CBRN Red Cross Seminar
December 8, 2016

Medical aspects of Radiation Emergencies

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Medical Emergency Preparedness specialist
Incident and Emergency Centre

IAEA
International Atomic Energy Agency

Objective

- Understand the basic concepts of and requirements for the management of medical consequences of a radiation emergency

Image courtesy IAEA

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Radiation Emergency: Definition

"A non-routine situation that necessitates prompt action, primarily to mitigate a hazard or adverse consequences for human health and safety, quality of life, property or the environment and in which there is, or is perceived to be, a hazard due to:

(a) The energy resulting from a nuclear chain reaction or from the decay of the products of a chain reaction; or

(b) Radiation exposure"

[IAEA Safety Glossary, 2007]

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Radiation Emergency: Spectrum

Event	Affected individuals
Radiation accident	Workers Members of the public Responders
Medical mishap	Patients
Malevolent acts	Members of the public Responders

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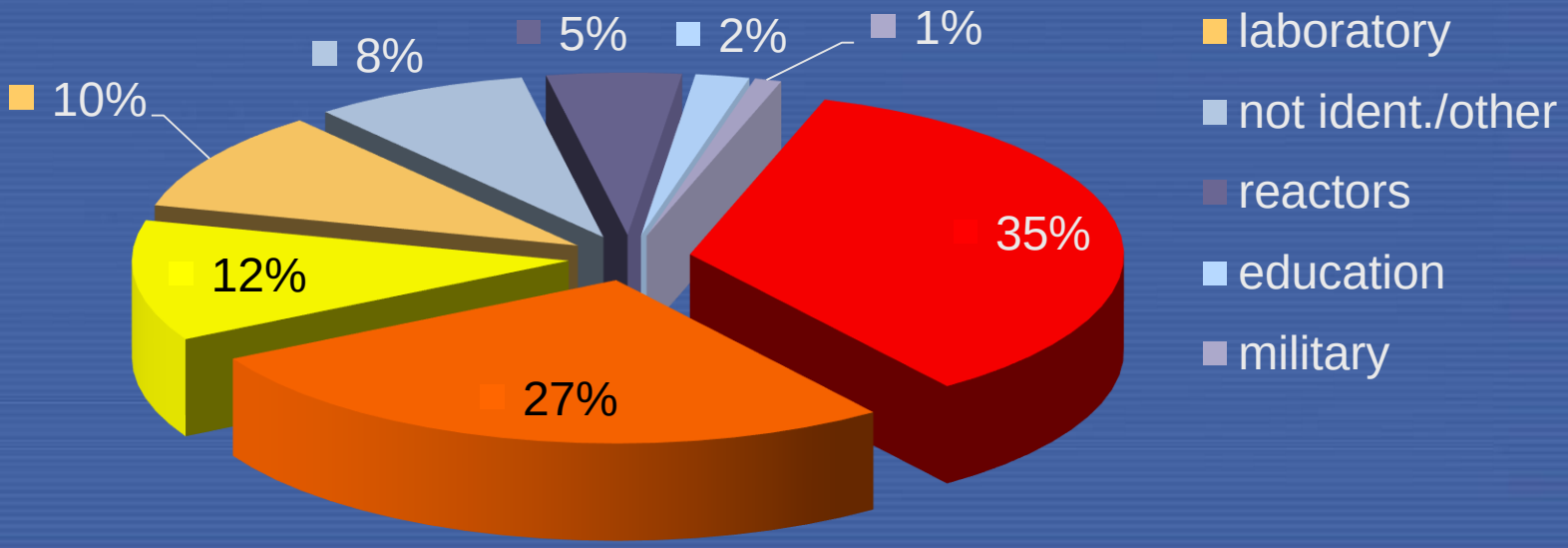
“Major” Worldwide Radiation Accidents

- Number: ~500 accidents
- Exposed persons: ~3,000
- Fatalities: ~140
  - Radiation related: ~130
  - Not related to radiation: ~10



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*M. E. Berger et al.: Medical Management of Radiation Injuries. Occupational Medicine 2006;56:162–172 doi:10.1093/occmed/kql011.
* Medical Preparedness and Response for a Nuclear or Radiological Emergency. Training Materials. IAEA, VIENNA, 2014. EPR-MEDICAL/T-2014/CD © IAEA, 2014

Discussion

"Why do people fear ionizing radiation?"

Can you give examples?

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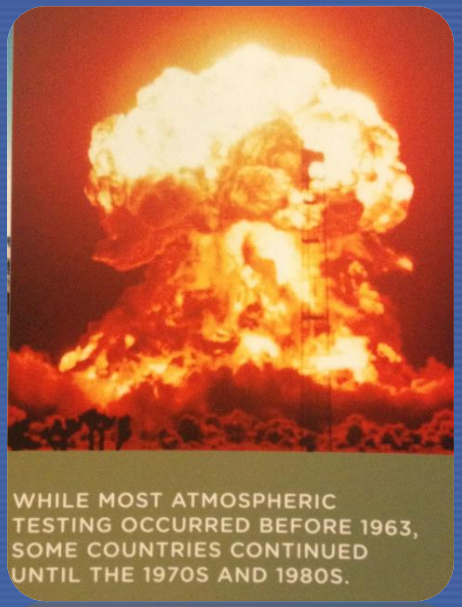
Risk Perception: Hiroshima-Nagasaki

Hiroshima

Nagasaki



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Images courtesy IAEA

Newspapers

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Good or Bad Radiation?

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Image courtesy IAEA

Radiation Emergency: Images (cont)

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Images courtesy IAEA

Risk Perception: other risks

WHO
- Tobacco kills up to half of its users
- Kills 6 million people each year
- 600 000 are the result of non-smokers being exposed to second-hand smoke.

WHO June 2016

WHO
- 1.25 million people died from road traffic injuries in 2013
- 20–50 million people sustaining non-fatal injuries

WORLD HEALTH STATISTICS: 2016
Indicator 3.6.1: Death rate due to road traffic injuries

Inadequate consumption of fruits and vegetables increases the risk of cardiovascular disease and some cancers and accounts for some
1.7 million deaths a year.

