

Swimming pool contact dermatitis caused by 1-bromo-3-chloro-5,5-dimethyl hydantoin

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Summary

Background. Bromo-3-chloro-5,5-dimethylhydantoin (BCDMH) is a chemical used as a disinfectant for recreational water. BCDMH was described as being responsible for an epidemic of irritant contact dermatitis in the UK (1983), and its sensitizing capacity was also discussed.

Objectives. The aim of this study was to assess whether BCDMH used to disinfect swimming pools and spas can cause allergic contact dermatitis among its users.

Methods. Ten patients suffering from dermatitis associated with using swimming pools disinfected with BCDMH and 40 controls were studied. Several dilutions of BCDMH, 10% to 1 ppm, were patch tested.

Results. All 10 patients studied showed a positive patch test reaction to BCDMH 1% in petrolatum. At least one case showed occupational relevance, with a positive reaction even at 1 ppm.

Conclusion. On the basis of the clinical findings, the positive patch test reactions to BCDMH, and the negative patch test reactions in controls, the suggested diagnosis was allergic contact dermatitis caused by BCDMH used as a disinfectant in the swimming pool water. Contact allergy should be taken into consideration when patients suffer from swimming pool-associated itchy dermatitis.

Key words: 1-bromo-3-chloro-5,5-dimethylhydantoin; allergy; contact dermatitis; hydrotherapist; occupational dermatitis; swimming pool.

Bromo-3-chloro-5,5-dimethylhydantoin (CAS 16079-88-2; BCDMH) is a chemical structurally related to hydantoin that reacts slowly with water, releasing hypochlorous acid and hypobromous acid. It is used as a disinfectant for recreational water. BCDMH has advantages as a swimming pool disinfectant as compared with chlorine, because it has no unpleasant odour, there

is only minor eye membrane irritation, and its stability to changes in pH is as good as that of chlorinated products. BCDMH was described as being responsible for an epidemic of irritant contact dermatitis in the UK (1983) (1), and its sensitizing capacity was also discussed (2, 3).

A series of patients who developed dermatitis associated with the use of BCDMH-disinfected swimming pools is presented. The individuals affected were exposed to different BCDMH-treated swimming pools; their symptoms appeared in 2009–2010. The aim of this study was to assess whether BCDMH used in swimming pools and spas can cause allergic contact dermatitis among its users. The recommended BCDMH concentration range in swimming pools is 3–6 ppm measured as halogen.

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Patients and Methods

Patients

Ten patients, 7 women and 3 men aged 32–67 years, with BCDMH-disinfected, swimming pool-associated dermatitis, were studied at either the Hospital Universitari de Tarragona Joan XXIII, IISPV, or the Hospital del Mar, Universitat Autònoma Barcelona. All patients developed visible eczematous cutaneous symptoms.

Forty controls, 20 from each centre, were BCDMH-tested after informed consent had been obtained, using the same protocols. Controls included healthy individuals and consecutive patients.

Each patient and control provided written informed consent to participate in the study. The diagnostic study was conducted in compliance with the Declaration of Helsinki and applicable local and European laws and regulations.

Patch testing

In all patients and controls, patch tests were performed with the European baseline series and other relevant series and allergens (Hermal Trolab-Almirall® and Allergeaze Marti-Tor®) and with BCDMH at various dilutions (see below). The allergens were applied with 8-mm aluminium Finn Chambers® on Scanpor® tape and fixed to the back with an adhesive tape such as Fixomullstretch® or Micropore™. The allergens in petrolatum filled slightly more than half of the chamber volume, and for aqueous allergens, a filter paper disc (Whatman 3M) was placed into the chamber. The routine patch test exposure time was 2 days. The results were recorded according to international guidelines (4). The standard 'positive outcome' (allergic reaction) of the patch test was defined as a morphologically + to +++ reaction between D2 and D4 after the application of the patch test that was not, upon final evaluation, considered to be irritant.

