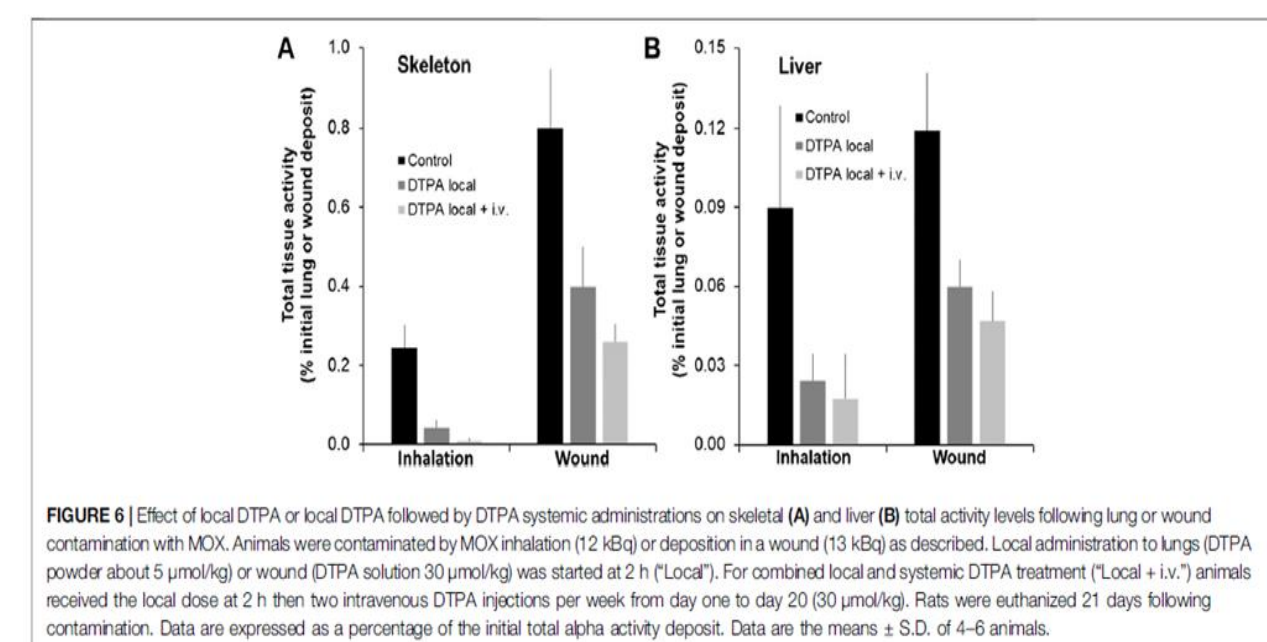


The decontamination process for wound contaminations with radiocompounds in a nuclear power plant, about a concrete case

ABSTRACT

The management of contaminated wounds follows well-defined sequences to optimize the effectiveness of the early decontamination process. The first action to be carried out after the accident is to evaluate the severity of the wound and to identify the nature of radioactive compounds. Surgical emergency always takes precedence over the radiological emergency. The first decontamination action, recommended for actinides contamination, is the in-situ cleaning with DTPA on the wound by direct rinsing or by the use of compresses soaked with DTPA applied to the lesion. The experimental wound models in rats relate a very rapid passage of americium or plutonium and the effectiveness of a local chelate application. If possible, a superficial epidermis excision can also participate to the decontamination process. The second step is an active washing of the wound with potable tap water for 10 minutes, in the decontamination room. This will contribute to highly effective decontamination of radioactive compounds through the mechanical action of the flow. Furthermore, in accordance with the recommendations of emergency medicine, active cleaning of the wound with potable tap water contributes to the elimination of germs and allows deferred surgical treatment without infectious risk up to 6 hours after the injury. In parallel, we injected intravenous Ca-DTPA (0,5g) diluted in 100 to 200ml of isotonic saline, with a high level of tolerance. The 24-hour urine samples over the first 3 days after the event must be collected and analyzed to assess an eventual transfer to the internal compartment. The third step before surgery consists of disinfecting the wound. This step should not precede the use of DTPA because disinfectants can reduce the chelating action of DTPA through chemical interactions. The fourth step is the surgical time: The NRC report N°156 (NCRP 2006) recommends that saved doses exceeding 10 times the annual limit may be appropriate for surgical excision. Chelation treatment is more effective for soluble plutonium, whereas surgical excision is more appropriate for particles and fragments.