World Heart Federation

Radiation Emergency: Images

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Images courtesy IAEA

Radiation Emergency: Images

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Image courtesy IAEA

Importance of Plain Language Explanations

Bq

Sv

Dose

Bq/kg

Contaminated

cps

µSv/h

Risk

High doses

Not clearly answering this question has resulted in:

- Voluntary abortions
- Unsafe evacuation of patients (deaths)
- Not treating patients
- Stigma
- Economic impacts
- Psychological distress
- etc.

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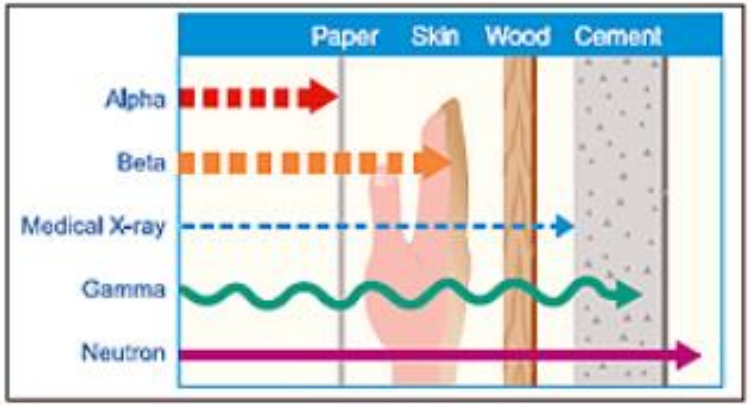
Image courtesy IAEA

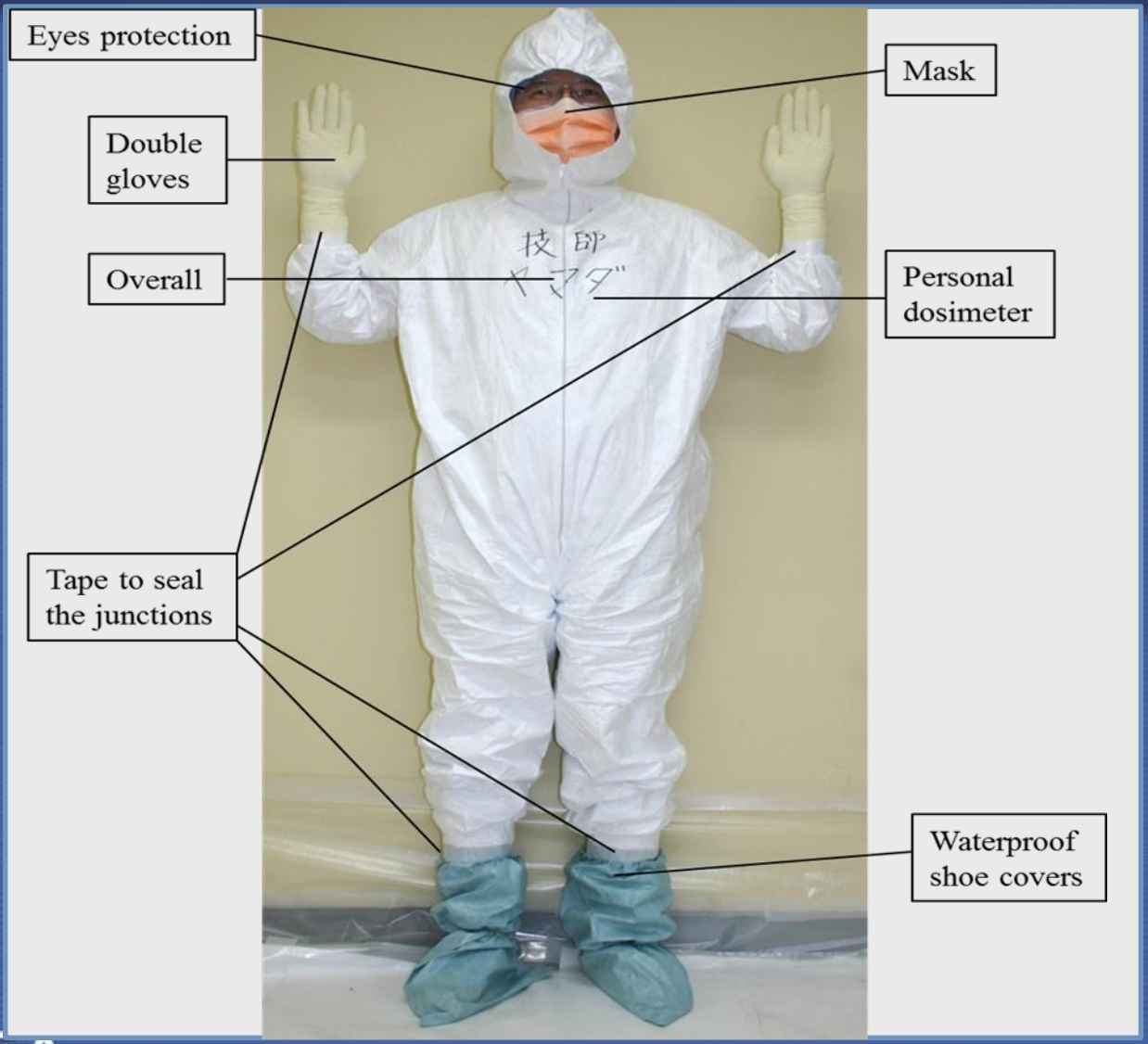


Alpha

Beta

Gamma

Irradiation vs contamination


Eyes protection
Mask
Double gloves
Overall
Personal dosimeter
Tape to seal the junctions
Waterproof shoe covers

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Triage at the Emergency Department

Image courtesy NIRS

- Medical assessment and triage at hospital
- First aid and resuscitation
- Medical stabilization
- Radiological assessment

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Principles

- A radiological assessment or decontamination should never take precedence over significant medical conditions
- Action taken to avert exposure is much more effective than the provision of medical treatment after exposure has occurred

