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REVIEW

Dermatological aspects of a successful introduction and continuation of alcohol-based hand rubs for hygienic hand disinfection

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Summary With the new Centers for Disease Control and Prevention (CDC) guideline on hand hygiene, hospitals often introduce alcohol-based hand rubs for hand disinfection. Healthcare workers, however, may reject the new products because of skin irritation or other skin-related problems, which they experience after years of handwashing. In order to facilitate a successful introduction and continued use of alcohol-based hand rubs in hospitals, we have reviewed and summarized the major studies on the topic. Occupational hand dermatitis may occur in up to 30% of healthcare workers. It is mainly described as an irritant contact dermatitis caused by detergents. The diagnosis is usually clinical. Allergic reactions are very rare. After using an alcohol-based hand rub for the first time, healthcare workers may have a burning skin sensation that can be explained by pre-irritated skin. In this case the skin barrier has usually been impaired by frequent handwashing or occlusive gloves. This may result in a vicious circle whereby the healthcare worker increases the frequency of handwashing and reduces the frequency of hand disinfection. Prevention of irritant contact dermatitis is possible by selection of a low-irritating hand rub, which contains emollients, the correct use of the hand rub and a clear guideline when to disinfect and wash hands in the clinical setting. Common mistakes in the use of alcohol-based hand rubs are application to pre-irritated skin and washing hands before hand disinfection, which is, in general, not necessary, or after hand disinfection, which results in washing off the emollients. Clear preparation and guidance of healthcare workers before the introduction of alcohol-based hand rubs can help to enhance compliance in hand hygiene. The switch from handwash to alcohol-based hand rub will improve healthcare workers skin if mistakes are avoided and hand rinses are used correctly.

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Table I Comparative maximum permissible levels of important impurities in ethanol and propanol according to the European Pharmacopoeia

Type of impurity	Ethanol ^a	n-Propanol ^b	iso-Propanol
Methanol	<200 ppm	<0.1%	No limit mentioned
Acetaldehyde and acetal	<10 ppm	<0.1%	No limit mentioned
Benzene	<2 ppm	<0.1%	<2 ppm
Non-volatile compounds	No limit mentioned	<0.004%	<20 ppm
Total number of impurities	<300 ppm	<0.3%	No limit mentioned

^a For both ethanol (96%) and ethanol, anhydrous.

^b Data for n-propanol are obtained from a draft monograph in Pharmeuropa.

Background to alcohol-based hand rinses (ABHRs)

Hand hygiene is currently undergoing a global renaissance. For decades antiseptic or plain soaps have been considered to be the first choice for hand decontamination in many countries, e.g. the United States and the United Kingdom.¹ In many central European countries, however, ABHRs have been used at the same time.² This is explained mainly by their faster antimicrobial activity,³ broader spectrum of antimicrobial activity³ and better skin tolerance.⁴ Their use has now been endorsed by the new Centers for Disease Control and Prevention (CDC) guideline on hand hygiene, which clearly favours ABHRs for hygienic hand disinfection.⁵ Many hospitals and their infection control teams now face the challenge of introducing a new type of hand antiseptic. Experiences with the introduction of ABHRs have been reported. In France, for example, both compliance and skin condition improved after introduction of an ABHR.⁶ In a US hospital, however, compliance increased, but the overall satisfaction with the hand rub was modest.⁷ This review highlights the most important dermatological aspects that should be considered when introducing ABHRs in a healthcare institution.

Quality of ABHRs

Most ABHRs for hygienic hand disinfection or surgical hand disinfection in Europe are classed as medicinal products. They are therefore subject to national or European drug laws. This has a major impact on the quality and documentation required for the hand rinse. Active ingredients must have a quality that is compatible with the European Pharmacopoeia.⁸ A minimum level of purity is thereby guaranteed. The purity of raw materials certainly has an impact on the local tolerance of a hand rinse.

Ethanol and iso-propanol are for example listed in the European Pharmacopoeia,⁸ n-propanol has been described in a draft.⁹ Impurities with a possible negative impact on the skin are specifically limited (Table I).