FOR AN EARLY CHELATION PROCESS



The intervention will mobilize part of the Pu from the wound into the blood. It is why, the excision will be carried out under DTPA infusion: 1 g passed in 15 minutes if it has not already been an injection during the day or 500 mg if an injection has already been done within 24 hours. The 24 hours urine sample over the first 3 days after the event must be collected and analyzed to assess an eventual transfer to the internal compartment and urine 24 hours before and after each injection. **Traitement par le Ca-DTPA des contaminations internes par le plutonium et l'américium : Recommandations pour la rédaction de protocoles dans les centres CEA et AREVA** Radioprotection 2009 DOI: 10.1051/radiopro/2009022 Vol. 44, n° 4, pages 447 à 461 L. GRAPPIN, J.-P. LEGOFF, L. CARBONE, C. COURTAY A.-L. AGRINIER, M. ANNAT, J.-C. AMABILE, A. FLORIN, F. ANDRE

EFFICACY OF SUPERFICIAL EPIDERMIS EXCISION ON DECONTAMINATION PROCESS

Our concrete case : 1200 Bq ^{60}Co carried out on an epidermal skin sample without anatomical damage

COMBINED DRUG AND SURGERY TREATMENT OF PLUTONIUM CONTAMINATED WOUNDS: INDICATIONS OBTAINED USING A RODENT MODEL (Nina M. Griffiths, Sylvie Coudert, Jean Claude Wilk, Daniel Renault, Jaime F. Angulo, and Anne Van der Meeren*) : The combination of pre-treatment with DTPA and wound excision markedly increases urinary Pu excretion and reduces tissue retention. Second, it is clear that the later treatment with DTPA at 1 wk after contamination has a significant beneficial effect shown by reduced Pu organ retention.

LIMITED EFFICACY FROM DTPA TO COBALT OXIDES

In vitro assessment of cobalt oxide particle dissolution in simulated lung fluids for identification of new decorporating agents

Anne van der Meeren, David Lemaire, Sylvie Coudert, Guillaume Doucet, Myrtille Beaumont, Céline Goussier, Chen Young Hee, Pauline Bruneau, Bastien Trochu, Magali Pithon, et al.

Following inhalation of $^{60}\text{Co}_2\text{O}_3$ particles, the most likely scenario at the work place, chelation by DTPA is expected to concern mainly the ionized form of cobalt, Co^{2+} , suggesting that DTPA treatment would have limited efficacy (Van der Meeren et al., 2020). Limiting, in case of inhalation of poorly soluble compounds, such as plutonium oxides, only the solubilized fraction present in lung fluids was accessible to DTPA (Grémy et al., 2010).

"DTPA is unable to dissolve, and therefore chelate, plutonium compounds in oxide form. By analogy, DTPA is not expected to dissolve cobalt oxides, especially as its affinity for Co^{2+} is much lower than that for Pu^{4+} "Actinides" include uranium and neptunium but DTPA is only effective on plutonium and americium..." O. Gremy

