

Appendix D

Evaluating Skin Decontamination Techniques¹

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Both *in vitro* and *in vivo* techniques have been developed to determine skin decontamination. A brief introduction to the models and a summary of the relative data from recent studies follows. The models described below have been developed with nonvesicant agents that are available for occupational and home use.

IN VIVO DECONTAMINATION MODEL

Wester et al. (1991) tested the extent and rate of decontamination on rhesus monkeys. A water-soluble chemical, glyphosate, was completely removed from rhesus monkey skin with three successive soap and water or water only washes. Approximately 90-percent of the glyphosate was removed in the first wash. There was no difference between washing with soap and water and washing with water only. Alachlor, a lipid-soluble chemical, was also removed by washing with soap and water and water only. In contrast to glyphosate, however, more alachlor was removed with soap and water than with water alone. Although the first alachlor washing removed most of the chemical, successive washings contributed to overall decontamination.

Methylene bisphenyl isocyanate, an industrial chemical, is a potent

¹The following material was prepared for the use of the principal investigators of this study. The opinions and conclusions herein are the authors' and not necessarily those of the National Research Council.

contact sensitizer. Decontamination potential was determined *in vivo* in rhesus monkeys. A grid of 1-cm areas was drawn on the abdomen of the monkey (the same can be done with humans) and the same amount of chemical applied to all areas. At set times, individual grid areas were washed/decontaminated by water-only, 5-percent soap, 50-percent soap, polypropylene glycol, polypropylene glycol cleaner, and corn oil. After each washing procedure, skin tape stripping was used to quantify residual contamination. Water-only and soap-and-water washing were minimally effective. Polypropylene glycol, polypropylene glycol cleaner, and corn oil were more effective. The chemical that was not removed by the washing procedures was recovered in the tape stripping (Wester and Maibach, 1999a). Two factors affect *in vivo* skin decontamination: (1) the "rubbing effect" that removes loose surface stratum corneum from natural skin desquamation, and (2) the "solvent effect," which is related to chemical lipophilicity and may influence the washing effects (Wester et al., 1991).

van Hooidonk et al. (1983) evaluated a wide variety of common materials as skin decontaminants against chemical agents. Flour followed by wet tissue paper removed 93 percent of VX and 98 percent of mustard. This treatment also reduced the penetration of mustard (measured by radiolabel) and VX (measured by anti-acetylcholinesterase activity). *In vivo* tests confirmed a significant reduction in mortality with flour/wet tissue paper after VX and soman exposures. The authors found that washing alone (with no flour pretreatment), either with water or soap and water, was highly effective against nerve agents, but resulted in much larger areas of skin damage for mustard. Therefore, the authors concluded that the best decontaminant for mustard, VX, and soman was decontamination with flour followed by an after-treatment with wet tissue.

IN VITRO DECONTAMINATION MODEL

In vitro skin mounted in diffusion cells can be decontaminated with solvents. The mounted skin is fragile, however, and cannot be rubbed as vigorously as *in vivo* skin. Another *in vitro* technique is mixing powdered human stratum corneum with radiolabeled formulations (Wester et al., 1987). For example, a water-only wash (and subsequent centrifugation) removed only 4.6 ± 1.3 percent of the "bound" alachlor. However, when the bound alachlor- powdered human stratum corneum was washed with 10-percent soap and water, 77.2 ± 5.7 percent was removed; with 50-percent soap and water, 90.0 ± 0.5 percent was removed. This model would predict that alachlor cannot be removed from the skin by washing with water alone but that soap will decontaminate the skin. The reason

may be that the “lipid” constituents of soap offer a more favorable partitioning environment for the alachlor (Wester and Maibach, 1999b). These results were confirmed in *in vivo* studies. Large-scale *in vitro* decontamination screening can be done with the powdered human stratum corneum model.

In vitro studies conducted by decontaminating pig skin exposed to radiolabeled DFP (an organophosphorus compound, cholinesterase inhibitor) and radiolabeled n-butyl 2-chloroethylsulfide (a vesicant) compared the decontamination efficiency of a water shower (tap water), the M-258 kit, and a pad impregnated with a reactive resin mixture. Decontamination efficiencies were found to be similar for all three methods (Reifenrath, 1990). Shower decontamination with an aqueous surfactant solution did not increase the skin penetration of topically applied soman or thickened soman (Reifenrath et al., 1984).

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