compared to the military response (20). It's a challenge for authorities to reduce the time required to deploy decontamination processes after chemical exposure and limit potential health impacts to citizens. Removing clothing is a simple and highly effective action to remove external contaminants in the first minutes after the incident. Disrobing can remove 80% to 90% of contamination and specfically the external layer of clothes (21). Disrobing needs an ethical approach which must be organized at the crime scene, in the hospitals for emergencies, and widely advised to individuals returning home after exposure.

24.5.4 First Decontamination

The first decontamination process, also called emergency or early decontamination, must be immediately set up, preferably before the identification of the hazardous substance. In order to save victims and avoid cross contamination, first decontamination must be considered when contamination is suspected by the emergence of toxidromes e.g. clinical symptoms of vesicants, such as blistering and swelling, whereas cholinergic symptoms e.g. copious secretions and respiratory muscle paralysis are indicative of nerve agent exposure. This essential process of early decontamination allows a rapid setup of medical countermeasures (22); therefore, versatile decontaminants able to adsorb the largest part of hazardous chemicals may be used as the first line.

24.5.5 Secondary Decontamination

Secondary or technical decontamination may complete the first decontamination. In some cases, gross mass water decontamination could be required on the crime scene to rapidly aid all exposed people.

If first decontamination has been performed following a gross mass water decontamination process based on the channeling of water from firefighting trucks, a secondary decontamination may be set up in mobile units, providing mass showering facilities that allow more thorough decontamination with warm or lukewarm water and soap, and bleach if necessary (23). Caution should be practiced when skin is washed, as the wash-in (W-I) effect may increase local cutaneous and systemic toxicity (24).

Experimental data on various chemicals are urgently needed. In any case, decontaminants applied onto the skin must be harmlessness and efficient.

24.5.6 Decontamination Control

Measuring the efficiency of decontamination procedures towards chemical agents, breakdown products, or degraded chemicals needs to be evaluated. Some techniques, such as skin wipes, are useful to measure toxicant levels on the skin surface, predict dermal absorption, and measure the potential systemic contamination level (25, 26).

The efficiency of Fuller earth towards 4-cyanophenol, as a chemical agent, was assessed ex vivo (27). Studies based on the application of nontoxic chemicals, also called simili, to measure the efficiency of water shower ladder pipe systems, underlined that under certain conditions, showering in the presence of contaminated clothing resulted in the transfer of chemicals to the skin surface (28). Quantitative comparison of different decontamination protocols were carried out by the topical application of an ultraviolet (UV) fluorescent compound onto human volunteers. This highlighted that performance of protocols is necessary to assess efficiency. Improved decontamination procedures is a priority to manage short- and long-term chemical incidents (29). Low-level chemicals require technologies able to detect low concentrations in the order at least of parts per million (ppm).

24.6 DESIGN OF THE DECONTAMINATION PROCESS

Decontamination methods could be developed following various concepts. They can be ranked in three categories: (1) physical removal, (2) washing, and (3) neutralization ranging from the simplest to the most elaborate process in reference to the mechanism of action described for the methods.