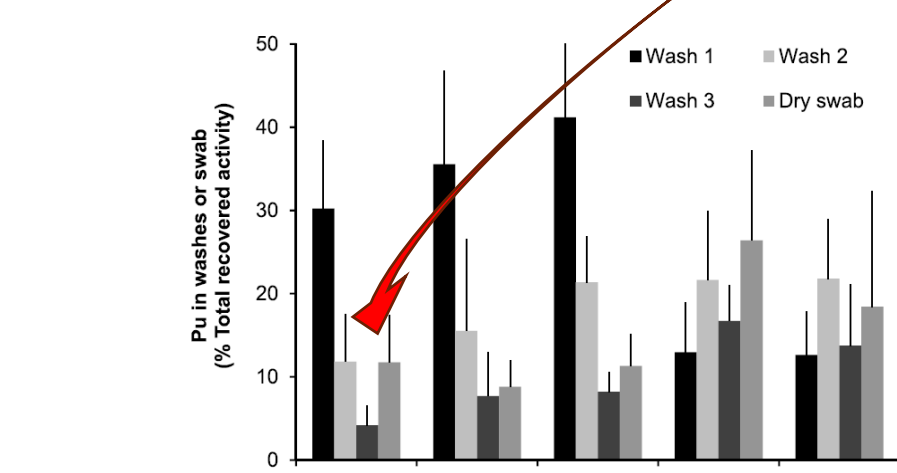
In the absence of certainty on the solubility class of the product, the initial DTPA treatment is recommended

PROVEN EFFECTIVENESS FROM WATER FLOW WASHING FOR ACUTE WOUND AND DECONTAMINATION PROCESS

Research
Emergency medicine

Water is a safe and effective alternative to sterile normal saline for wound irrigation prior to suturing: a prospective, double-blind, randomised, controlled clinical trial

Eric Alan Weiss¹, George Oldham¹, Michele Lin¹, Tammy Foster¹, James Victor Quinn¹
Correspondence to Dr Eric A Weiss, weisse@ucsf.edu



There is no difference in the infection rate of wounds irrigated with either TW or SS solution, with a clinical trend towards fewer wound infections in the TW group, making it a safe and cost-effective alternative to SS for wound irrigation

A Simple, Rapid, Comparative Evaluation of Multiple Products for Decontamination of Actinide-contaminated Rat Skin Ex Vivo Nina M. Griffiths, Karine Devillers, Pierre Laroche, and Anne Van der Meeren
Comparison of sequential decontamination steps with different products on 1 cm² rat skin samples: Even use with three successive washes from 3X500ml washes, the water is efficient through the mechanical flow action. We recommended abundant use of potable water for at least 10 minutes
Of course the decontamination waste water must be collected

The potable tap water irrigation has been reported to reduce colonisation of wounds and infection rates significantly. It has also been found that the rate of infection and outcome of wounds cleansed with potable tap water are similar to wounds cleaned with normal saline.. (Cleansing of wounds by tap water? An evidence-based systemic analysis) Chia-Yu Huang, Mun-Yau Choong, Tsong-Shiun Li

Simple Effective Ways to Care for Skin Wounds and Incisions: Don Lalonde, MD* Nadim Joukhadar, MD† Jeff Janis, MD‡ (Plast Reconstr Surg Glob Open 2019;7:e2471; doi: 10.1097/GOX.0000000000002471; Published online 29 October 2019.)

Open raw wounds will heal with proper care even if there is exposed fat, bone, tendon, muscle, or joint. If the wound is red, it has lost the waterproof barrier of skin and it is an open or raw wound that oozes liquid as our bodies are 80% water. The most important part of the care of raw wounds is to keep them clean and greasy so the tissues do not dry and die. Simple principles such as pain-guided healing, keeping raw wounds clean and greasy with a daily shower, and clean dressings are all that is required for most wounds to heal well

Wound Healing Society Evidence-Based Care of Acute Wounds: A Perspective

Dirk T. Ubbink, Fleur E. Bro, Imann, Peter M. N. Y. H. Go, and Hester Vermeulen

1. The cleansing of primarily closed wounds is dissuaded.
2. Dirty open wounds (street, bite, or cut wound) should be cleansed.
3. If a wound needs cleansing, then drinkable tap water suffices. This should be applied in a patient-friendly way using lukewarm water and a gentle squirt.
4. The use of disinfectants to cleanse acute wounds is dissuaded.
5. Bathing of wounds in whatever solution, even water, should not be part of wound cleansing

Declaration of interest:

