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Medical aspects of recent radiation accidents: The Georgian radiation accident and the treatment of local radiation injuries

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The threat of accidental radiation exposure for soldiers nowadays still exists. This danger cannot be estimated high enough. Medical prepardness for radiation accidents requires both intensive scientific and medical effort in the field of radiobiology. Interdisciplinary cooperation is of particular importance. Planning and dealing with radiation accidents requires close colaboration with international institutions like WHO and IAEA.

For the following reasons the *Lilo accident* (1) is a suitable candidate to serve as a model for radiation accident:

First of all, it constitutes a military medicine scenario, since military personnel was involved. Secondly, it is comparable with civilian accidents, since orphan radiation sources, for instance radiation sources used for so-called non-destructive material testing, play an important role in many radiation accidents, and people can be affected around the world.

The *Lilo accident* is to some extent a low-level radiation scenario, a type of scenario, which military medicine was not used to dealing with, or even bothered to think about in former times when the threat posed by the atomic -bomb was real.

But what is most important is the fact, that the Georgian accident showed just how necessary and effective close collaboration can be between the various institutions and agencies across national borders e.g. between WHO, IAEA, the Rempan centers in France, Russia and Germany. Even in the face of local accidents within a single coun-

Figure 1.

try (and even without any direct threat, for instance, from radioactive contamination) international cooperation is absolutely vital. No country can solve these problems on its own.

Figure 1. shows the geographically location of Lilo.

Lilo is situated about 25 km east of Tbilisi, the capital of Georgia, a state which belonged to the former Soviet Union.

The Lilo incident

The Lilo training center for border guards was previously a Soviet training camp for nuclear, biological and chemical warfare. At this base border guards undergo basic training.

In the period from about May 1996 to August 1997 11 soldiers suffered from nausea, headache, general fatigue and weakness. They also developed erythemas and skin lesions on different parts of the body. The patients were treated in different hospitals where bacterial infection, skin diseases or anaerobic phlegmonas were diagnosed. The real cause of the symptoms, an acute and subsequently chronic radiation disease was not established until June 1997, that is to say several months after initial examination by doctors. Nobody knew the origin of the radiation until the radiation sources were finally discovered in September 1997. Most of the sources were mainly cesium 137 sources with a dose rate of up to 13000 mGy/h and one was cobalt. Two types of cesium 137 sources were identified, one for calibration, the other for training purposes.

