Acta Dermatovenerol Croat 2014;22(3):189-195 CLINICAL ARTICLE

Occupational Dermatoses Caused by Contact with Metalworking Fluids in the Region of Central Slovakia from 2000 to 2012

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Received: August 20, 2013
Accepted: June 20, 2014

SUMMARY Metalworking fluids (MWFs) are a common cause of allergic and irritant contact dermatitis. MWFs being currently used are mostly water based, containing biocides, emulsifiers, and other additives.
We performed a retrospective analysis of the etiology of the occupational dermatoses caused by metalworking fluids in three regions of Central Slovakia (population of approximately 2 million) between 2000 and 2012. The primary aim was the analysis of metalworking fluid-induced dermatoses, which involved determining the particular disease type (allergic or irritant), its regional distribution, and the specific chemical causing the disease. The secondary aim of the study was to assess the level of knowledge and competence among dermatologists in performing patch testing for allergens contained in metalworking fluids using a study-specific questionnaire.
Of the total number of 422 dermatoses during the analyzed period, 64 (41 in men and 23 in women) were caused by metalworking fluids. The implicated fluids were all aqueous, synthetic MWFs. 39 patients developed an allergic and 25 an irritant-induced contact dermatitis. 51 patients were tested using a special Trolab® metalworking battery (Almirall Hermal GmbH, Reinbek, Germany). The test identified a positive reaction to one of the following chemicals: methylchoroisothiazolinone/methylisothiazolinone (MCI/MI), formaldehyde, 1,2-benzisothiazoline-3-one, abietic acid, chloroxylenol, triclosan, amerchol L101, dichlorophene, propylenglycol, metylene (bis-methyl oxazolidine), monoethanolamine, and diethanolamine. The questionnaire showed that a large majority of Slovak dermatologists have no experiences with testing of MWFs.
Metalworking fluids were found to be the most frequent cause of occupational contact dermatitis. They also are the second largest group of all occupational dermotoses. Their incidence corresponded with the presence of machine industry in the region. Several unresolved problems include detection of specific allergens and standardization of patch test performance among individual dermatologists. Low levels of experience in testing of MWFs revealed need to educate both dermatologists and residents.

KEY WORDS: occupational dermatoses, contact dermatitis, metalworking fluids, Slovak Republic

INTRODUCTION

The metal-working compounds (MWFs) (synonyms include cooling emulsions, technical lubrication liquids) are one of the most frequent causes of occupational dermatoses worldwide. Their toxic and allergic effects are exacerbated by the following factors: cumulative exposure, maceration by humidity and synthetic soaps, micro-traumatization by metal particles, alkaline pH, use of aggressive detergents, and failure to use protective gloves. Currently, the use of emulsifiable compounds with a higher irritation and allergenic potential is prevalent (1) Additionally, chemicals used in metalworking may cause both skin and respiratory allergies (2). The risk of occupational eczemas caused by cutting fluids developing into the state of chronicity is significant. Pryce *et al.* state that in 7% of metal workers the symptoms persisted for 2 years after being switched to another job (3). We analyzed the occurrence of occupational eczemas and dermatoses in the region of Central Slovakia caused by cutting fluids over the course of 2000 to 2012.

METHODS

We performed a retrospective analysis of incidence and etiology of occupational dermatoses in three counties – Banska Bystrica, Zilina, and Trencin (30 districts, population of approximately 2 million), evaluated at the Regional Occupational Skin Diseases Referral Center. All patients were assessed by regional dermatologists. Allergic contact dermatitis was linked by positive patch test to either MWFs or their components. Diagnosis of irritant dermatitis was based on personal and work history and an elimination/exposition test. The analysis of metalworking fluid-induced dermatoses involved determining i) the particular disease type (allergic or irritant), ii) its regional distribution, and iii) the specific chemical causing the disease.

The assessment of specific chemicals was performed in a subgroup of 51 patients tested using a special test battery for metalworking compounds, Trolab® (Almirall Hermal GmbH, Reinbek, Germany). Causative clinical relevance of positive tests was also evaluated.

The secondary aim of the study was to assess the level of knowledge and competence among dermatologists in performing patch testing for allergens contained in metalworking fluids. This was done using a study-specific questionnaire that was sent to 46 private dermatologists.

RESULTS

From a total of 422 cases of occupational skin diseases, 64 were dermatoses caused by metalworking compounds (41 in men and 23 in women, average age of 38.5 years). Metalworking fluids were found to be the second most frequent cause of all occupational dermatoses and the most frequent form of occupational contact dermatitis (Table 2).