The author report a conflict of interest related to his employer, EDF

Dr Hubert PEIFFER

Medical Doctor

CNPE de Flamanville 1 2

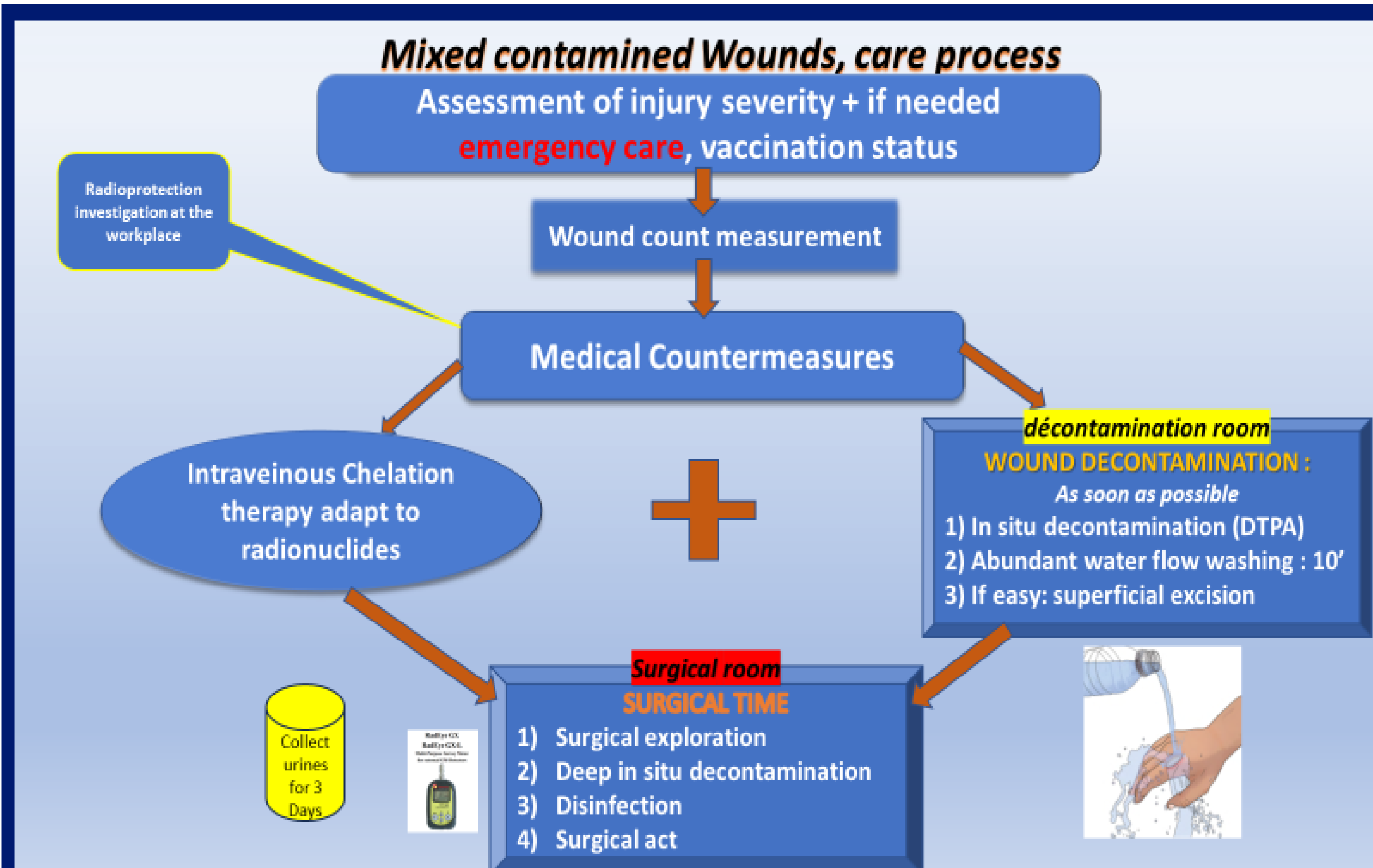
SPST

BP4 50340 LES PIEUX

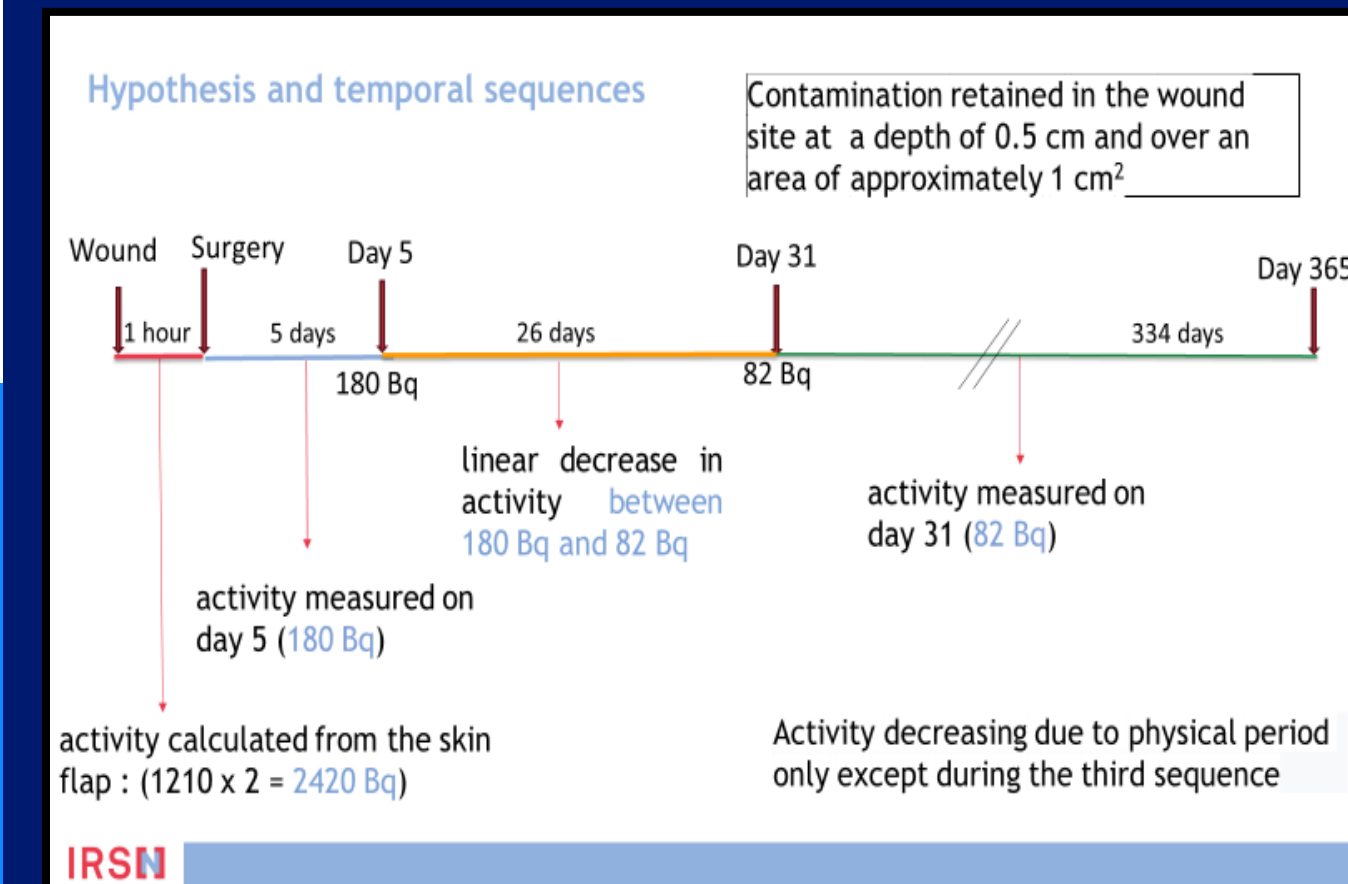
hubert.peiffer@edf.fr

ACKNOWLEDGEMENTS

Anne Van Der Meeren & Olivier Gremy Researchers at CEA, Laboratory of Radio Toxicology, Paris-Saclay University
Dr Jean Phan van, Dr Stephanie Paolini & Dr Marc Teissier
Dr Zhanat Kenbayeva Caar & Dr Chunsheng Li
Cédric Lewandowski Executive EDF Director
Flamanville & Civaux Medical Team