Patch test preparations

Special patch test series for patients with suspected swimming pool dermatitis caused by BCDMH were prepared by the pharmacy departments in both hospitals.

The patch test material was based on Aquabrome® tablets from Bayrol; Aquabrome® is a commercial BCDMH product that is commonly used in swimming pools. BCDMH represents >90% of the weight of the tablets (pH 4.6), with 70% active bromide. No excipient was stated as being present in the product composition. The recommended concentration of BCDMH for use in swimming pool disinfection is 1–3 mg/l. The solubility of BCDMH in water is 1.5 g/l; its density is 1.9 g/cm³.

Although the recommended BCDMH patch test concentration is 1–2% aqua (5), BCDMH was also tested in pet.

The series from Hospital Joan XXIII were tested with BCDMH in serial dilutions in water solution at 3, 0.3 and 0.03 mg/l. They were also tested with BCDMH at dilutions of 1%, 5% and 10% pet.

The series from the Hospital del Mar were tested with BCDMH in serial dilutions in pet. at 1, 10, 100 ppm, 0.1% (1000 ppm), 1%, and 5%.

The very low concentrations were applied in an attempt to determine the lowest concentration that was able to induce a positive patch test reaction.

A commercial patch test preparation of dimethylol dimethyl hydantoin 2% aqua (Allergeaze Marti-Tor®) was also used.

Results

Clinical manifestations

At Hospital Joan XXIII, 8 patients (6 women), aged between 32 and 67 years, were investigated. They presented with recurrent eczematous areas with itchy papules and vesicles, 6–24 hr after swimming in pools disinfected with BCDMH. One patient would usually develop the lesions after hydrotherapy sessions in a swimming pool at a medical centre; in the remaining 7 patients, the lesions appeared after they had been practising aqua gym at a fitness centre. The patients had no problems when using the same pools before they were disinfected with BCDMH or when they used pools disinfected with chlorine. None of the patients knew which type of chemical was being used at their usual swimming pools prior to medical consultation. This information was obtained by the clinicians.

At Hospital del Mar, a 36-year-old woman and a 38-year-old man suffering from generalized and recurrent itchy papulovesicular dermatitis occurring exclusively after immersion in BCDMH-treated swimming pool water were investigated (Fig. 1). Symptoms lasted for 6 and 12 months, respectively. The woman used to work as swimming and aqua aerobic teacher for 2–3 hr a day, 3 days a week. Water from a particular swimming pool treated with BCDMH triggered her symptoms. She was free of disease after using chlorinated and ozone-disinfected swimming pools. After a self-provocation test in a brominated swimming pool, a skin biopsy showed a large lymphohistocytic and eosinophilic dermal infiltrate with spongiosis and exocytosis. The man developed eczema when chlorine was replaced with BCDMH at the swimming pool that he attended weekly. None of

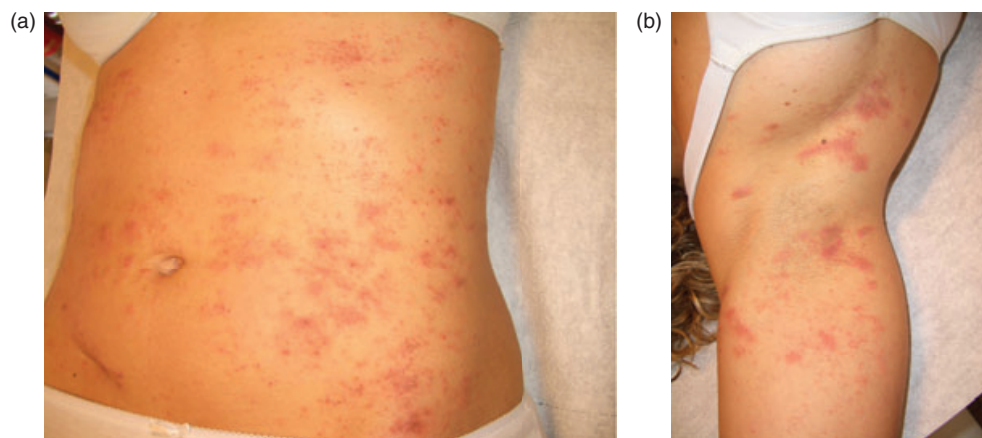


Fig. 1. A generalized delayed eczematous skin reaction on the trunk (a) and axillae (b) 96 hr after a provocation test. The patient was immersed free of disease in a BCDMH-disinfected swimming pool for 45 min.

the patients knew which type of disinfectant was used at the swimming pool before the medical consultation; this information was obtained by the clinicians.