In some European countries ABHRs may be found as cosmetic products and do not need to comply with the European drug regulations however they must still comply with the Cosmetic Product Directive.⁶¹

Frequency of occupational hand dermatitis among healthcare workers (HCWs)

ABHRs are mainly used by HCWs. This occupation is a classical risk factor for hand dermatitis.¹⁰⁻¹³ The most extensive investigations concerning the epidemiology of hand dermatitis in the general population were performed in Sweden. Meding et al.^{14,15} reported a one year prevalence between 9.7 and 11.8% (with a tendency to decrease in the later years) and a point prevalence of 5.4%.¹⁵ In HCWs, a far higher point prevalence of hand dermatitis (17-30%^{10,16}) can be found. This is supported by a retrospective study of Smit and Coenraads,¹² in which an overall incidence of 6.5 cases/1000 person-months in nurses and 1 case/1000 person-months in office employees was estimated. The consequences are serious because many employees lose their jobs due to hand dermatitis (occupational skin disease). In a population-based register study of occupational skin diseases in Northern Bavaria, Dickel et al.¹³ observed an annual incidence rate of 7.3 cases per 10 000 healthcare workers.

Causes of occupational hand dermatitis

In epidemiological studies it is very difficult to

determine the cause of hand dermatitis, as contact dermatitis is not a notifiable disorder. The most frequent cause of hand dermatitis in the general population seems to be irritant contact dermatitis (ICD, 35%), followed by atopic dermatitis (22%) and allergic contact dermatitis (19%).¹⁵ In HCWs the pathogenesis of a contact dermatitis is also most frequently an irritant dermatitis. Allergies are of secondary importance.¹³ Of the many topical preparations HCWs work with, disinfectants (like ABHRs) and detergents are the most frequent contact substances. The results of a questionnaire showed frequent skin contact with disinfectants (76%) and detergents (72%) in the workplace.¹³ Mostly, relevant allergies in HCW are due to sensitization against glove ingredients (Latex, rubber chemicals, starch glove powder) and disinfectant ingredients (glutaraldehyde, formaldehyde and glyoxal).¹⁷⁻¹⁹ With respect to these disinfectant ingredients an increase of the sensitization rate of HCWs compared with the general population is noticeable: glutaraldehyde (9.9% versus 2.6%), formaldehyde (3.6% versus 2.1%) and glyoxal (4.2% versus 1.4%). No allergies have been proven for the alcohol component of the hand disinfectants. However, many nurses complain about burning sensations after contact with ABHRs and assume an allergy to the product.²⁰ In these cases, allergic patch tests usually show no sensitization. As stated above, an allergy to ABHRs can therefore be discounted.

However, the potential for irritation caused by ABHR, has to be considered. In a detailed patch test study, it was found that a 60% n-propanol solution did not induce any irritation on healthy skin.²¹ Even on pre-irritated skin, the damage to the skin (evaluated by measurement of transepidermal water loss and skin surface capacitance) caused by a 60% n-propanol solution which is the concentration used in daily practice, was very low. For a 100% n-propanol solution, the irritation was much greater.²¹ It can be concluded that the alcohol part (at least n-propanol) of ABHRs rarely provokes relevant irritation on intact skin and that for most procedures of daily hand hygiene, ABHRs should be preferred.^{22,23}

Clinical symptoms of occupational hand dermatitis

The reason for the burning sensation on contact with ABHRs is a pre-irritated skin. If the skin barrier is disrupted, e.g. by frequent wet work,²⁴⁻²⁷ alcohol may penetrate more easily into

the epidermis. Even in the epidermis there are nerve receptors²⁸⁻³⁰ that are simulated by the alcohol, resulting in a burning sensation, but not in further irritation.²⁰ The cause of the problem of the burning sensation is therefore the pre-irritated skin, leading to an impaired epidermal barrier and not the negligible irritation caused by the alcohol itself.³¹ A burning sensation after alcohol application may indicate that the skin barrier is seriously impaired.