Return to work after 28 days.
Healing: No functional after-effects



Equivalent dose to the skin

Monte Carlo simulations with the MCNPX code
worker's hand modeled by a homogeneous volume of soft tissue
1 cm² surface source positioned at a depth of 0.5 cm
dose at 70 μm depth over 1 cm² (gamma and beta components of cobalt-60)
equivalent dose rate to the skin:
7.2x10⁻⁶ mSv.h⁻¹.Bq⁻¹

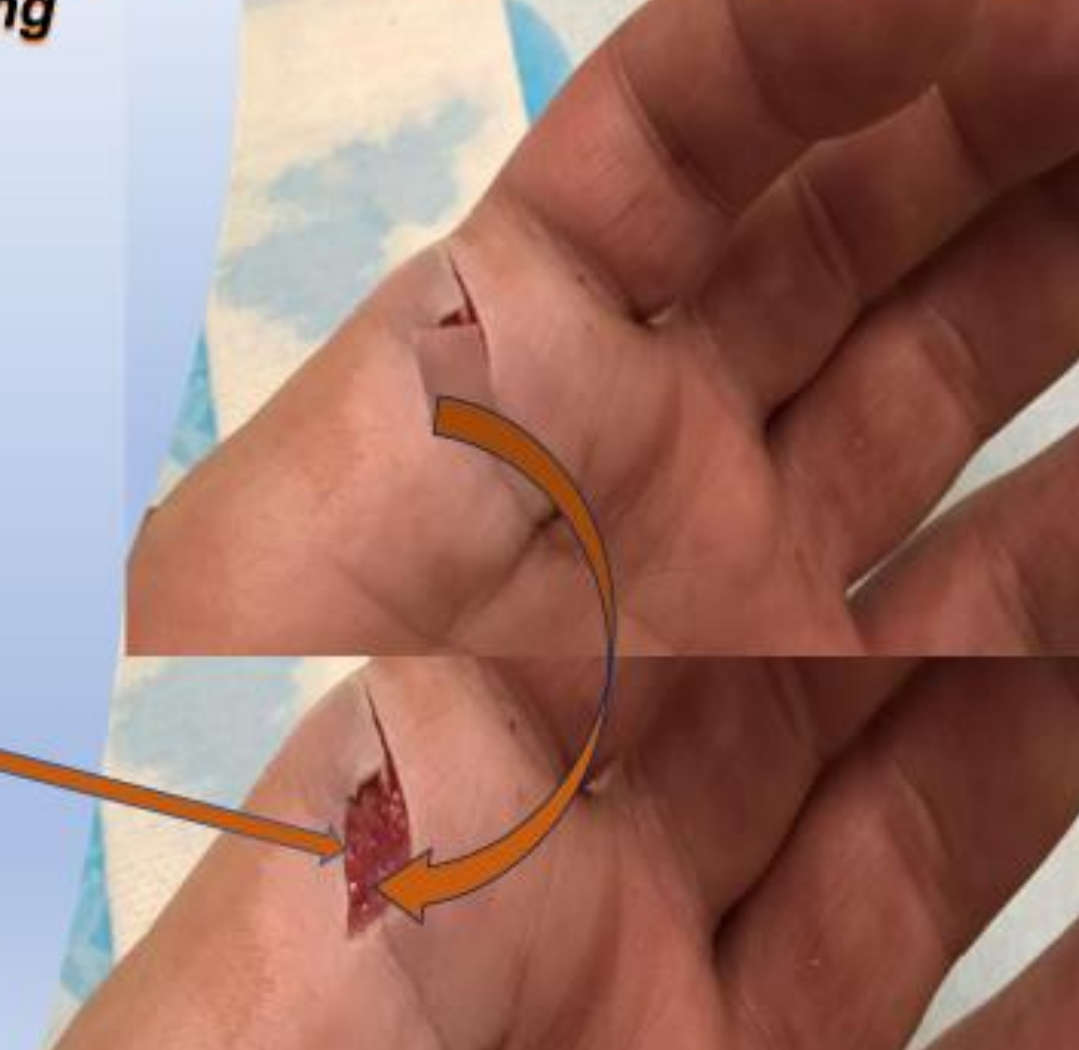
$$D = 24 \times 7.2 \times 10^{-6} \times \left(2420 \int_0^1 e^{-0.00036035t} dt + 180 \int_0^5 e^{-0.00036035t} dt + 82 \int_0^{334} e^{-0.00036035t} dt \right)$$

