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Baking soda misuse as a home remedy: case experience of the California Poison Control System

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SUMMARY

What is known and objective: **Baking soda is a common household product promoted by the manufacturer as an antacid. It contains sodium bicarbonate and has the potential for significant toxicity when ingested in excessive amounts. Characterizing the patterns and outcomes from the misuse of baking soda as a home remedy can guide the clinical assessment and preventative counselling of patients at risk for use of this product.**

Methods: **We conducted a retrospective review of all symptomatic cases involving ingestion and misuse of a baking soda powder product that were reported to the California Poison Control System between the years 2000 and 2012.**

Results and discussion: **Of the 192 cases we identified, 55·8% were female, ages ranged 2 months to 79 years, and the most common reasons for misuse included antacid (60·4%), 'beat a urine drug test' (11·5%) and treat a UTI (4·7%). Most cases (55·2%) had significant symptoms warranting a medical evaluation, whereas 12 patients required hospital admission developed either electrolyte imbalances, metabolic alkalosis or respiratory depression.**

What is new and conclusion: **Misuse of baking soda can result in serious electrolyte and acid/base imbalances. Patients at highest risk of toxicity may include those who chronically use an antacid, those who use the method to 'beat' urine drug screens, pregnant women and young children. Self-treatment with baking soda as a home remedy may also mask or delay medical care thereby complicating or exacerbating an existing medical problem. We suggest that healthcare providers counsel high-risk patients about the potential complications of misuse of baking soda as a home remedy.**

WHAT IS KNOWN AND OBJECTIVE

Baking Soda is a common household product that contains sodium bicarbonate and is marketed to consumers for baking, household and personal care uses (Arm & Hammer®[1]). Baking Soda is frequently used as antacid despite the availability of other pharmaceutical antacids. The most common case reports of baking soda toxicity involve its excessive use as an antacid.[2–5] A review of the National Poison Data System (NPDS), consisting of cases reported to US poison centres over a 12-year period ending in 2011, revealed five deaths attributed to ingestion of baking soda.[6]

The leading manufacturer of baking soda markets its use as an antacid and provides dosage recommendations on the side of the package: 'Add 1/2 teaspoon to 1/2 glass (4 fl. oz.) of water every 2 h, or as directed by physician. Dissolve completely in water. Accurately measure 1/2 teaspoon. Do not take more than the following amounts in 24 h: seven 1/2 teaspoons or three 1/2 teaspoons if you are over 60 years'.[1] According to the manufacturer, each teaspoon of baking soda contains 4·8 g, corresponding to 59 mEq of sodium and 59 mEq of bicarbonate.[1] By comparison, oral sodium bicarbonate tablets (650 mg) contain only 7·7 mEq of sodium and 7·7 mEq of bicarbonate.[7]

After December 1990, the printed instructions were modified to advise against administering the product to children under age 5 years, because of reported seizure and respiratory depression in children.[5,8] The seizure occurred in a 6-week-old baby who had being receiving 'a pinch' of baking soda in water from his mother to help the infant burp.[5] A dose as low as 1–3 tbs of baking soda was associated with death in a child as per the NPDS.[6] Ingestion of baking soda has also been reported as a treatment for urinary tract infections, method to detoxify the body and to pass or 'beat' urine drug screens.[9,10] Baking soda misuse has been reported to cause significant electrolyte and acid-base abnormalities including alkalosis, hypernatremia, hypokalemia, hypochloremia and hypocalcaemia.[11–22] The pathophysiology and expected clinical findings from excessive ingestion of baking soda are summarized in Table 1.

Our objective was to characterize the patient demographics, reason for use, symptoms and outcomes from cases involving the ingestion and misuse of baking soda powder products reported to California Poison Control System (CPCS) over a 12-year period. We suspected that inappropriate self-administration of baking soda as a home remedy still occurs and has led to significant toxicity. In addition to that, healthcare providers should be aware of baking soda misuse patterns and the associated adverse effects.