The regional occurrence of dermatitis induced by metalworking compounds corresponded to the density of the engineering industry. The highest number of cases of occupational dermatitis and eczema was recorded in districts in Northern Slovakia (Figure 1).

Toxic/irritant dermatitis was diagnosed in 25 patients (Figure 2), and allergic contact eczema in 39. In 38 patients the symptoms were localized to the hands; in 26 both the hands and forearms were affected.

The following fluids were the most frequent causes of the disease: Cimstar MB 604 (8 patients), Castrol Sintolin EBD and Castrol Honillo 981 (5 patients), Ecocool 68 CF2 (4 patients), Castrol DC 282 and Macron Shell (3 patients) (Table 3). 54 of the 64 cases (84.3%) of dermatitis were caused by synthetic MWFs.

Specific allergens were identified in 23 patients. A positive reaction to (MCI/MI) was identified in 5 cases, formaldehyde in 4, sodium salt of the 1,2-benzisothiazoline-3-one in 4, triclosan in 2, abietic acid in 2, and methylene-bis-(methyl-oxazolidine), propylene glycol, amerchol L101, chloroxylenol, diethanolamine, and monoethanolamine in 1 case each (Table

Table 1. Questionnaire used to evaluate the level of knowledge on the methodology of performing patch tests for potential allergens in metalworking fluids

1. Do you use patch testing with metalworking fluids as a part of your clinical practice?	Yes (continue)	No (do not continue)
2. I test metalworking fluids	As is	In serial dilutions
3. Do you use the different dilutions for pure and dirty fluids?	Yes	No
4. Do you test the control group?	Yes	No
5. Do you consider the pH of the fluid?	Yes	No

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Figure 1. Occurrence of occupational metalworking compounds-induced dermatitis in the regions of Central Slovakia. The highest incidence in the northwern regions of Central Slovakia correlates with the highest number of engineering factories .

4). The clear clinical relevance was proven only in two patients: allergy to formaldehyde in the first and to MCI/MI in the second.

The study-specific questionnaire was filled out by 46 dermatologists in private practices. It showed that 40 of the 46 do not test for individual metalworking fluids from the patient´s workplace. The technique used for patch testing differed among the 6 physicians who reported testing the patients.

Table 2. Occurrence and causes of occupational dermatoses in the region of Central Slovakia between 2000 and 2012

Cause	No. cases
Trichophytia	100
Metalworking fluids	64
Scabies	62
Metals (Ni, Cr, Co)	49
Rubber	43
Plastics and glues	29
Orf	18
Disinfectants	10
Colophony	6
Alkalies	5
Hair dyes + cosmetics	5
Textile and leather dyes	5
Erysipeloid	4
Medicaments	3
Industrial vaselines	3
Others	16
Total	**422**

Figure 2. Irritant contact dermatitis from metalworking fluid on the hands and forearms in a female patient

DISCUSSION

Working with metals involved several procedures for shapening raw prefabricated metal into the final product, such as tools and engineering components. The main function of metalworking fluids is cooling, lubrication, and flushing. Despite automation or semi-automation, which significantly reduces direct contact with the material, the working process still requires some direct contact. The most exposed parts of the body are the hands and forearms (4). The use of work gloves is limited by the fact that it makes performing fine tasks more difficult and risks a glove getting stuck in the machine.

Metalworking compounds are divided into pure oils, which usually have anticorrosive qualities and lubrication capabilities under a heavy mechanical burden, and soluble oils, which are mostly used for cooling and lubrication. The soluble oils are further divided into emulsifiable (containing 40-60% mineral oil), semi-synthetic (10-50% mineral oil) and synthetic (without any mineral oil) (5,6). In our patient population, all cases of occupational dermatoses were found to be the result of skin contact with soluble oils. All of those oils except for 5 were found to be the cause of dermatoses in the patients.