DECONTAMINATION ROOM AREA

Principles for local treatment:

Abundant local DTPA decontamination / Superficial excision/ Abundant water washing

- 1) Local wound decontamination with Dtpa
- We recommend a first local abundant decontamination with Dtpa.
- 2) Abundant water washing:
- The use of 35° drinking water from the tap, for at least 10 minutes, through the mechanical action of the flow, will contribute with efficacy to the decontamination process and avoid germs.
- 3) If possible, superficial epidermis excision:
- After the first decontamination treatment, we proceed to remove the flap of epidermis (1cm²) which is no longer vascularized. The flap is taken in the CIQ position with the NAI spectrometry. After application of the correction factor, the activity is estimated at 1200 Bq of Co60
- After several rinses with DTPA, the last NAI spectrometry examination in classic configuration (arm along the body) measures an activity around 600 Bq



Surgical room

Testing des fléchisseurs



4) Surgical exploration

- Any hand wound requires surgical exploration to look for damage from underlying structures, such as nerves, tendons, vessels, bones and joints, as well as the presence of foreign bodies.
- We recommend local anesthetic with lidocaine 1%.
- The use of adrenaline xylocaine which can reduce the bleeding and the transfer to the blood compartment but carries risks of necrosis in areas with terminal vascularization (finger, nose...) is not recommended,

5) Deep in situ DTPA decontamination:

Health Physician + Nurses

- the wound was deeply washed with a DTPA solution
- To check radioactivity, before using the Rad eye Sx (modern compact multi-purpose survey meter for external Geiger Mueller counter tubes.) dry strictly the wound not to undervalue activity
- the wound and gauze compress used during the decontamination time were checked after each cycle and allowed the presence of Co 60
- Several cleaning, rinsing and activity measurement cycles were carried out

Comparison of Local and Systemic DTPA Treatment Efficacy According to Actinide Physicochemical Properties Following Lung or Wound Contamination in the rat published: 26 March 2021 doi: 10.3389/fphar.2021.635792 Nina M. Griffiths*, Anne Van der Meeren and Olivier Grémy Laboratoire de RadioToxicologie, CEA, Bruyères le Chatel, France

6) Surgical time

- The NRC report N°156 (NCRP 2006) recommends that saved doses exceeding 10 times the annual limit may be appropriate for surgical excision.
- Chelation treatment is more effective for soluble plutonium, whereas surgical excision is more appropriate for particles and fragments. The review of literature demonstrated that surgical excision is highly effective in removing the activity deposited in the wounds. Similarly, chelation can enhance urinary excretion by a factor from 1 up to 130, on average to be 50 (Los Alamos National laboratory: Some Considerations for Chelation Treatment and Surgical Excision Following Incorporation of Plutonium in Wounds Poudel, Deepesh, Bertelli, Luiz Klump, John Allan Waters, Tom L.)
- In our case the decision for a non mutilating act was taken by looking at the moderate Co60 residual Bq activity. We preferred to preserve the functional prognosis over the low contamination.
- On the wound, which will have been cleaned, disinfected and dried, we used a Conservative procedure with a Blair Donati suture