Patch test results

The patients studied from the Hospital Joan XXIII showed the following positive reactions to BCDMH: 8 patients to 1%, 5% and 10% BCDMH pet.; 5 patients with 3 mg/l aqua; and 2 patients with 0.3 mg/l aqua. Four and 3 patients reacted positively (D4 ++ or +, respectively) at 1% BCDMH pet. Two and 1 patients reacted positively (D4 ++ or +, respectively) at 3 mg/l aqua BCDMH. Patch tests with dimethylol dimethyl hydantoin 2% aqua gave negative results in all of the patients.

Patch tests with BCDMH (aqua and pet.) at the concentrations described above were also performed in

20 controls (5 of them with atopic diathesis). BCDMH 10% pet. was positive in all 10 controls patch-tested and BCDMH 5% pet. in 5 of 10 controls patch-tested. Twenty controls patch-tested with BCDMH 1% pet. showed negative results. These results are summarized in Table 1.

Patch tests performed with the baseline series were positive in 8 patients. These results are also summarized in Table 1.

Both patients studied at the Hospital del Mar were positive to BCDMH. The woman showed a strong vesicular reaction (D4 +++) to BCDMH 5% pet., erythematous infiltrated papules (D4 ++) at 1% to 100 ppm, and erythema (D4 +) at 10–1 ppm. The man also reacted positively with a vesicular reaction (D4 +++) at 1–5% BCDMH pet. Two other patients suffering from itchy skin after using BCDMH-disinfected swimming pools were also

Table 1. Summary of bromo-3-chloro-5,5-dimethylhydantoin (BCDMH) patch-tested patients at Hospital Universitari de Tarragona Joan XXIII, IISPV

Case number	Modified baseline series (positive reactions)	BCDMH 0.03 mg/l 0.03 ppm aqua	BCDMH 0.3 mg/l 0.3 ppm aqua	BCDMH 3 mg/l 3 ppm aqua	BCDMH 1% pet. 10 000 ppm	BCDMH 5% pet.	BCDMH 10% pet.
1	Ni, Co	—	—	—	+	++	++
2	Formaldehyde, quaternium-15	—	+	++	++	++	++
3	Ni, Co, Cr	—	—	—	+	+	++
4	Ni, Co	—	—	—	+	+	+
5	Ni	—	—	+	++	++	++
6	Ni	—	—	+	++	++	++
7	<i>p</i> -Phenylenediamine, thiomerasol, carba mix	—	—	++	++	++	++
8	Co, Cr	—	+	+	++	++	++
Controls (n = 20)	Not tested	— (n = 10)	— (n = 10)	— (n = 10)	— (n = 20)	IR in 5 (>n = 10)	IR in 10 (n = 10)

Table 2. Summary of bromo-3-chloro-5,5-dimethylhydantoin (BCDMH) patch tested patients at Hospital del Mar-Universitat Autònoma

Case number	Modified baseline series	BCDMH 1.0 pet.	BCDMH 10 pet.	BCDMH 100 pet.	BCDMH 0.1% pet. 1000	BCDMH 1% pet.	BCDMH 5% pet.
9	—	+	+	++	++	++	+++
10	—	—	—	—	—	+++	+++
Two suspected cases because of complaints of itching	—	—	—	—	—	—	—
Controls (n = 20)	Not tested	— (n = 20)	— (n = 20)	— (n = 20)	— (n = 20)	— (n = 19), + (n = 1)	— (n = 20)

patch-tested, but had negative results. Twenty healthy controls (n = 16) and consecutive patients (n = 4) were tested with BCDMH. A single positive reaction (+) at 1% pet. on D4 was observed. These results are summarized in Table 2.