A wide variety of additives are used to improve the physical qualities of the individual fluids. These include emulsifiers, stabilizers/antioxidants, high-pressure additives, anti-foam additives, corrosion

Table 3. Sources of professional contact dermatitis from metalworking fluids (MWFs) (N=64)*

Source	Type of MWF	ACD	ICD	Total
Cimstar MB604	S	6	2	8
Castrol Sintolin EBD	S	4	1	5
Castrol Honillo 981	NO	5	0	5
Ecocool 68 CF2	S	4	0	4
Castrol DC 282	S	1	2	3
Shell Macron 221CM	NO	2	1	3
Concor	S	0	2	2
Castrol Syntilo 2000	S	2	0	2
Hosmac S 928.9	S	1	1	2
Sulnite UP	S	2	0	2
Aralux RP	S	0	1	1
Imexim TS	S	1	0	1
Trim C270	S	1	0	1
Cut-Max 570	S	1	0	1
Petropal	?	0	1	1
Wiolan HS	NO	1	0	1
Manpower	?	1	0	1
Hosmac AL 120	S	1	0	1
Hosmac S 558	S	0	1	1
Fluid H	NO	1	0	1
Mobil DTE 25	S	1	0	1
Shell Adrana D 208	S	1	0	1
Mobilcut 232	S	0	1	1
Castrol Rustilo DWX 30	NO	1	0	1
Shell Metalina E3203	S	1	0	1
Aral Resilan LD	S	0	1	1
SG 1650 2C	?	1	0	1
NS	?	0	11	11
Total		**39**	**25**	**64**

* ACD = allergic contact dermatitis, ICD = irritant contact dermatitis, NO = neat oil, S = synthetic/semi-synthetic, NS = not specified, ? = unknown

inhibitors, and perfume components. In terms of dermato-allergology the most significant allergens include preservatives. Some of them release formaldehyde, colophony (emulsifier), epoxides, and mercaptobenzothiazol (corrosion inhibitors) (4).

Our understanding of occupational sensitization caused by micro particles of metals during working is inconclusive. EU regulations regard alloys as sensitizers if they contain at least 1% of an allergenic metal. The most frequent contact allergen in engineering is chromium followed by nickel and cobalt. (7)

In this study, the most frequent allergens were found to be formaldehyde releasers – MCI/MI, 1,2-benzisothiazoline-3-one, and formaldehyde. Clear clinical relevance was proven only in two patients (in 1 for formaldehyde and in 1 for MCI/MI). This number is surprisingly low. This fact could be explained as follows: an important issue related to testing metalworking compounds is identifying their composition. Fluid composition is often a trade secret. Material safety data sheets include only general information. As a consequence, confirmation of presence of positive tested allergen in MFW is sometimes difficult. As a result, the dermatologist is often unable to judge the clinical relevance of a positive test.

Nevertheless, our results correspond with those of Grattan English and Foulds, who tested 174 patients with dermatitis caused by cutting fluids. Biocides, formaldehyde-releasing and non-releasing, were the most frequent cause of dermatitis among their patient population (8). In the Finnish study metalworking fluids were the most common source of sensitization to formaldehyde and formaldehyde releasers (9). In our study, only compounds of cutting fluids were analyzed, whereas nickel and other metals were not included in our analysis. Brinkmeier *et al.* performed review of 408 metalworkers and obtained a positive patch test for Biobans P 1487, CS 1246, and CS 1135 in 13 patients (3.4%). Most of the reactions were a weak positive and could be reproduced on re-testing in only 2 out of 10 patients (10). In another study 160 metalworkers were investigated from 1999 to 2001. Sensitization to monoethanolamine, collophonium/abietic acid, and fragrance mixes was most frequently observed. Diethanolamine, formaldehyde, and formaldehyde releasers have also been identified as important allergens (11). Another German study (12) found that among the current MWF allergens, monoethanolamine ranked the 1st, with 11.6% positive reactions. Diethanolamine (3.0%), triethanolamine (1.1%), and diglycolamine (1.9%) elicited positive reactions far less frequently. Allergic reactions to p-aminoazobenzene were frequently observed (6.0%), but the relevance of these reactions is still obscure. Aside from traditional allergens, some new allergens appeared during the past decade, including diglycolamine (13), imazalil (14), and sodium pyrithione (15).

The occurrence of occupational dermatoses caused by metalworking compounds varies. De Boer puts the occurrence of dermatitis at 27% of 286 metalworkers in the Netherlands. By far the most cases were of irritant origin; in only 2.8% was a contact sen-

Table 4. Identified allergens (N=51)