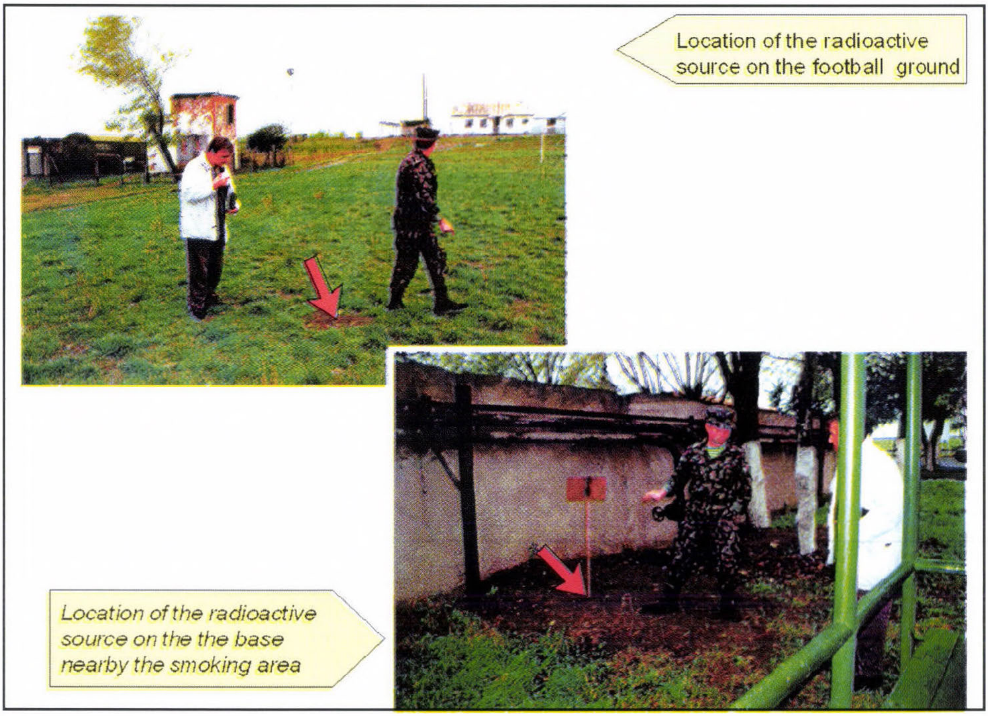

Figure 2.

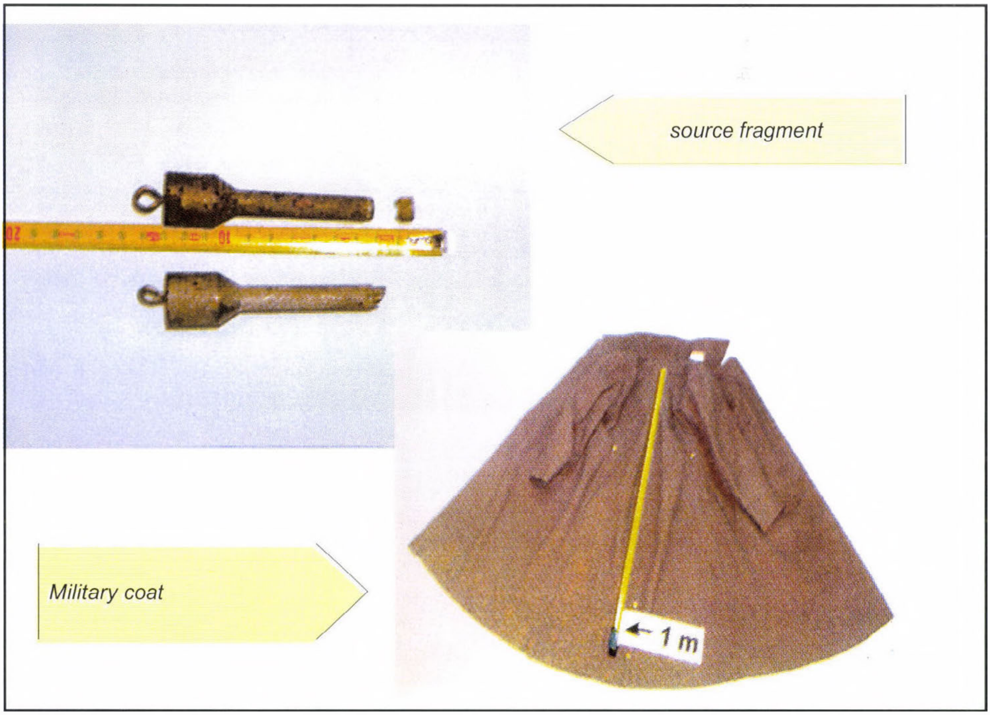

Figure 3.

Figure 2. shows the surroundings area: sources of the second type were hidden in the ground all around the training area and even beyond which meant that the patients were unwittingly exposed to ionizing radiation even during their leisure acitivities, for instance on the soccer field.

The sources were mounted on a source holder. A dismantled fragment of one radiation source was put in the pocket of a military coat by patient no. 10 *(Figure 3).*

Unfortunately, this coat was passed around among all eleven soldiers during duty hours and also used as a blanket at night in the dormitory they shared. The radiation source was then able to cause skin lesions where the body came into contact with the source in the coat.

The estimated hypothetic mean effective radiation doses ranged from 0.5 to 1.6 Gy (2).

The Georgian accident is a good example of successful collaboration between international partners. Seven of the patients were hospitalized in the WHO Rempan center in Ulm and four in the WHO Rempan center in Paris. Patient data and treatment protocols were readily exchanged.

