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Exposure analysis using X-ray fluorescence device and a cobalt spot test in four patients with cobalt allergy

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While positive patch test reactions to cobalt are commonly observed, identification of exposure and assessment of clinical relevance are often difficult. Established sources of cobalt include jewelry, magnets, hard metal alloys, and leather.[1,2] The cobalt spot test, and recently the introduction of a handheld X-ray fluorescence (XRF) device, have improved exposure analysis. Here, we present the exposure analysis of four patients with cobalt allergy.

METHODS

A handheld XRF device (X-MET8000 Series, Uedem, Germany) and a cobalt spot test were used to measure the content of cobalt in items suspected to contain and release cobalt (Figure S1) as both methods present feasible and less expensive alternatives compared with laboratory chemical analyses. The XRF device bombards the material with high-energy X-ray beams, capturing the emitted secondary characteristic radiation of each element contained in the material. The device presents the content of each element in weight percentage (wt%) along with a range on statistical measurement error based on single-point measures. The analytical mode "Alloy" was used for both leather and metallic items using an energy source of 40 kV, an analytical depth of 100 μm, and 8 seconds of measuring time. Furthermore, the certified detection limit of cobalt in a metallic matrix was 0.02 wt% while no information was available for leather matrices. A cobalt spot test was used to evaluate the release profile of different materials. One drop of the yellow cobalt test reagent (50 μL) was added on the tip of a cotton stick which was then rubbed for 30 seconds against the test item; a color change from yellow to red was indicative of cobalt release.[3]

Allergens for patch testing were obtained from allergEAZE (SmartPractice, Canada) and applied to the upper back in Finn Chambers (8 mm; Epitest, Tuusula, Finland) and fixed with Scanpor tape (Norgesplaster Alpharma, Vennesla, Norway). Patch testing was done with the European baseline series, including cobalt chloride 1% pet., and additional series suggested by the patient's medical history. Readings were made on day (D) 2, D3 or D4, and D7 according to the ESCD recommendations.[4] Patch test reactions designated as +, ++, or +++ were interpreted as positive test reactions. Irritant responses and doubtful (?+) or negative readings were interpreted as negative responses.

CASE REPORTS

Details on the patch test results and exposure analysis are given in Table 1.

Case 1. A 36-year-old non-atopic and non-pierced aircraft mechanic presented with 6-year lasting hyperkeratotic fissured hand eczema involving the right palm and the left side of the third finger and the right side of the fourth finger of his right hand. He had no history of prior skin disease. The only positive reaction was to cobalt chloride (+). Several tools were scanned with the XRF device and nine contained 0.03 to 10.1 wt% cobalt. The cobalt spot test was positive on a drill (Figure 1). This exposure was judged to be clinically relevant. The patient was instructed to use flexible gloves during work, which resulted in improvement of eczema, yet without complete resolution.

Case 2: A 64-year-old non-atopic and non-pierced man without a history of prior skin disease suffered from chronic vesicular hand and foot eczema with crusting of 15 years' duration. Cobalt and chromium were detected in frequently used riding gloves (0.03-7.2 wt%) and riding pants and a belt (2.3-32.1 wt%). The cobalt spot test was negative for all leather items. In addition to cobalt (++), the patient had positive patch test results to chromium (++), nickel (++), fragrance mix (+), and thiuram mix (++). Avoidance of leather resulted in an improvement of eczema in all body sites except the hands where the eczema remained.

Case 3: A 56-year-old non-atopic and non-pierced woman developed a demarcated erythematous eczematous patch on the dorsal

TABLE 1 Overview of patch test results, scanned objects, and cobalt content in four cobalt allergic patients

Case	Patch test reaction to cobalt	Other patch test findings	Object	Cobalt content wt% (±SD[a])
1	+	–	Blank part of a torque wrench	Head: 0.2 (±0.01)[a]
			Big fixed ball wrench	Handle: 0.3 (±0.01) Head: 0.3 (±0.01)
			Little wrench	Handle: 0.1 (±0.01) Head: 0.1 (±0.01)
			Big wrench	Handle: 0.5 (±0.01) Head: 0.6 (±0.01)
			Screwdriver	0.1 (±0.01)
			Brass chisel	Head: 0.03 (±0.004)
			Long metal tube	Handle: 0.1 (±0.01) Head: 0.1 (±0.01)
			Black metal drill	0.43 (±0.02)
			Cobalt drill	10.1 (±0.09)
2	++	Nickel (++), chromium (++), Thiuram mix (++), FM1 (+)	Riding gloves	Dorsal part (exterior): 0.8 (±0.2) Flap: 1.7 (±0.4)
			Riding pants	Leather part (exterior): 7.2 (±0.3) Leather part, lower leg (inside): 3.3 (±0.2)
			Brown belt	Inside: 1.2 (±0.2) Buckle: 0.03 (±0.004)
3	++	–	Leather chair	0.8 (±0.2)
4	+	–	Goalkeeper gloves	Interior: 0.1 (±0.04) Dorsal aspect (exterior): 0.2 (±0.06)
			Mobile phone case	Inside of the case, above the magnet: 0.3 (±0.1) Flap (exterior): 0.6 (±0.08) Dorsal aspect of the case: 0.3 (±0.07)

[a]Statistical measurement error.

part of her upper left arm, which spread to the right upper arm, neck, back, and thighs. She had no history of prior skin disease. The only positive test reaction was to cobalt chloride (++). The patient suspected that her leather chair might be the source of exposure as she experienced itching and spreading of eczema several times when using it. An XRF scan of a piece of leather from the chair showed 0.8 wt% cobalt content. The cobalt spot test was negative. Removal of the leather chair resulted in a complete resolution of eczema.