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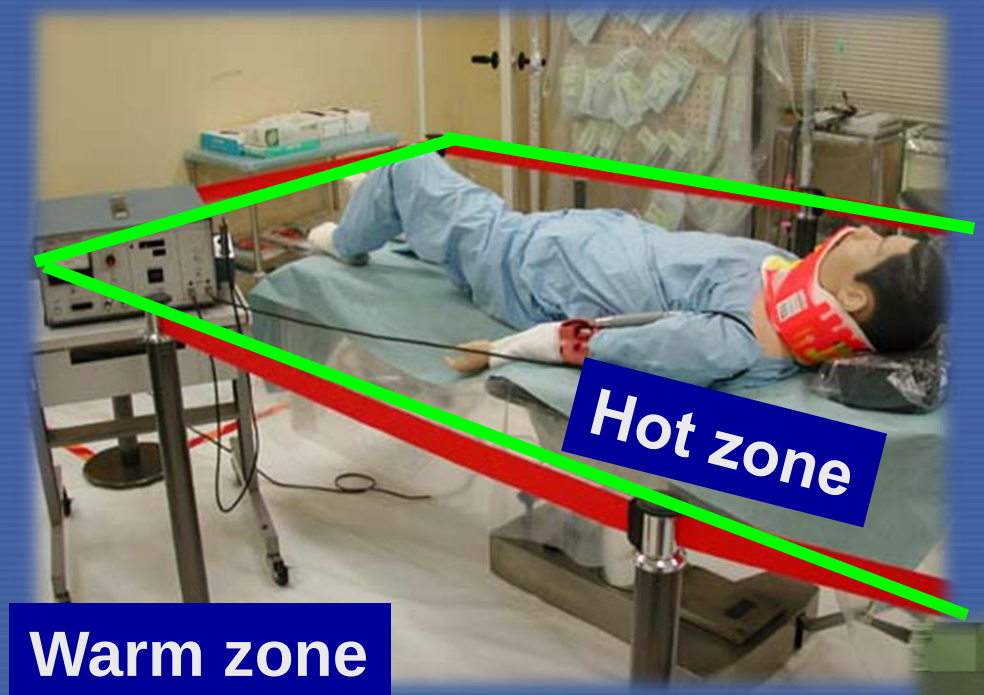
Images courtesy NIRS

Supplies

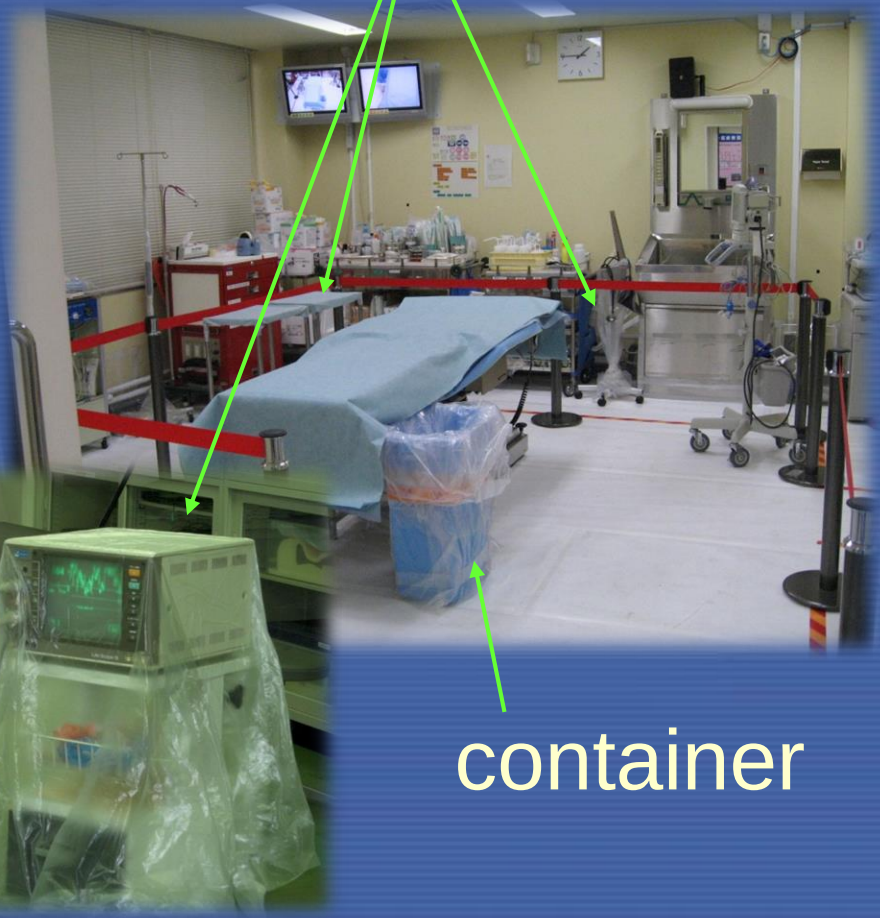
- Protective clothing
- Instrumentation and dosimeters
- Material for securing the area and controlling contamination (i.e. rope and signs)
- Materials for bioassay
- Materials for decontamination
- Life support and other medical equipment and supplies