Clinical data

Most of the patients –, though it is important to notify, not all, – suffered from, what in isolation seemed to be rather uncharacteristic general clinical complaints, such as headaches, nausea, vomiting, fatigue, and loss of appetite. But taken together and knowing the real case history of radiaton exposure, these symptoms can well be attributed to ionizing irradiation. The only problem is, that you have to put the pieces of the puzzle together.

Patient no 2, for instance, was at the training center from 5/96 to 4/97. He was exposed to cesium 137. In May 1997 he first showed red macules on the right forefoot and the right inner and lateral malleolus. In September 1997 he started to develope ulcers on the left lower leg. Parallel to the first clinical symptoms on the skin he complained of nausea, vomiting, diarrhoe, and sometimes headache. It is important to notify, however, there were a number of patients that showed no acute symptoms such as nausea or fatigue, but who developed multiple ulcers.

In some patients the bone marrows showed an excessive cell loss but regenerating process was already manifest. Chromosomal studies indicated the presence of dicentrics and fragments. All in all, there were signs of a reversible hematological change in these patients.

The 11 patients treated in France or Germany developed ulcers in different regions of the body. The number of ulcers ranged from 1 to 33 per patient. *Figure 4.* shows an example of multiple ulcers on the trunk at different clinical dermatological stages. Hypopigmented, areas that had already healed could be seen next to fresh ulcers in various dimensions and depths. Treatment of these patients required hospitilization over several months. Two principal treatments must be distinguished between here.

Figure 4.
Multiple radiation induced ulcers on the trunk

First of all, the classical dermatological ulcer treatment involving externally applied solutions and so, ointments combined with systematic ulcer cleansing and facilitation of granulation. The second method is the surgical approach. Skin grafting with either autologous split or mesh-grafts, dermatoplasty or – what is new and was performed in Paris, – so-called temporary wound closure with an artificial skin consisting of a collagen sponge on a silicon layer. At a later date the wound is closed definitively with the help of an epidermal autologous skin graft .

The lesson to be learned from the case histories of the Lilo patients is, that a radiation ulcer is no normal ulcer. Although it might look like one, it can not be classified under other classical clinical ulcers, such as the diabetic or venous ulcer. No-one can predict if, when and how these radiation ulcers will heal. If they close, they may sooner or later re-open. The pathophysiological mechanisms of radiation ulcers are different and not known to us yet. As the Lilo patients once again demonstrated. After being discharged from hospital in Germany or France some of the patients were subsequently treated in the Russian WHO-Rempan center in Obninsk. At a meeting in Oxford last year, where the treatment of these patients was discussed, our Russian colleagues were able to show pictures of new ulcers that had developed either adjacent to ulcers that had already healed, or in different regions which had hitherto been free of ulcers. Some succesfully treated ulcers had reopened this years after the original radiation exposure.

Treatment of local radiation injuries

For diagnosis and treatment of post-radiation hematopoetic failure common standards have been set [3], but for treatment of damage to other organs such as the skin, there is as yet no such common standard. Apart from the previously mentioned, standard treatments for ulcera, such as steroids or disenfectant solutions, small controlled case studies looking into other treatment options are to be found. For instance, *Gottlober* et al. [4] could show for five patients suffering from cutaneous radiation syndrome after radiation therapy that the later effects, e.g. fibrosis of the skin, could be improved by administering gamma interferon subcutaneoulsy. Other options such as pentoxyfille and alphatocopherol [4], are being looked at in experimental studies which already point to benefitcial influence on fibrosis. For cytokine treatment there are as yet no valid data. Controlled studies covering larger groups of patients in different controlled treatment study fields have not been performed so far. A great deal remains to be done in this field.

That dermatological complications may be the limiting factor in patient survival – has again been proven in *Tokaimura* – where in two out of three patients complications were responsible for the outcome. Attending to skin complications in post-radiation accident patients is most important for several reasons. The localization, extent and time intervall of its appearance is crucial for the further course of radiation response. It is hardly surprizing, therefore, that the so-called erythema threshold dose was the established dosimetry parameter until the introduction of the *Roentgen* in 1928. In those days patients were irradiated until the appearance of a skin erythema. Today, by contrast, these clinical signs can prove valuable as a kind of clinical dosimetry.