Case 4: A 13-year-old boy with no history of atopic dermatitis or pierced ears developed long-lasting bilateral vesicular palmar eczema which also involved the fourth finger and the left side of the fifth finger (Figure 2). The only positive test reaction was to cobalt chloride (+). Using the XRF device, we found 0.1 to 0.2 wt% cobalt in goalkeeper gloves and 0.3 to 0.6 wt% cobalt in a mobile phone case used by the patient. The cobalt spot test was negative for both items. The eczema resolved after disposal of the goalkeeper gloves.

DISCUSSION

We showed that potential sources of exposure to cobalt could be identified by use of XRF and a cobalt spot test, with leather being the most common item. Clinically relevant cobalt exposure was established for case 1 while cobalt was also suspected to be involved in the remaining clinical cases due to a chronological improvement of the eczema after avoidance of the exposure in question. However, the multiple allergies made it difficult to substantiate the role of cobalt in case 2.

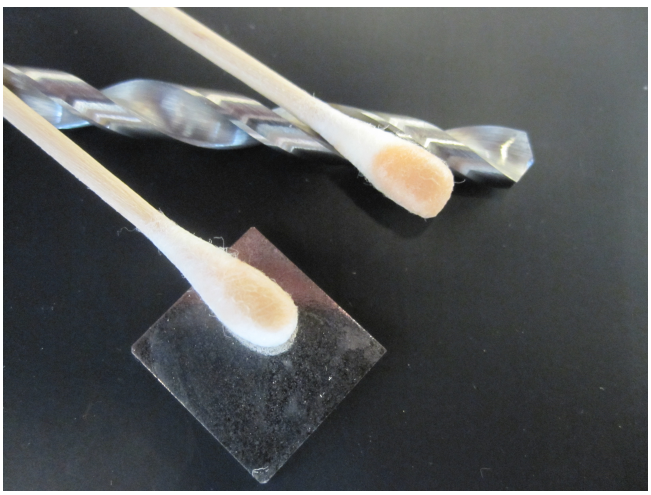

FIGURE 1 Positive cobalt spot test to a drill

FIGURE 2 Localized allergic cobalt contact dermatitis on the hands with crusting in case 4

We found over 10 wt% cobalt in a cobalt drill along with a positive result in the cobalt spot test of the drill (Figure 1). Hard metal alloys constitute the primary cause of occupational allergic contact dermatitis to cobalt.[5] Consumer exposure to cobalt has been described as well, including jewelry and more recently leather objects. Based on a clinical case in 2013, suspicion was raised toward cobalt release from leather as a hitherto unrecognized source of cobalt allergy and dermatitis.[6] In this study, we found cobalt content in leather parts of a chair (0.8 wt%), gloves (0.1-1.7 wt%), pants (7.2 wt%), and a brown belt (3.3 wt%). Recent studies have also shown cobalt content and release from leather articles, including leather shoes (>5 wt%) and leather gloves(>1 wt%).[7,8]

The XRF device represents a promising screening method to identify the composition of metals in leather.[9] However, an important limitation of this study is the lack of measurement of cobalt release from the leather items. In addition, our study was limited by not assessing the skin deposition of cobalt by directly spot testing the skin.[10] The cobalt spot test has resulted in disclosure of new putative sources of exposure but it is not applicable to leather items illustrated by sensitivity and specificity estimates of 20% and 14%, respectively.[9] In conclusion, cobalt was detected by XRF analysis in various sources of exposure, suggesting that the use of this device may be helpful in the exposure assessment of cobalt allergic patients.

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CONFLICTS OF INTEREST

The authors declare no potential conflict of interest.

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REFERENCES

1. Barceloux DG. Cobalt. *J Toxicol Clin Toxicol*. 1999;37:201-206.
2. Bregnbak D, Opstrup MS, Jellesen MS, Johansen JD, Thyssen JP. Allergic contact dermatitis caused by cobalt in leather - clinical cases. *Contact Dermatitis*. 2017;76:366-368.
3. Thyssen JP, Menné T, Johansen JD, et al. A spot test for detection of cobalt release - early experience and findings. *Contact Dermatitis*. 2010;63:63-69.
4. Johansen JD, Aalto-Korte K, Agner T, et al. European Society of Contact Dermatitis guideline for diagnostic patch testing - recommendations on best practice. *Contact Dermatitis*. 2015;73:195-221.
5. IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Cobalt in hard metals and cobalt sulfate, gallium arsenide, indium phosphide and vanadium pentoxide. *IARC Monogr Eval Carcinog Risks Hum*. 2006;86:1-294.
6. Thyssen JP, Johansen JD, Jellesen MS, et al. Consumer leather exposure: an unrecognized cause of cobalt sensitization. *Contact Dermatitis*. 2013;69:276-279.
7. Hamann CR, Hamann D, Simonsen AB, Zachariae C, Johansen JD, Thyssen JP. Cobalt content of a convenience sample of leather shoes and gloves in Denmark. *Contact Dermatitis*. 2019;80:248-249.
8. Prevodnik A. Report: Bad shoes stink–product survey focusing on certain hazardous chemicals in leather shoes. Swedish Society for Nature Conservation; 2009. http://www.kirstenbrodde.de/wp-content/uploads/2010/11/badshoes1.pdf. Accessed April 3, 2019.
9. Hamann D, Hamann CR, Kishi P, Menné T, Johansen JD, Thyssen JP. Leather contains cobalt and poses a risk of allergic contact dermatitis: cobalt indicatorsolution and X-ray florescence spectrometry as screening tests. *Dermatitis*. 2016;27:202-207.
10. Midander K, Julander A, Skare L, Thyssen JP, Lidén C. The cobalt spot test-further insights into its performance and use. *Contact Dermatitis*. 2013;69:280-287.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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