METHODS

Study design and case inclusion

A retrospective chart review of the California Poison Control System (CPCS) electronic database was conducted for sodium bicarbonate cases reported between 2000 and 2012. The CPCS

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Table 1. Pathophysiology of baking soda misuse associated acid/base and electrolyte imbalances

Acid/base and electrolyte imbalance	Pathophysiology	Expected finding
Alkalosis	Bicarbonate diuresis causes a reduction in vascular fluid volume which decrease glomerular filtration rate[8] Hypokalemia and hypochloremia[2,10]	High serum bicarbonate levels cause a compensatory respiratory acidosis and apnoea which have been reported in children[1,8]
Hypernatremia	Due to sodium load as one teaspoon of baking soda will have 53 mEq[5]	Irritability, lethargy and seizure[1,11,12]
Hypokalemia	Intracellular shift of potassium[13,14] Urinary excretion of bicarbonate can enhance potassium renal losses if sodium depleted[15] Once sustained hypokalemia occurs, it can worsen the alkalosis by stimulating proximal renal H+ excretion and net bicarbonate reabsorption[16]	Hypokalemia can cause muscle weakness, QT prolongation and ventricular arrhythmias[2,10,17]
Hypochloremia	Loss of gastric acid due to vomiting[3] Worsen alkalosis by preventing distal collecting ducts protein transporter 'pendrin' exchange of bicarbonate and chloride in luminal membranes preventing furthering bicarbonate excretion[18]	Worsens metabolic alkalosis (chloride depletion alkalosis)[18]
Hypocalcaemia	Alkalosis decrease ionized calcium by increasing protein-calcium binding[19]	Tetany, cardiac arrhythmias[20]

provides treatment advice and referral assistance to the public as well as to healthcare providers through four highly integrated sites operating under a single administration. CPCS services are available to all residents of the state of California through the CPCS toll-free emergency hotline, 24 h a day, 365 days a year. Each reported poisoning case is entered prospectively into a clinical database (Visual Dotlab) by trained specialists in poison information (SPIs). The SPIs are licensed pharmacists or nurses with special training in clinical toxicology through a regional poison centre. They are individually certified by the American Association of Poison Control Centers (AAPCC) after passing a standardized national examination. For each case, the SPIs enter specific symptom, treatment and outcome codes according to AAPCC criteria; initial and follow-up notes are also entered into a text field for individuals referred to a healthcare facility.

Eligible cases involved those with a reported symptomatic intentional misuse ingestion of a baking soda powder form product. Misuse was defined as the inappropriate use of either dosages that exceeded that of the manufacturer, or for unproven indications, or if administered to children <5 years of age. The exclusion criteria were accidental exposures (i.e. unintentional ingestions that were not planned or unforeseen. For example, a child gains access to a box of baking soda or an adult inadvertently ingests baking soda such as mistaking for another product, for example toothpaste, cornstarch for cooking or in a contaminated drink or beverage.), asymptomatic cases, suicidal intent, all other routes of exposure (dermal, respiratory, eye, vaginal, etc.) and use of tablet dosage forms.

Data analysis

Cases meeting the inclusion criteria were analysed with the following data fields of interest: patient demographics (age/gender), quantity ingested, reason for use, symptoms, management site (e.g. non-healthcare facility vs. healthcare facility) and pregnancy status. A descriptive data analysis was performed using Microsoft Excel® 2010 (Microsoft Corp., Redmond, WA, USA). Cases with significant outcomes were defined as those that required hospitalization associated with baking soda ingestions. These cases were individually summarized with additional tabulation of abnormal serum electrolyte and arterial blood gas levels, and treatment.

The study was reviewed and approved by the University of California San Francisco Committee on Human Research.

RESULTS AND DISCUSSION

A total of 1299 cases were collected following the initial screening of the CPCS database. Of these, 192 met our inclusion criteria, and reasons for exclusion of cases are summarized in Fig. 1. The majority of cases, 55·8% (85/192), were female with a wide range of ages from 2 months to 79 years old. Baking soda was most commonly misused as an antacid, 60·4% (116/192), followed by use to pass or 'beat' a drug test, 11·5% (22/192), to treat a UTI, 4·7% (9/192), and to detoxify the body [either balance pH or cleanse body and colon], 4·7% (9/192). It was used also to induce vomiting in 3·6% (7/192), and 3·1% (6/192) used it for miscellaneous reasons with one patient each [to treat gout, fibromyalgia, chest pain, cancer, laxatives and for weight loss] with one patient. Reasons of use were unknown in 12% (23/192).