Allergen	No. in men	No. In women	Total	Clinical relevance
MCI/MI	4	1	5	1
Formaldehyde	4	0	4	1
1,2-Benzisothiazoline-3-one, sodium salt	4	0	4	0
Triclosan	2	0	2	0
Abietic acid	1	1	2	0
Methylene-bis-(methyl-oxazolidine)	1	0	1	0
Propylene glycol	1	0	1	0
Amerchol L101	1	0	1	0
Chloroxylenol	1	0	1	0
Monoethanolamine	1	0	1	0
Diethanolamine	1	0	1	0
Total	**21**	**2**	**23**	**2**

sitization established (5,6). Alomar *et al.* and Key *et al.* state that 80% cases of dermatoses are caused by irritation and only 20% by allergies (4,16). Grattan *et al.* tested 174 patients with suspected allergy to cutting fluids and documented allergic reactions in as many as 43% of the cases (5). In our group, 2/3 of the reactions were allergic (17). Since we documented a lack of standardization in testing of individual metalworking compounds, the question remains whether all positive reactions to metalworking fluids constitute proof of the allergy. The testing of fluids varies depending on the practices of a particular workplace. This may be the cause of false positive or negative reactions. This fact was confirmed by a short questionnaire addressed to 46 dermatologists in private practices. 40 of 46 responders do not test metalworking fluids at all. This outcome was surprising. A large majority of Slovak dermatologists has no experience with testing MWFs. This indicates the need for education of dermatologists and residents in this field.

The exact algorithm of patch testing is not uniform. Geier, Uter and Lessmann tested 141 metal workers with their MWFs as is and diluted. They concluded that testing with the actual undiluted fluid is preferred. Irritation is rare, and many reactions were missed if the fluids were diluted (18). Procedures applied by different authors are summarized in table 6 (19-22) .

As mentioned previously, detailed fluid composition is not indicated in safety data sheets. As a result, the dermatologist is often unable to judge the clinical relevance of positively tested specific allergens. Our findings correspond with a recently published article by de Groot (23), where there was a lack of reliable data on the clinical relevance of formaldehyde releasers in MWFs for contact allergies. Most studies provided no data on the relevance, and in those that did relevance was often found only for a (very small) minority of the reactions.

The last issue is testing of a metalworking compound on healthy volunteers (controls). Testing of colleagues from the workplace is recommended. Here we encounter an ethical-legal issue, because such an action requires signing of an informed consent, and also the issue time. Administering and reading the test after 48 and 72 hours means being absent from work 3 times, which can be met with unwillingness on the part of the potential participant.

Table 5. Questionnaire results (N=46)

1. Do you use patch testing with metalworking fluids as a part of you your clinical practice?	Yes (continue)	6	No (do not continue)	40
2. I am testing metalworking fluids	As is	1	In serial dilutions	5
3. Do you use the different dilutions for pure and dirty fluids?	Yes	1	No	5
4. Do you test the control group?	Yes	2	No	4
5. Do you consider the pH of fluid?	Yes	2	No	4

Table 6. Patch testing with individual metalworking fluids according to various authors (19, 20, 21, 22)

Author	Neat oils		Synthetic fluids	
	pure	dirty	pure	dirty
Fisher (1979) (3)	25% / oil		25% / oil	
Mardesicova (2000) (7)	As is 50% / oil	As is 50% / oil	As is 50% / oil 10% / oil	As is 50% / oil 10% / oil
Foulds (2000) (4)	As is 50% / oil 10% / oil	Do not test (false positivity)	As is 50% / oil 10% / oil	Do not test (false positivity)
Barbaud (personal communication)	10% (oil)		10% (oil)	
	10% and as is–semi-open test		10% and as is–semi-open test	
Dastychova (personal communication)	pH 6-7: As is 50% / oil 10% / oil	pH 8-8.5 50% / oil 10% / oil 1% / oil	pH 9 10% / oil 1% / oil 0,1% / oil	pH 10 1% / oil 0.% oil

The relatively high incidence of occupational dermatoses caused by metal-working fluids indicates primary and secondary prevention is needed. Recommended measures include thorough screening of new employees during their initial check-up, use of protective tools, and education. Preventive measures should include the use of less harmful fluids by taking technological measures which focus on manufacturing less irritating substances (for example reduction of anion complexes), exclusion of sensitizing substances, using an appropriate concentration, and regular pH checking. Technological measures involving machinery should be aimed at automation of manufacturing, effective filtration of fluids, and working at low temperatures, which reduces evaporation.

CONCLUSION

The results of this study confirmed the role of metalworking compounds as the most frequent cause of occupational dermatitis and eczemas. Emulsifiable fluids were the most harmful. We have pointed out the problems related to testing this group of substances. The high number of cases of this type of occupational both, allergic and irritant dermatitis indicates that increased preventive measures and standardized patch test performance among individual dermatologists is needed.