Pathogenesis of occupational hand dermatitis

In HCWs, the predominant mechanisms of skin irritation are repeated exposure to moisture, work with occlusive gloves and contact with aggressive surface disinfections.^{13,18} Even water on its own can be an irritant.³² These risk activities often lead to a subclinically impaired skin barrier, before the first clinical irritation (often in the interdigital spaces) becomes apparent.^{33,34} Further aggravating factors are an atopic disposition,³⁵⁻³⁸ genetic predisposition³⁹ and climatic conditions.^{40,41} The strongest influence on the manifestation of irritant skin changes is, by far, individual behaviour. When mild irritations (like handwashing) affect the skin frequently, the regenerating mechanism can no longer maintain a sufficient barrier.⁴² The skin barrier gets more and more disrupted and further irritation occurs more easily.

In daily routine, HCWs are exposed to both handwashing and disinfection with ABHR. If the epidermal barrier becomes disrupted and alcohol causes a burning sensation during use, this is often interpreted by the user as 'aggressiveness' of the ABHRs. As a logical consequence, the user reduces applications of ABHR and tries to compensate with increased handwashing. This leads, unfortunately, to more barrier disruption, which is for a while unnoticed, but will often lead to clinically relevant hand dermatitis. A vicious circle is initiated.

Diagnosis and treatment of occupational hand dermatitis

The diagnosis of ICD is predominantly clinical one. Diagnostic tests (like patch tests) are usually performed to exclude allergic contact dermatitis. Because most subjects suspect that an allergy to ABHR is responsible for their hand dermatitis, an allergic patch test is often performed. As the true explanation is usually not the ABHR but rather the

individual's behaviour (e.g. frequent handwashing), these tests are usually negative. Irritant tests, like the epicutaneous patch test with sodium lauryl sulphate, are helpful in evaluating an individual skin susceptibility, but the value of these tests should not be overestimated, because the pathogenesis of ICD is based on the combination of individual predisposition with external irritation.⁴³

When skin changes are apparent and the diagnosis is clear, early treatment is essential. In HCWs, ICD appears mostly in the interdigital spaces and on the dorsum of the hands. Rough and scaly skin is predominant with only minor inflammation. The main symptom (if any) is a burning sensation. This stage of the disorder is best treated by avoidance of the irritation and the application of lipid-rich tropical agents. When the inflammation gets worse, a short application of a corticosteroid-containing external agent is often required.^{44,45} If the ICD is not treated adequately, allergens may penetrate the disrupted barrier into inflamed tissue with numerous stimulated immunocompetent cells, causing a second problem: allergic contact dermatitis.⁴⁶ At this stage, the skin often shows pronounced erythema and vesicles, and the predominant problem is itching. The best therapy at this stage is immunosuppressive topical external agents such as corticosteroids or tacrolimus. In the chronic stages, ICD and allergic contact dermatitis of the hands may have a similar clinical picture.

Prevention of occupational hand dermatitis

There are several measures possible to prevent the above course of events. The most effective is primary prevention,⁴⁷ which can be separated into collective and individual measures. The development of low-irritating disinfectants (like ABHR) is a preventive measure and part of the creation of a safe occupational environment. The correct use of hand disinfections is important among the individual measures of prevention.⁴⁸ In general, it is not necessary that irritants (e.g. handwashing) are avoided completely. In most cases a reduction of the duration or frequency of exposure is sufficient.⁴⁹ Wherever possible replacement of incorrect, irritant behaviour (here handwashing) by less irritant measures (like use of ABHR) is recommended. This change in behaviour must be taught, as must the correct use of gloves and protective clothing. Regular teaching is one of the most important measures in the prevention of ICD.^{18,24,50} This should take place during induction,

as well as at regular intervals during working practice. Knowledge about irritation and irritants, such as actual irritants in a given working environment, and the advantages of ABHRs over handwashing must be stressed. All possible individual means of prevention such as protection by gloves, clothes, barrier creams and correct skin cleaning should be considered.⁵¹ Practical illustrations such as the testing of cream applications with a fluorescence technique are very helpful.^{52,53}