The doses used varied, whereas most were <2 teaspoons (tsp), 24% (46/192), followed by 19·7% (38/192) who used >1 tablespoon (tbs) and up to four tbs. A significant number of patients used higher doses with 15·6% (30/192) using more than one-fourth of a 8 ounce box, followed by 10·4% (20/192) using half-box and 4·7% (9/192) using more than one 8 ounce box. The dosage was unknown for 15·6% (30/192). A significant proportion of patients, 48·44% (93/192), had multiple symptoms with the most common being gastrointestinal symptoms coupled with other symptoms such as lethargy or weakness. Patients that had a single presenting symptom included the following complaints in order of frequency: abdominal pain, 11·98% (23/192), vomiting, 10·94% (21/192), nausea, 8·85% (17/192), diarrhoea, 8·33% (16/192), and abdominal bloating and gas, 4·17% (8/192). Neurological symptoms, such as drowsiness 1·56% (3/192), lethargy and weakness 4·69% (9/192) and numbness 1·04% (2/192), were reported less frequently.

Most cases, 55·2% (106/192), had significant symptoms that required medical care and were referred to an emergency department or their primary care physician. Unfortunately, follow-up information was lost in the majority of these patients

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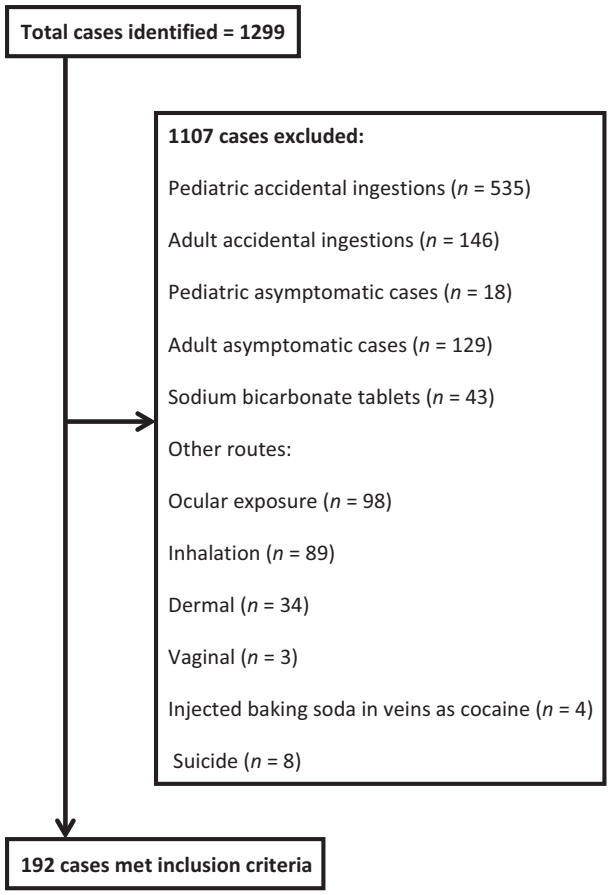

Fig. 1. Selection of identified cases of symptomatic baking soda ingestions.

with the exception of 12 admitted patients in whom details of their electrolyte and acid-base abnormalities, and treatment is summarized in Table 2. The most frequent use of baking soda in this group was as an antacid, and gastrointestinal symptoms were the most common presenting symptoms. Their electrolyte abnormalities included hypernatremia, hypokalemia, metabolic alkalosis and respiratory depression. An ECG was recorded for four of the admitted patients, three of which were described as abnormal including one described as ventricular ectopy. They all recovered with supportive care and intravenous fluids with potassium supplementation.