Discussion

There are few studies reviewing swimming pool-induced health problems. Skin disorders in swimming pool workers are rarely reported in the medical literature. Some environmental predisposing factors are highlighted (e.g. heat and humidity out of water, heat and wetting in water, wetting and drying agents, degreasing agents, infections, and chemicals) (6).

From a questionnaire answered by 190 hydrotherapists, it was concluded that 44% suffered skin complaints compatible with contact dermatitis (7). Seventy per cent of them showed skin symptoms after 6 months of being exposed to swimming pool water. There was no aggravation of a pre-existing tendency to eczema. Some study limitations should be taken in consideration: first, the skin disorders were self-reported; and second, patch testing was not performed (7). Studies comparing the prevalence and severity of the skin disorders developed in swimming pools disinfected with BCDMH, chlorine products or other disinfectants are lacking.

BCDMH is a chemical that has been used as a substitute for chlorinated products, owing to its higher effectiveness in destroying waterborne *Pseudomonas* (8), since the 1980s. Simultaneously, a high incidence of skin irritation was observed among brominated pool users and hydrotherapists. This suggested that bromine-based disinfection was more prone than others to cause irritation and possibly sensitization of the skin. Nevertheless, most of the cases at that time were published without patch testing with BCDMH-based products. Its capacity to irritate was assumed (9). BCDMH-based products can induce persistent itch without rash, and discoid or diffuse eczema or wheals. The signs and

symptoms become worse with increasing exposure to such products (10).

Although BCDMH does not show specific chemical alerts suggesting high sensitizing properties, at least four cases of BCDMH allergic contact dermatitis showing negative sodium hypochlorite 1% aqua and positive 1% and 0.5% aqua BCDMH patch test results have been reported in the literature (2, 3).

We report 10 cases of allergic contact dermatitis as a result of exposure to BCDMH when used as a disinfectant in different swimming pools. The 10 patients showed a positive patch reaction with BCDMH at 1% pet., 5 of them showed positive reactions at 3 mg/l aqua (approximately equivalent to 3 ppm or 0.0003%), and 1 even showed a positive reaction at 1 ppm pet. Most of these patients were swimming pool customers, and at least one case was work-related with present occupational relevance. The recommended concentration of BCDMH in swimming pool disinfection is 1–3 mg/l. The ideal level of BCDMH (3–6 ppm measured as halogen) was confirmed in the swimming pools by the technicians as being correct. Several measurements were performed during the time of the study. The cluster of patients in this study developed dermatitis during a single period (2009–2010).

On the basis of patch test results, BCDMH 1% pet. is an appropriate dilution and vehicle with which to test for suspected BCDMH allergic contact dermatitis. At least one case showed a mild positive reaction to BCDMH 1% pet. (case 4, D4 +), and 1 healthy control showed a 1+ reaction at D4, suggesting that false-positive reactions should be eliminated by retesting with more diluted concentrations. Further studies should consider simultaneously testing BCDMH at 0.1% and 1% pet. to assess which concentration would be more useful for the diagnosis of contact allergy.

Two special cases should be discussed. One of the cases showed a concomitant positive patch test reaction to formaldehyde and quaternium-15, probably because of cross-reactivity with BCDMH, as described previously by de Groot et al. (11, 12). The second involves the

exceptionally sensitive swimming teacher, who reacted down 1 ppm pet. Long exposures in the swimming pool could be relevant.

The positive patch test reactions and the negative reactions observed in the control group with BCDMH support the diagnoses of allergic contact dermatitis.

Dryness, itch and erythema are currently considered to be non-specific complaints in swimming pool customers. When visible eczema is diagnosed after contact with BCDMH-disinfected water, the possibility of developing irritant or allergic contact dermatitis should be taken into consideration.

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