CASE REPORT

A chemical mixer with dark-green nails

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SUMMARY

Nails are integral extensions of the skin and they together form the largest organ of the human body. Changes in nail appearance can be due to external insults or internal pathologies, and nail signs have to be interpreted in light of a good history. We present an interesting case of a man who developed dark-green discolouration of his nails over a short period of time. His work as a chemical mixer rendered him susceptible to hazardous chemical exposure. A notification was filed and the local Occupational Health Department discovered insufficient protective gear and lack of protocols regarding hazards of isocyanate-based resin. The patient also reported washing utensils with bare hands. Based on the meniscal demarcation borders between the discoloured and normal areas, plus a positive bacterial culture from nail clippings, the final diagnosis of isocyanate-resin-induced onycholysis with secondary *Pseudomonas* infection remained as the most likely clinical diagnosis.

BACKGROUND

Nails and hair are appendages of the human skin. Similar to the skin, nails and hair can develop signs diagnostic of environmental, infective and pathophysiological insults. Of all three, the nails grow and are shed at the slowest rate, hence are most capable of documenting the injurious culprit for further investigation. Nail scrapings are used commonly to differentiate fungal infections from psoriatic onycholysis. In forensics, scrapings under the nail and toxicological analysis of the nails are often core investigations for identifying human,^{1 2} chemical³ or medicolegal^{4 5} foul play. In the public health domain, nail analysis also plays a role in monitoring environmental exposure to heavy metals such as arsenic,^{6–8} lead^{9–11} and cadmium^{9–11} from water supply and food. Industrial chemicals are major sources of environmental toxins and inadvertent exposure in workers must be strictly prohibited by protocols and occupational health laws.

With the dawn of the electronics age and the abrupt increase in demand for personal computers, epoxy-resin compounds have been employed as core materials in the processes of potting, casting and adhering fragile components. One of the commonest resins is an epoxy type that is produced by mixing two separate liquid components: the resin (Part A) and the isocyanate (Part B). Isocyanates are also found in polyurethane foam used ubiquitously in packing consumer products, their potential toxicity to the human body is a serious public health concern.^{12 13} In patients exposed to suspected occupational hazards, exposure to isocyanate

compounds should be included on the list of differentials.

Healthy nails normally transmit a pink hue from the capillary bed of the nail matrix. Changes in nail colour may be due to

- Inherited causes, for example, yellow colour of yellow nail syndrome;¹⁴
- Metabolic derangements, for example, pallor from anaemia, sallow tint from jaundice and uraemia;
- Fungal infections, for example, white colour from *Candida*¹⁵ and green/yellow colour from *Trichophyton*;
- Bacterial infections, for example, green colour of *Pseudomonas aeruginosa*¹⁶ and black colour of *Proteus* spp;¹⁷
- Chemicals and dyes, which can be of various colours.

When confronted with signs of acute changes in nail colour, a detailed history including current medical conditions and possible exposure to environmental hazards is essential. The possibility of two or more causative events happening in tandem should be considered for a plausible diagnosis, as illustrated by our case as presented.

CASE PRESENTATION

A 58-year-old man working in an electronics start-up company at the University science park presented with a few weeks' history of greenish-black discolouration of four fingernails on his left hand. He said the colour change happened gradually, and he did not recall any trauma to the four affected nails. He did not experience pain or other symptoms from the nails or fingers. He had no personal or family history of chronic diseases or hereditary disorders. He began work at this company only a few months earlier, and his job involved mixing buckets of chemicals and occasionally dipping circuit boards into chemical baths. On learning of his nail changes, his supervisor promptly discharged him from his duties and urged him to seek medical attention. He also gave him a set of Material Safety Data Sheets (MSDS) describing the chemicals that the worker had been exposed to. The material turned out to be a polyurethane-based epoxy resin, widely used in electronics assembly for casting and fixing components. The epoxy resin is made by mixing two components, the resin (Part A) and the isocyanate (Part B), immediately before application. The patient stated that he would always wear latex gloves when working directly with the chemicals. However, at other times, he used his bare hands to wash up utensils in the area. Despite wearing gloves, he said his hands often felt wet. No other

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Figure 1 Intense green discolouration of nails of the first four digits of the left hand.

worker at the company had experienced any nail problems or similar health concerns.

On clinical examination, the nails of the first four fingers of the left hand showed deep green discolouration (figure 1) and signs of onycholysis (figure 2). On closer examination, the demarcations between the normal and discoloured areas were sharp and regular, highly suggestive of the meniscal line of any fluid in contact with a solid surface (figure 3).

INVESTIGATIONS

Blood tests were performed for full blood count, liver function, kidney function and thyroid function. Results were all within normal ranges. In view of the patient's occupational history of handling chemicals and the green discolouration highly suggestive of fungal/bacterial infections, nail clippings were sent off for toxicological analysis, bacterial culture and fungal identification. Other possible contributory factors including delayed-type hypersensitivity to either the epoxy resin or latex were considered unlikely in our case, as the patient did not show any signs of contact dermatitis. Also, one of the authors, JH, notified the regional department of Occupational Hygiene at the Ministry of Labour of a possible case of toxicity from occupational exposure. A site visit was promptly performed, which revealed insufficient provision of protective garments and inadequate enactment of their use. In particular, the disposable gloves were only latex types and not the correct type (made of butyl rubber, nitrile rubber, polyvinylchloride (PVC), or polyvinyl alcohol (PVA)) for handling isocyanate compounds.