Example of Area Setup



Control lines

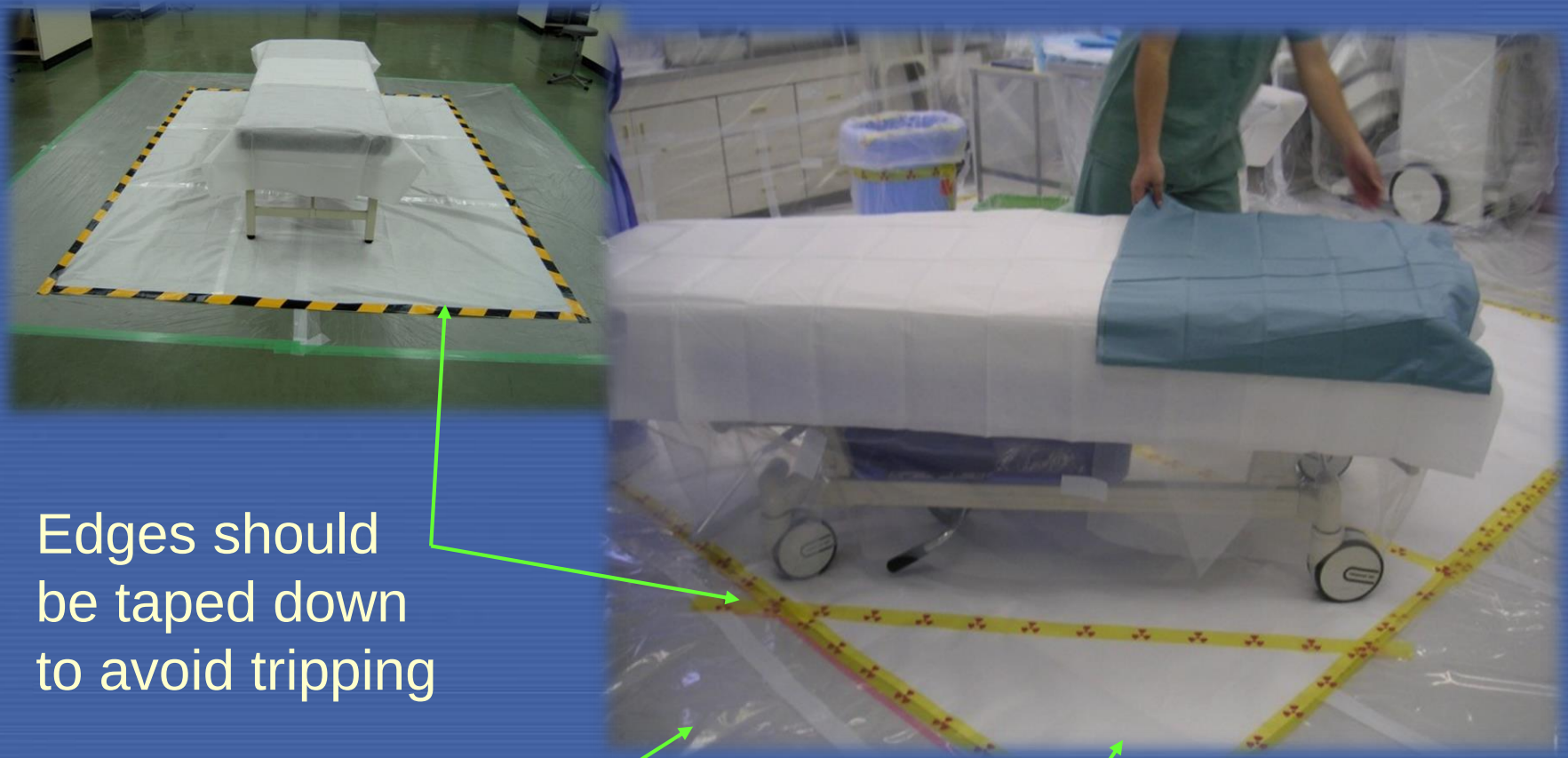
Covering equipment



container

Images courtesy NIRS

Example of Floor Covering



Edges should be taped down to avoid tripping

Plastic sheet

Paper sheet

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Images courtesy NIRS

Wearing Protective Clothing

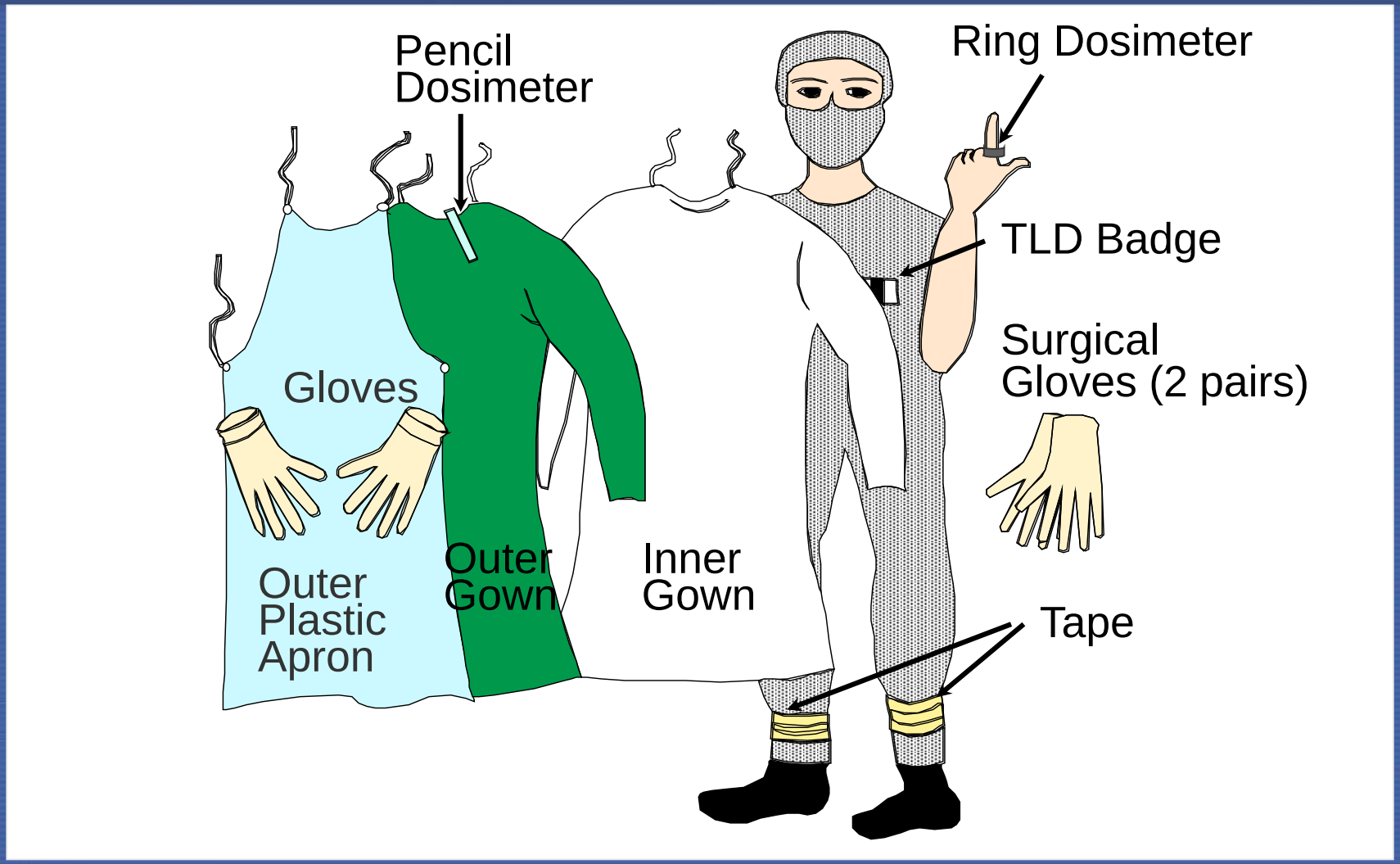

Image from R H Wagner, et. al. RadioGraphics 1994; 14:387-396

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Protective Clothing

- Purpose of protective clothing:
  - Keep bare skin and personal clothing free of contaminants
  - Against contamination not external exposure

