for this study. Children less than six years of age comprised 182 (84 %) cases with 110 (51 %) males [Table 1]. Most calls originated from home (81 %), while 13 % originated from an HCF or clinic, and 6 % from other sites, such as school. Attempts to quantify the number of beads ingested were made, but due to a large number of unwitnessed ingestions, the quantity was unknown in 89 (41 %) of cases. The quantity ingested was reported to be one bead in 77 (35 %) cases, two beads in 22 (10 %), estimated between one to ten beads in 22 (10 %) cases and between 11 and 20 beads in four (2 %) cases. Two callers reported ingestions of up to 30 beads and another as much as 70 beads without reported adverse effects. Patients developed symptoms in 21 (10 %) cases, 13 (6 %) of which reported vomiting. Time to onset of symptoms was reported in 15 cases, ranging from immediate to 228 h, with a median of 7 h. Final outcomes included 119 (54.8 %) patients with no clinical effect and nine (4.1 %) with minor effects [Table 2]. There were two cases coded as moderate effect due to vomiting. Of the 14 imaging studies, none demonstrated acute abnormalities [Table 1]. Furthermore, there were no cases of intestinal obstruction, procedures performed, or hospital admission. The majority of patients (83.4 %) were monitored at home, with the remainder seen in clinic or discharged from the emergency department. Follow-up calls were attempted up to seven days from ingestion. Follow-up was obtained in 53 % of cases, with an average of 45 h of follow-up time.

4. Discussion

Review of the 217 SAP ingestions reported to our poison center over a 21-year period revealed overall favorable outcomes. There was no apparent relationship between quantity of beads ingested and outcome based on our limited data. Our findings are similar to the study published by Texas Poison Centers in 2019 that exclusively reviewed 110 Orbeez™ ingestions that were largely managed outside of the healthcare system without serious complications [7]. Our study differed by utilizing a longer study period and inclusion of all SAPs.

A literature review published in 2022 that included only cases of bowel obstruction following SAP ingestion reported 43 cases of bowel obstruction with ages ranging 6 to 36 months in which all patients reported persistent vomiting with a mean expanded bead diameter of 30 mm (range 25–60 mm). Two patients underwent endoscopic removal, and 41 underwent surgical removal of the SAP with two fatal cases. The fatalities were due to complications from surgical removal

Table 1

Characteristics of superabsorbent polymer (SAP) ingestion cases reported to our regional poison center. *The estimated number of beads reported was widely variable and included ranges such as “1 to 6” and “less than 5” due to a large number of unwitnessed ingestions.

Study Population	N = 217
Male (% total)	110 (51 %)
Age, years, median (IQR)	2 (3)
Age group, years (% total)	
<6	182 (84 %)
6 to 12	26 (12 %)
13 to 18	2 (1 %)
>18	7 (3 %)
Caller origin	
Home	176 (81 %)
HCF/Clinic	29 (13 %)
Other	12 (6 %)
Type of product	
Expanding bead	211 (97 %)
Expanding crystal	6 (3 %)
Estimated Quantity Ingested*	
1 bead	77 (35 %)
2 beads	22 (10 %)
Between 1 and 10	22 (10 %)
Between 11 and 20	4 (2 %)
30 beads	2 (1 %)
70 beads	1 (0.5 %)
Unknown	89 (41 %)
Symptoms Developed?	
Yes	21 (10 %)
No	196 (90 %)
Symptoms	
Vomiting	13 (59 %)
Abdominal pain	4 (18 %)
Constipation	2 (9 %)
Fever	5 (23 %)
Choking	1 (4.5 %)
Diarrhea	2 (9 %)
Cough	1 (4.5 %)
Imaging	
Abdominal x-ray	11 (5 %)
Ultrasound	1 (0.5 %)
CT	1 (0.5 %)
Chest x-ray	1 (0.5 %)

and concomitant infection leading to sepsis in both cases [6]. These reported bowel obstructions cases are important to characterize but do not provide an estimate of risk due to the lack of a denominator of

Table 2

Outcomes and final disposition of patients with reported superabsorbent polymer ingestion to our regional poison center.

Outcome	N = 217
No effect	118 (54.4 %)
Minor effect	9 (4.1 %)
Moderate effect	2 (0.9 %)
Major effect	0 (0 %)
Death	0 (0 %)
Not followed, minimal clinical effects possible	66 (30.4 %)
Not followed, judged as nontoxic	17 (7.8 %)
Unrelated effect, the exposure was probably not responsible for the effect(s)	5 (2.3 %)
Disposition	
Stayed home	180 (83 %)
Outpatient clinic	3 (1.4 %)
Discharged from ED	34 (15.6 %)
Admitted to floor	0 (0 %)
Admitted to ICU	0 (0 %)

benign cases. Our study limitations included inconsistent follow-up, inconsistent documentation by specialists in poison information, unwitnessed ingestions, undocumented sizes and quantities of beads ingested, and inter-rater reliability was not assessed. In addition, benign ingestions are likely under-reported to poison centers. Despite these limitations our paper highlights the lack of serious complications over a 21-year review of data from a single poison center. Based on the findings of this study, we revised our poison center guidelines to reduce the frequency of phone follow-ups from nearly every day for five days to follow-ups only on days one and five after ingestion. We also advised calling the poison center back at any time if the patient develops any concerning symptoms. A larger study will be needed to determine a more accurate rate of adverse outcomes and to identify prognosticating factors. Less than 1 % (13 of 217) of patients developed vomiting in our study, and all cases of bowel obstruction reported in the literature review reported persistent vomiting, suggesting that there is likely low utility in imaging or procedural intervention in patients without persistent vomiting.

5. Conclusion

Our study demonstrated no bowel obstructions, operative interventions, hospital admissions, or severe or fatal outcomes from SAP ingestions reported to our poison center. The overall outcome from SAP ingestions appears to be favorable. However, given reports of serious outcomes in literature, clinicians should continue to use clinical judgment to evaluate patients on a case-by-case basis for potential complications, such as bowel obstruction.

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Consent of patients

This study was approved and determined to be exempt from the Institutional Review Board at Virginia Commonwealth University Health System.

CRediT authorship contribution statement

Catherine Dong: Writing – review & editing, Writing – original draft, Visualization, Supervision, Project administration, Methodology,

Investigation, Formal analysis, Data curation, Conceptualization. **Oyeyimika Oyekanmi:** Writing – review & editing, Writing – original draft. **Zach Deuell:** Writing – review & editing, Writing – original draft. **Andrew Chambers:** Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Emily Kershner:** Writing – review & editing, Methodology, Investigation, Data curation, Conceptualization. **S. Rutherford Rose:** Writing – review & editing, Supervision, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Kirk L. Cumpston:** Writing – review & editing, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Brandon K. Wills:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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