A further important fact about skin reactions is that in regions of the body where specific dermatological signs and symptoms appear, it is always essential to look for damage of deeper tissues or organs. Dermatological signs can be indicative of serious damage of to deeper organs.

How can we prepare for radiation accident management?

As we can see from the Lilo patients: the most important factor when dealing with radiation exposure is – to actually think of the possibilty of such exposure. Ionizing radiation is invisible, and one cannot feel it. When clinical symptoms do appear much precious time for early treatment has already elapsed. It is therefore important that all doctors concerned with such matters receive training in the basics of the pathophysiolgy of radiation reactions. Especially all military doctors are in need of such training, which should cover not only the diagnosis of a radiation exposure but and in particular, how to handle and treat affected patients. The past has shown, that when dealing with radiation accidents close cooperation between international, governmental and local institutions is of the essence. A central collection of data on the case history of radiation victims [6] can be very helpful in planning disaster medicine management. Military medicine has a role to play here, too. Equally, military medical authorities will not be able to take action in this field without involving the international institutions.

REFERENCES

[1] *Gottlober, P., Bezold, G., Weber, L., Gourmelon, P., Cosset, J. M., Bahren, W., Hals, H. J., Fliender, T. M., Peter, R. U.*: The radiation accident in Georgia: clinical appearance and diagnosis of cutaneous radiation syndrome. J. Am. Acad. Dermatol. 2000; *42:* 453-8.

[2] *Bottollier-Depois, J. F., Gaillard-Lecanu, E., Roux, A., Chau, Q., Trompier, F., Voisin, P., Gourmelon, P.*: New approach for dose reconstruction: application to one case of localized irradiation with radiological burns. Health Phys., 2000; *79:* 251-6.

[3] *Dainiak, N., Sorba, S.*: Early identification of radiation accident victims for therapy of bone marrow failure. Stem Cells, 1997; *15:* 275-85.

[4] *Gottlober, P., Steinert, M., Bahren, W., Weber, L., Gerngross, H., Peter, R. U.*: Interferon-gamma in 5 patients with cutaneous radiation syndrome after radiation therapy. Int. J. Radiat. Oncol. Biol. Phys., 2001; *50:* 159-66.

[5] *Lefaix, J. L., Delanian, S., Vozenin, M. C., Leplat, J. J., Tricaud, Y., Martin, M.*: Striking regression of subcutaneous fibrosis induced by high doses of gamma rays using a combination of pentoxifylline and alpha-tocopherol: an experimental study. Int. J. Radiat. Oncol. Phys., 1999; *43:* 839-47.

[6] *Friesecke, I., Beyrer, K., Wedel, R., Reimers, K., Fliedner, T. M.*: SEARCH: a system for evaluation and archiving of radiation accidents based on case histories. Radiat. Environ. Biophys., 2000; *39:* 213-7.

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Orvosi szempontok egy újabb sugárbaleset kapcsán: A baleset és a lokális sugárkárosodás kezelése

A „Lilo baleset" (1996–97) egy örményországi vegyi-radiológiai kiképző bázison jelentkezett. A 11 katona hányásról, hasmenésről gyengeségről, fokozott fáradékonyságról, fejfájásról számolt be, majd a későbbiekben e panaszokat erythenák és bőrkárosodások jelentkezése egészítette ki. Csak a későbbiekben állapították meg (1997. szept.), hogy a panaszok oka főleg a Cs-137 és kisebb mértékben a Co-60 sugárforrások, amelyekkel a kiképzés során kerültek kontaktusba. A gyorsan felvett nemzetközi kapcsolatok eredményeként 7 beteget a WHO Rempan program keretében Ulmban, 4 beteget Párizsban kezeltek, a továbbkezelés Obnins-ban történt. A szerzők beszámolnak a klinikai adatokról és a lokális sugárkárosodások kezelési szempontjairól. Külön felhívják a figyelmet a szakmai továbbképzés, a helyi szervek, a kormányzat és a speciális nemzetközi egészségügyi szervezetek együttműködésének fontosságára.

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