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Image courtesy IAEA

Examples of Protective Clothing

Surgical clothing

Eye protection

Tape

Personal dosimeter

Cap

Mask

Surgical gloves

Name (front and back)

Gown

Waterproof shoe covers

Tape

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Image courtesy NIRS

Management of Contaminated Patient

- Ensure stabilization of patient
- Survey whether contaminated or not
- Identify decontamination priority
    1. Wound
    2. Orifices (eyes, mouth, nose, ears)
    3. High level intact skin
    4. Low level intact skin

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Laboratory Studies

- Blood count: attention to lymphocytes → Whole-body exposure diagnosis and dose assessment
- Cytogenetic analysis
- Urine and stool samples for later evaluation of radionuclide incorporation → Internal contamination diagnosis and burden assessment
- Other laboratory studies for diagnosis and medical treatment if necessary

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In all Cases of Radiation Injury

Samples needed	Why?	How?
Complete blood count (CBC), followed with absolute lymphocyte counts every 6 hours for 48 hours when history indicates possibility of total-body irradiation	To assess the radiation dose; initial counts establish a baseline, subsequent counts reflect the degree of injury	Choose a non-contaminated area for veni-puncture; cover puncture site after collection
Routine urinalysis	To determine if kidneys are functioning normally and establish a baseline of urinary constituents; especially important if internal contamination is a possibility	Avoid contaminating specimen during collection; if necessary, give the patient plastic gloves to wear for collection of specimen; label specimen "Number I ," with date and time

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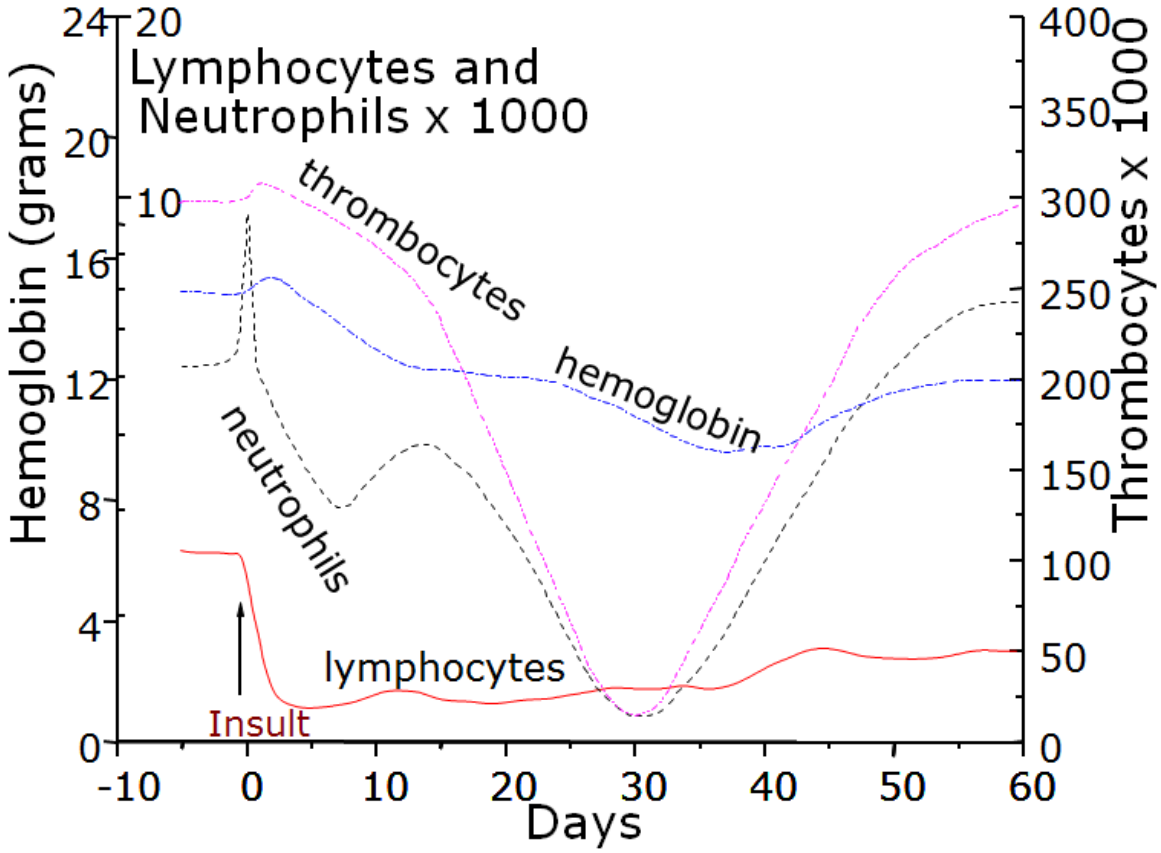
Example: CBC w/ differential after high dose



Lymphocytes are white blood cells that govern the body immune response (directs fighting disease and infection)
Neutrophils are a subset of white blood cells that fight infection
Thrombocytes (platelets) are for clotting
Hemoglobin is the component of red blood cells that carry oxygen