There were a couple of special population groups of patients that we found in our study. The first group included six children, who ranged in age from 2 months to 8 years of age, whereas five were given baking soda as an antacid and three were sent to the emergency department. The second group included five pregnant females in which four of them were using baking soda as antacid, whereas one required admission for medical care.

Baking soda was commonly found to be misused as an antacid in this study as the majority of patients, 60·4% (116/192) were using it as antacid and many in different dosages than that recommended on the product label. It is noteworthy that six children, aged 2 months to 8 years old, were given baking soda as an antacid despite the printed instructions that advised against administering the product to children under age 5 years due to the risk of inducing significant acid-base and electrolyte abnormalities.[1] Serious toxicity and death from baking soda ingestion have been reported in children.[5,8,14] Therefore, healthcare providers should warn parents against using baking soda as an antacid in younger children. We also found further evidence that use of baking soda in children may be a common practice by the public after reviewing and noting several information calls to the CPCS regarding from parents contemplating its use for their children. We excluded cases of dermal exposure of baking soda as it was our intention to evaluate its misuse as an antacid by ingestion. However, systemic toxicity can also result from topical application of baking soda as treatment of diaper rash if used in excessive amounts.[23]

The patients requiring hospital admission from ingestion of baking soda were more likely to have self-administered baking soda as an antacid, 42% (5/12), and in a higher dosage with two of these patients having ingested an 8-ounce box of baking soda or more, which is equivalent to at least 48 tablespoons of sodium bicarbonate corresponding to 691 g or 8496 mEq of sodium and bicarbonate. Six patients developed hypokalemia (<3·5 mEq/L) with the lowest recorded serum level of 2 mEq/L, and five patients required potassium replacement. Three of our patients had an abnormal ECG attributed to severe hypokalemia, which were a prolonged QT interval, ST wave changes and ventricular ectopy. They were at potential risk of serious cardiac arrhythmias if their hypokalemia had not been treated promptly as ventricular tachycardia have been previously reported with baking soda use.[2,12,19] Four patients had evidence of hypoventilation based on arterial blood gases with PCO_2 values >50 mmHg, indicating a compensatory hypercapnia. Compensatory hypoventilation is well-known physiological response to metabolic alkalosis, but is thought to be limited by the development of hypoxia.[8,24,25]

One patient in our series was using the baking soda as antacid and subsequently was diagnosed with a perforated bowel requiring surgical intervention. This case was illustrative of the problem of using a home remedy treatment which could delay seeking medical help, as well complicate or exacerbate an existing medical problem. The instructions on the package for baking soda state 'stop use and ask a doctor if symptoms last more than 2 weeks'.[1] This may be an inappropriate time frame as some patients may need medical intervention more urgently based on more serious symptomatology. The package also warns the user not to take the product when the stomach is overly full from food or drink. This warning was added at the request of the U.S. Food and Drug Administration (FDA) because of multiple case reports of spontaneous gastric rupture due to production of large volumes of carbon dioxide on neutralization of stomach acid by the baking soda.[26,27]

We found that a significant proportion of our cases, 11·5%, were ingesting baking soda to pass or 'beat' a urine drug test. This idea is propagated by online blog websites.[9] Of note, we found some consistency between the dosage recommended by online websites and that utilized by our cases with the majority using high dosages ranging from 2 to 12 tbs.[10] Another smaller proportion, 4·7%, of our cases were using baking soda to treat their UTI. This indication is included in some homeopathic books that suggest that baking soda can help decrease the burning sensation from a UTI by alkalinization of the urine.[28] This recommendation is based on the assumption that acidic urine is associated with more severe burning pain upon urination in a patient with a UTI. Although the suggested doses of baking soda are small for this indication (e.g. 1

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Table 2. Summary of the demographics, dose and reason for ingestion, serum electrolyte and acid-base abnormalities, and treatment for admitted patients following misuse of baking soda (n = 12)