DIFFERENTIAL DIAGNOSIS

Differential diagnoses for the green discoloured nails include (1) occupational chemical exposure to isocyanate and related compounds, (2) onychomycosis, (3) *P. aeruginosa* infection and

Figure 2 Signs of onycholysis in the discoloured nails.

Figure 3 Careful inspection of discolouration revealed sharp demarcation consistent with a meniscal border of fluid-solid contact.

(4) any combination of the above. Owing to unavailability of toxicology analysis, presence of isocyanate compound could not be confirmed with the nail clippings. However, MSDS of the epoxy resin did not mention possible discolouration of nails on contact. Fungal identification was negative. However, bacterial culture confirmed presence of *P. aeruginosa*. Nevertheless, de novo *Pseudomonas* infection of nails rarely, if ever, renders a homogeneously green discolouration, nor will the discoloured area conform to a meniscal demarcation border as seen in figure 3. Hence the most likely diagnosis is primary chemical onycholysis of nails on exposure to the epoxy resin compounds with inadequate barrier protection, and secondary colonisation of the onycholytic space with *P. aeruginosa* due to constant moist environment from insufficient wearing of latex gloves.

TREATMENT

Removal of the nails was offered as a treatment but the patient declined. He was started on topical polymyxin B cream for 2 months with a view to extend treatment depending on progress. Other treatment options for *Pseudomonas* nail infections such as topical nadifloxacin¹⁸ and tobramycin drops¹⁹ have been reported, but they were not available in Canada.

OUTCOME AND FOLLOW-UP

At 2 months' follow-up, there was near resolution of the discolouration with regrowth of normal looking nail on the second and fourth digit (figure 4). In view of the normal values of blood results, other internal factors that predispose to nail dystrophy (eg, iron deficiency anaemia, hypoproteinaemia and hypothyroidism) were considered unlikely. Topical polymyxin treatment was extended for two more months and resolution

Figure 4 After 2 months of topical treatment, near resolution of signs in two of the four digits.

was then complete. The patient had no more recurrence of discolouration at 6 months' follow-up.

DISCUSSION

In the electronics manufacturing industry, exposure to hazardous chemicals is a major concern. The major fronts of contact include the skin and its appendages (nail and hair), the eyes, ear, nose, mouth and the lungs. In Canada, the department of Occupational Hygiene at the Ministry of Labour is responsible for defining the actual hazards of all known industrial chemicals and ensuring that appropriate protocols are enforced to protect workers who are exposed to them. However, protective measures are often carried out insufficiently in real life. Our case illustrates a classic example of occupational exposure to a known hazardous compound most likely due to insufficient protection, which would remain unnoticed had it not manifested with the characteristic discolouration due to secondary *Pseudomonas* infection of the chemically onycholysed nails.

Once suspected, any occupational hazard should be reported as a statutory duty of the clinician. Equally important is to consider patient advocacy to avoid repercussions on the patient's employment once a report is filed. If possible, confirmation of the causative agent should be sought but it may not be possible due to limitation of resources.

Close liaison with Occupational Health specialists will help to manage the patient and monitor treatment progress.

Chemical exposure hazard is often a sequel to insufficient or substandard protective garments. Latex gloves, while common in medical practice, are permeable to certain chemicals and hence unable to provide skin protection, as in this case. The MSDS for isocyanate compounds recommends protective gloves made of butyl rubber, nitrile rubber, PVC, or PVA. The actual thickness of the gloves also determines the breakthrough times of these chemicals.¹⁷ Gloves break down with time and exposure, and they should be changed once or twice in a work shift. One other common mistake is wearing gloves of insufficient length, allowing entry of chemicals, which may back-flow and pool at the hand and fingertips.

In our case, the injurious compound was an epoxy resin of the polyurethane type, containing isocyanate and related

polymers. These materials are known skin irritants and respiratory sensitizers. Isocyanate asthma is a well-known occupational hazard due to chronic skin or inhalation exposure.¹⁴ In Ontario, exposure to isocyanates is regulated under the Designated Substances Regulation, Ontario Regulation 490/09, which sets out special requirements for employers and workers handling this type of material.¹⁶

As an important clinical lesson, clinicians should consider possible chains of events happening in sequence leading to a diagnosis, as illustrated in our case of onycholysis by injurious chemicals to be followed by opportunistic infection with *P. aeruginosa* from a moist work glove.

Contributors JH wrote the initial draft which was revised by LKL with significant addition of contents and bibliography. LKL also compiled the draft into the *BMJ* template and took the four photos as included in the figures.

Competing interests None declared.

Patient consent Obtained.

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Learning points

- In electronics manufacturing and packing industries, potentially hazardous chemicals are often involved, among which isocyanate-containing resin is a common culprit.
- Protective garments must be worn to avoid occupational exposure to injurious chemicals, and appropriate rules and protocols must be enforced and enacted.
- Special non-latex gloves (made of butyl rubber, nitrile rubber, polyvinylchloride or polyvinyl alcohol) of sufficient thickness and lengths must be worn when handling isocyanate-containing compounds.
- Green discolouration of nails is a pathognomonic sign of *Pseudomonas aeruginosa* infection.
- Onycholysis can be due to chemicals, which give a sharp meniscal line of separation.

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