Image courtesy IAEA

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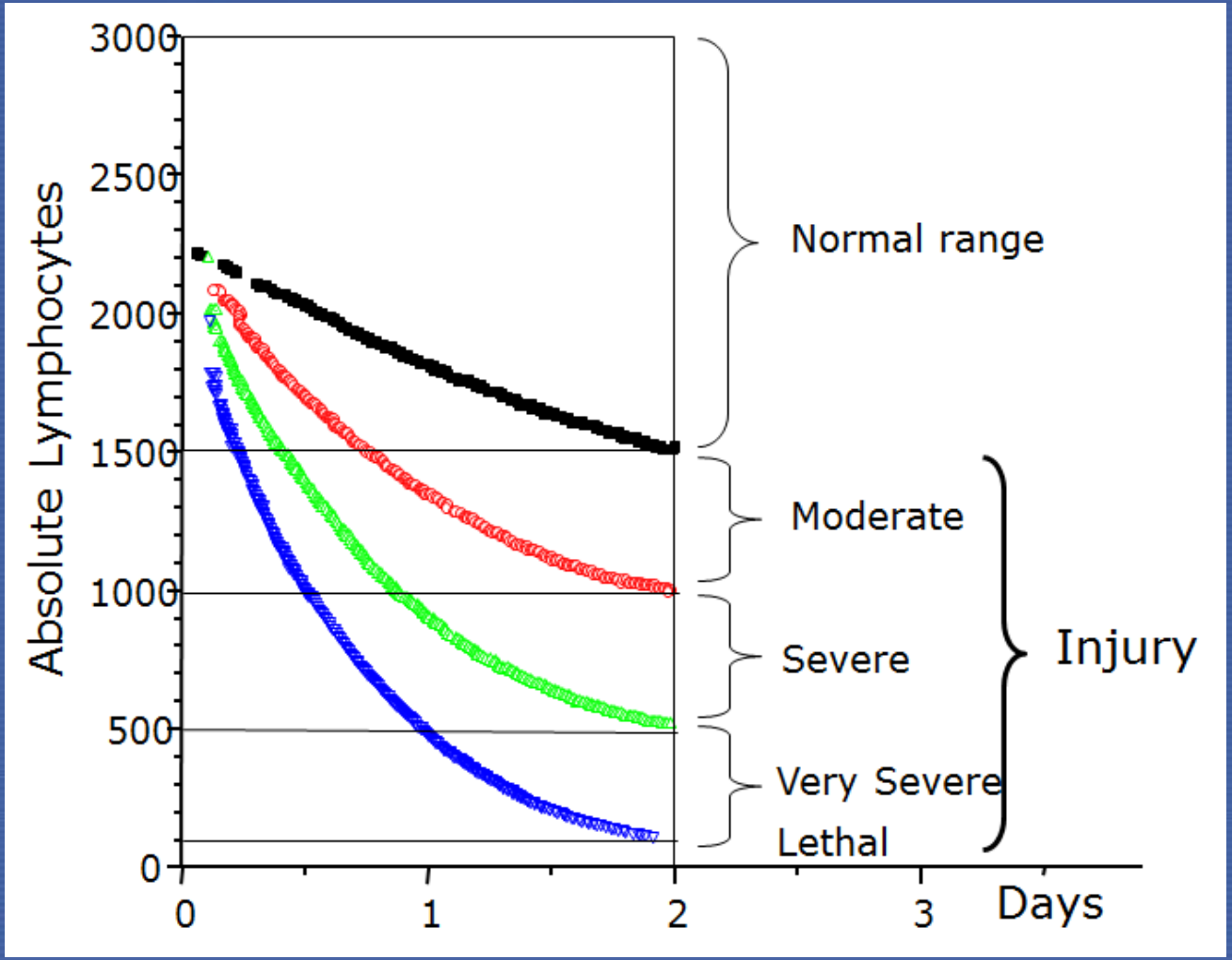
Lymphocyte depletion kinetics



Images courtesy IAEA

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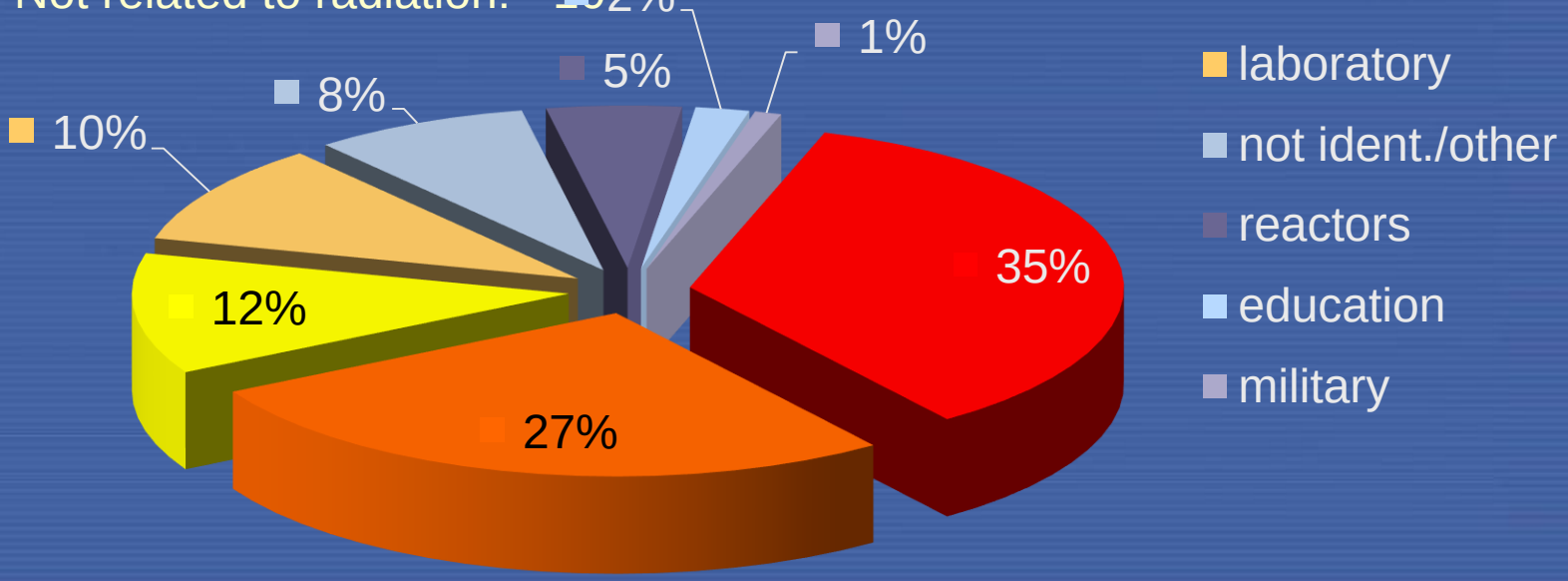