The use of a moisturizer in supporting the regeneration of the skin barrier is widely accepted even by affected individuals. It forms part of secondary prevention, because it is mostly introduced after the first skin changes are visible. This approach is supported by most dermatologists, but its efficacy is unconfirmed. Only a few studies with repeated irritation and subsequent application of a moisturizer have been undertaken.⁵⁴ Usually, a slight improvement was noted at the treated areas, but the effect was not dramatic. Further studies, especially under daily working conditions, are needed.

Common mistakes in the use of ABHR

Unhealthy/irritated skin

Damaged skin is not always visible and may well be tolerated by the HCW if no alcohol is applied. Especially in situations where ABHR are introduced for the first time, it is crucial to make sure that the skin is healthy before the alcohol is applied. Otherwise there might be a burning sensation, erythema or fissures. The HCW might reject the ABHR due to symptoms that are the result of pre-existing skin disorders.

Handwash before hand disinfection

In general there is no need to wash before hygienic hand disinfection. Washing the hands will result in moist skin, which predisposes to toxic skin reactions. In addition washing removes the superficial sebum layer of the skin and thereby enhances skin irritation and dryness. For this reason ABHR should only be applied to dry hands.

Handwash after hand disinfection

Hands should not be washed immediately after hygienic hand disinfection. This will remove not only the superficial sebum layer of the skin, but in

Table II Aspects of correct hand hygiene with ABHR

Type of procedure	Aspect of use	Correct application
Hand disinfection	Type of alcohol-based hand rub	Hand rub with emollients, ⁵⁵ minimal risk of skin irritation and minimal risk of skin sensitization Apply product to dry and clean skin. Rub the product into the skin until the skin is dry (approx. 30 s). No handwashing immediately after hand disinfection. Minimize number of handwashes between disinfections
	Procedure for hand rub	
Handwashing	Type of soap	Mild, non-alkaline Cold water. Minimize duration of handwashing. Do not use brushes. Rinse off residual soap. No handwash immediately before hand disinfection unless hands are visibly soiled
	Procedure for handwash	
Skin care	General aspects	Use lotions or creams between hand hygiene procedures. Older skin may require more intensive skin care
Gloves	General aspects	Hands should be dry before gloves are put on (after handwashing or hand disinfection). Wear gloves only as long as necessary

Hands should only be washed when they are visibly soiled.

addition the emollients that are included in many ABHR in order to improve the skin care after use.

Choice of ABHR

The ABHR should be a formulation with emollients.⁵⁵ Lack of emollients may lead to dryness of the skin and may impair compliance. Subjective assessment of the emollient effect may reveal considerable differences.⁵⁶ The hand rub should have only a minimal risk of skin irritation and sensitization.⁵⁷⁻⁵⁹ Finally user acceptability may be a key factor irrespective of other objective factors. User acceptability may be influenced by factors like smell, skin feeling after application and speed of drying.⁶⁰ Gels should, in addition, be assessed for tackiness and build up.^{7,60}

How to use ABHR correctly

The right way to use ABHRs is summarized in [Table II](#). As stated above, hand rubs should only be applied to dry and clean skin. A product should be rubbed into the skin until the skin is dry. This will take approximately 30 s. Hands should not be washed immediately after the hand disinfection, because it will remove the superficial skin sebum and the emollients of the hand rub. Between applications of hand rubs, hands should be washed only when they are visibly soiled. A mild, non-alkaline soap should be used. Water for a handwash should be cold. The duration of the handwash should be as long as necessary to remove visible contamination but at the same time as short as

possible. Residual soap should be rinsed off completely. Brushes should not be used.

Skin care lotions and creams should be used between hand hygiene procedures, especially at the end of a shift. Older skin may require more intensive skin care. Hands should be dry before gloves are put on. Gloves should be worn only as long as necessary.

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