Age (years)/ Sex	Dose	Reason	Presenting symptoms	Na (mEq/L)	K (mEq/L)	CL (mEq/L)	HCO_3 (mEq/L)	Arterial blood gas values: PCO_2 (mmHg), PO_2 (mmHg)	Treatment
19/F	1 box	To pass drug test	Vomiting	152	NA	NA	NA	NA	IVF
41/F	¼ box	Antacid	Abdominal pain	145	2·9	92	32	NA	NA
36/M	>1 box	Antacid	Multiple GI	162	4	11	35	NA	IVF
46/F	1/8 box	To treat cancer	Muscle pain	140	3·9	105	27	NA	IVF
25/F Preg	NA	Antacid	Multiple GI, lethargy	132	3	0	21	NA	IVF &KCL
43/M	NA	NA	Confused, lethargic	154	2·9	99	38	pH = 7·48/PO_2 = 60	IVF &KCL
44/M	½ box	Antacid	Vomiting	133	2	73	66	pH=7·58/PCO_2 = 54	IVF &KCL
21/F	½ box	To pass drug test	Multiple GI	159	3·1	102	45	pH = 7·49/PCO_2 = 51·2	IVF &KCL
55/M	NA	Treat chest pain	Chest pain	138	NA	NA	34	NA	NA
40/F	NA	Antacid	Abdominal pain	136	NA	NA	25	NA	NA
19/F	¼ box	Induce Vomiting	Lethargy	155	2·7	107	40	pH = 7·33/PCO_2 = 70/ PO_2 = 76	IVF &KCL
45/M	1/8 tsp	NA	Multiple GI, lethargy	143	4·3	104	35	NA	IVF

F, female; M, male; NA, not available; box, package with 8 ounces; tsp, teaspoon; Multiple GI, several symptoms related to the gastrointestinal system; Na, serum sodium; K, serum potassium; Cl, serum chloride; HCO_3, serum bicarbonate; IVF, Intravenous fluid; KCl, potassium supplements.

tsp), most of these patients may exceed these doses if they experience persistent pain upon urination.

There were six pregnant females in our series who were using baking soda as antacid. One required hospital admission and treatment for intravenous fluid hydration and electrolyte correction. Use of baking soda as an antacid during pregnancy has resulted in serious toxicity with case reports of rhabdomyolysis or pregnant patients manifesting signs and symptoms mimicking pre-eclampsia.[29,30] Alcoholics are another high-risk group of patients for toxicity from use of baking soda. Alcoholic patients are at greater risk of volume depletion and electrolyte disturbances from poor oral intake. Serious toxicity have been reported including renal failure requiring dialysis with long-term abuse of baking soda in alcoholic patients.[4,31] However, we were unable to obtain the alcohol use history in our patients. In addition, patients taking diuretics should be advised not to use baking soda as they are at a higher risk of sodium load and hypokalemia.[2,17]

LIMITATIONS

There are several major limitations to the present study. First, the retrospective study design and data source used (poison control case reports) were an inherent limit to completeness of the data. SPIs and related personnel responsible for documenting PCC cases were not under protocol to collect information that would be interesting to this study that were not necessary for patient management (e.g., past medical history, alcohol use, other medications). As a result, much information is missing in our data set. Another factor for missing information in PCC reports is incomplete follow-up of patients. Patients are frequently lost to follow-up due to various reasons beyond the control of PCC personnel (e.g. patient leaving against medical advice or having already been discharged upon follow-up call). The ingested dose may not be precise in all cases as some of which were estimates and quantities expressed in different ways including teaspoon, tablespoon, cup and box.

WHAT IS NEW AND CONCLUSION

Baking soda if misused in excessive amounts can result in serious acid/base and electrolyte imbalance requiring medical treatment. Patients often exceed the doses recommended on the product label, but adverse side effects were also noted when the recommended doses were administered. Those at highest risk include those who chronically self-administered an antacid or those who use a method to 'beat' a urine drug test. Other patient populations that should avoid use of baking soda include young children, pregnant women, alcoholics and those who are on diuretics. Self-treatment with baking soda as a home remedy may also mask or delay medical care thereby complicating or exacerbating an existing medical problem. We recommend that healthcare providers be aware of this common practice and provide advice to patients who potentially misuse baking soda chronically as a home remedy.

CONFLICT OF INTERESTS

None of the authors have any conflict of interests.

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