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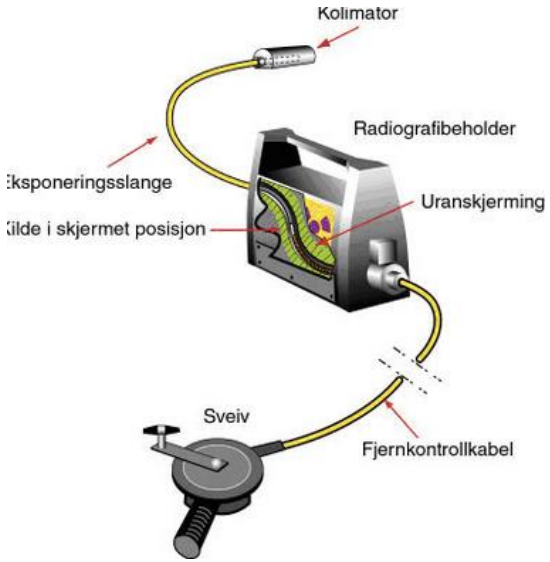
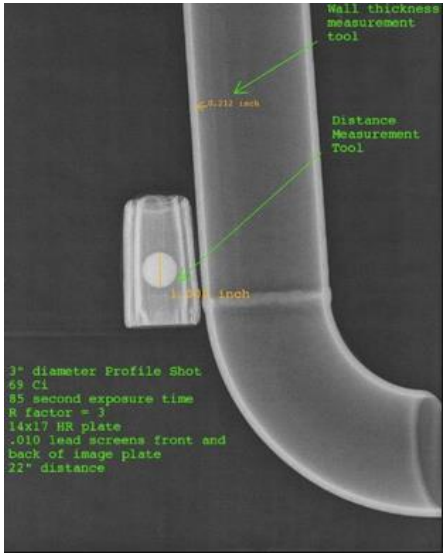
*M. E. Berger et al.: Medical Management of Radiation Injuries. Occupational Medicine 2006;56:162–172 doi:10.1093/occmed/kql011.

Distribution

Sector	Number of cases
Industrial	33 (27: gamma-graphy)
Radiotherapy	8
Orphan	2
Criticality	1
Inspection	1
Medicine (occupational)	1
Total	46

Industrial Radiography





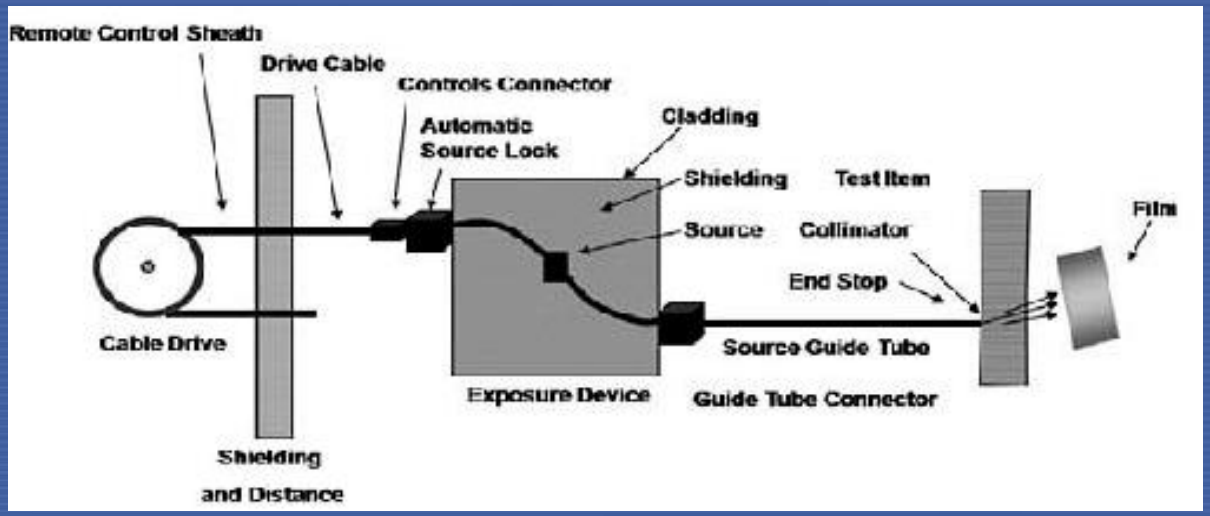
Industrial radiography

Industrial radiography

Industrial radiography is used to test:

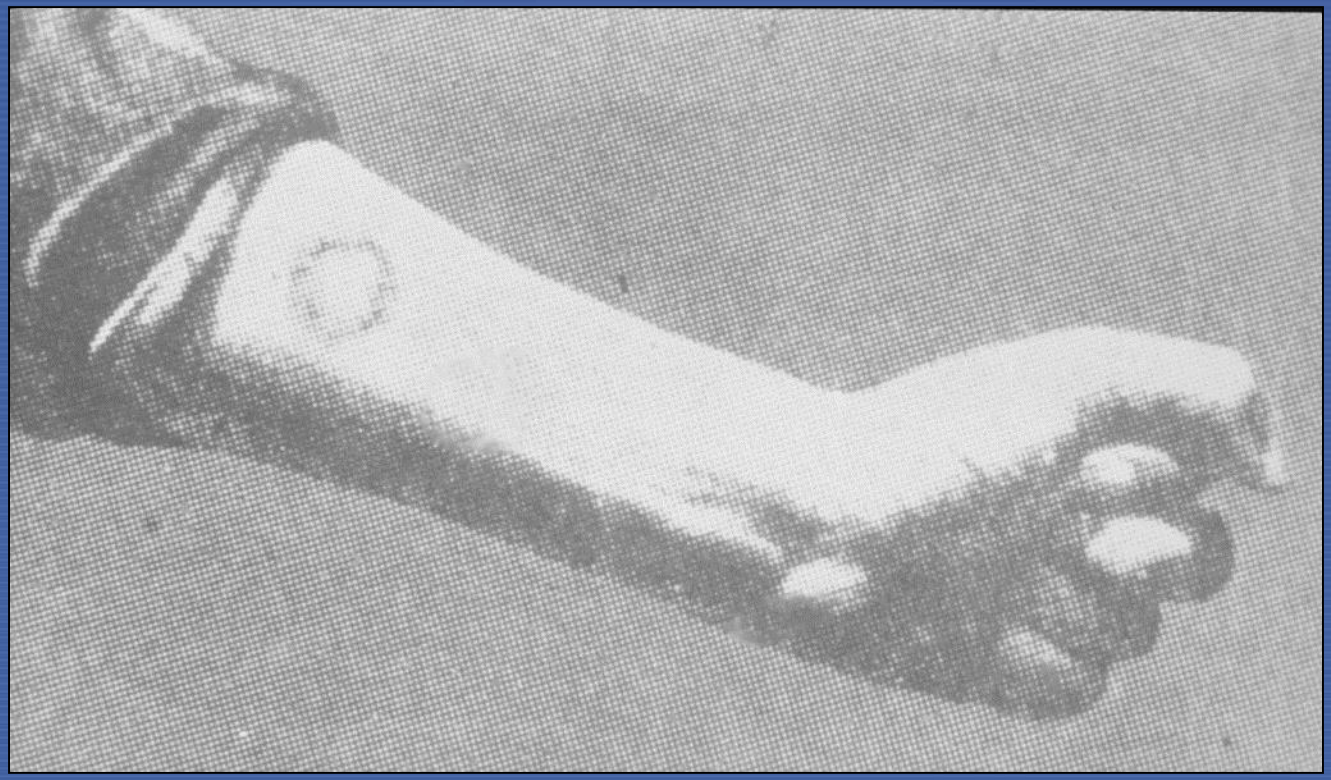
- Gas and oil pipelines.
- Metal welding.
- Boilers.
- Vehicle parts.
- Aircraft parts.