References

1. Urbanček S. Metalworking fluids [Kovoobrábacie zmesi]. In: Urbanček S, Dastychová E, Vocilková A, Buchvald D eds. Kontaktné alergény v pracovnom a životnom prostredí ("Contact allergens in the workplace and in environment"). Banská Bystrica, Polygrafia Guttenberg 2005:93-101.
2. Suuronen K, Aalto-Korte K, Piipari R,Tuomi T, Jolanki R. Occupational dermatitis and allergic respiratory diseases in Finnish metalworking machinists. Occupational Medicine 2007;57:277-83.
3. Pryce DW, Irvine D, English JSC, Rycroft RJG. What happens to patients with soluble oil dermatitis. Br J Dermatol 1989;121(Suppl. 34):27-8.
4. Alomar A, Conde-Salazar L, Romaguera C. Occupational dermatoses from cutting oils. Contact Dermatitis 1985;12:129-38.
5. DeBoer EM, Van Ketel WG, Bruynzeel DP. Dermatoses in metal workers – II. Allergic contact dermatitis. Contact Dermatitis 1989;20:280-6.
6. de Boer EM, van Ketel WG, Bruynzeel DP. Dermatoses in metal workers. (I). Irritant contact dermatitis. Contact Dermatitis. 1989;20: 212-8.
7. Geier J, Lessmann H. Metalworking fluids. In: Johanssen JD, Frosch PJ, Lepoittevin J-P. Contact dermatitis. 5th ed. Berlin Heidelberg: Springer-Verlag, 2011, 681-94
8. Grattan CEH, English JSC, Foulds IS, Rycroft RJG. Contact dermatitis 1989;20:372-6.

9. Aalto-Korte K, Kuuliala O, Suuronen K, Alanko K. Occupational contact allergy to formaldehyde and formaldehyde releasers. Contact Dermatitis 2008;59:280-9.
10. Brinkmeier T, Geier J, Lepoittevin J-P, Frosch PJ. Patch test reactions to Biobans in metal workers are often weak and not reproducible. Contact Dermatitis 2002;47:27-31.
11. Geier J, Lessmann H, Schnuch A, Uter W. Contact sensitisations of metalworkers with occupational dermatitis exposed to water-based metalworking fluids. Results of the research project FaSt. Int Occup Environ Health 2004;77:543-51.
12. Geier J, Lessmann H, Dickel H, Frosch PJ, Koch P, Becker D, *et al.* Patch test results with the metalworking fluid series of the German Contact Dermatitis Research Group (DKG). Contact Dermatitis 2004;51:118-30.
13. Geier J, Lessmann H, Graefe A, Fuch T. Contact allergy to diglycolamine in a water-based metalworking fluid. Contact Dermatitis 2002;46:121.
14. Piebenga WP, van der Walle HB. Allergic contact dermatitis from 1-[2-(2,4, dichlorphenyl)-2-(2 propylenoxy)ethyl]-imidazole in a water-based metalworking fluid. Contact Dermatitis 2003;48:285-6.
15. Isaksson M. Delayed diagnosis of occupational contact dermatitis from sodium pyrithione in a metalworking fluid. Contact Dermatitis 2002;47:248-9.
16. Key MM, Ritter EJ, Arndt KA. Cutting and grinding fluids and their effects on the skin. Am Ind Hyg Assoc J 1996;17:423-7.
17. Grattan CEH, Foulds IS. Outcome of investigation of cutting fluid dermatitis. Contact Dermatitis 1989;20:377-8.
18. Geier J, Uter W, Lessmann H. Patch testing with metalworking fluids from the patients workplace. Contact Dermatitis 2004;51:172-9.
19. Fisher AA. Allergic contact dermatitis of the hands due to industrial oils and fluids. Cutis 1979;13:131-4.
20. Mardešičová L. Contact dermatitis in machine industry [Kontaktní dermatitidy ve strojírenství]. Postgraduální medicína 2000;1:84-91
21. Foulds IS. Cutting fluids. In: Kanerva L, Elsner P, Wahlberg JE, Maibach HI. Handbook of Occupational Dermatology. Berlin-Heidelberg-New York: Springer;2000. pp 691-700.
22. Urbanček S, Vrtikova E, Fetisovova Z, Vilcek R. Occupational dermatoses from metalworking fluids in Slovakia. Do we perform the patch tests correctly? 20th anniversary meeting of the American Contact Dermatitis Society, March 2009, San Francisco. In: Book of abstracts p. 31.
23. de Groot A, Geier J, Flyvholm MA, Lensen G, Coenraads PJ. Formaldehyde-releasers: relationship to formaldehyde contact allergy. Part 2: Metalworking fluids and remainder. Contact Dermatitis 2010;63:129-39.