Industrial radiography



Iridium-192 is a strong gamma ray emitter.

Radiopathology of the Skin



Radiopathology of the Skin (1)

Dry desquamation

- **Dose in derma from 8 to 12 Gy**
- Dry epithelitis, with desquamation
- Compensation of epidermis leakage:
  - protection of the cutaneous barrier
  - absence of serum exudation
  - absence of skin crust formation
- Epidermis thickening: rough, dry, pigmented aspect

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Radiopathology of the Skin (2)

Moist desquamation

- **Dose in derma from 12 to 20 Gy**
- Epidermis leakage sufficient for:
  - serum exudation
  - skin crust formation
- 3 to 4 weeks for epidermis leakage, blistering formation, apparition of dripping, pink skin area which dry and form skin crust
- Stripped area covered by fibrin

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Radiopathology of the Skin (3)

Radionecrosis

- **Dose >30 Gy**
- Endothelium loss, drop of capillary density, drop of blood perfusion
- Huge dermal inflammatory response
- Stripped area covered by fibrin
- Intense and long-lasting moist desquamation induced secondary dermal lesion

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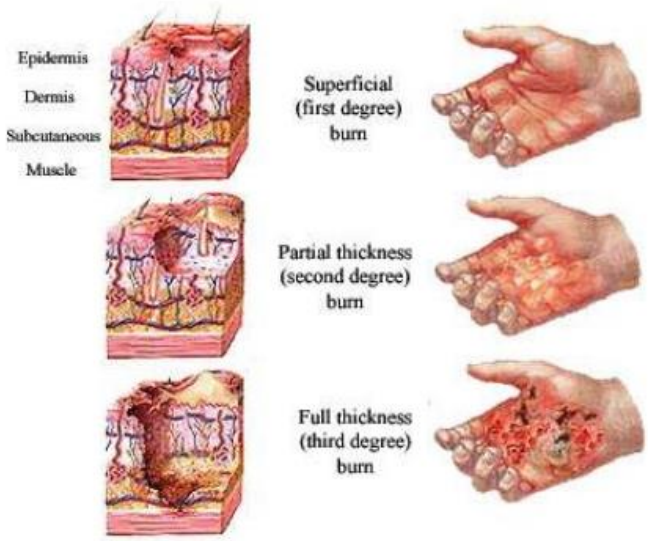
Skin burn Classes



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Specificity of the Radiological Burn

- The radiological burn is a dynamic process
- Unpredictable spatiotemporal evolution with successive inflammatory waves
- Pain +++ resistant to classical drugs
- The occurrence of pain is prognostic for a new wave of recurrence

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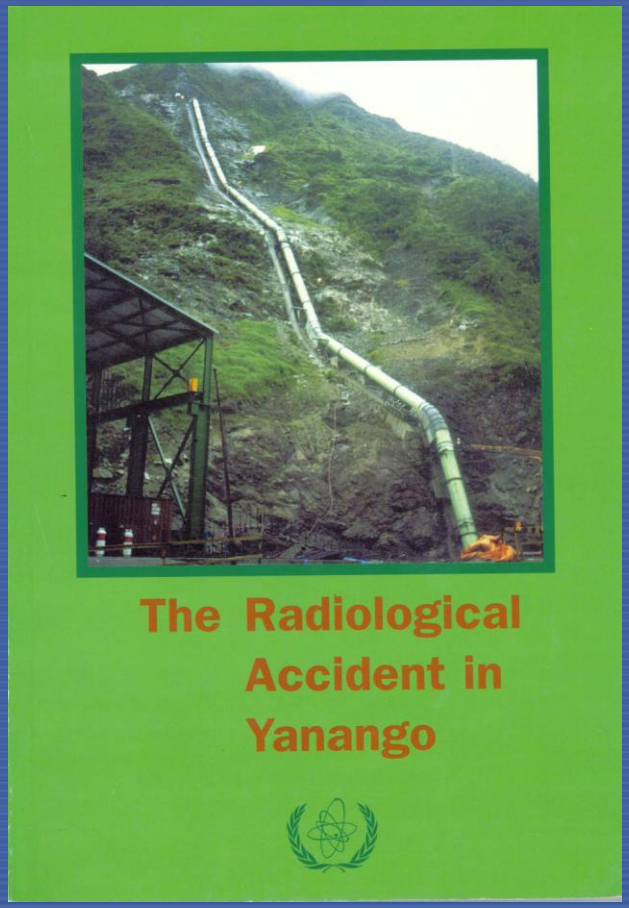
The Radiological Accident in Yanango, Peru, 1999



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Initial Lesion – Day 3

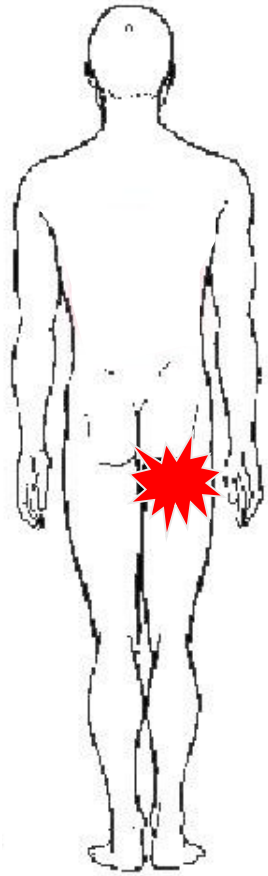
On 21 February (Day 1), the patient was admitted to Institute of Neoplasic Diseases (INEN) in Lima

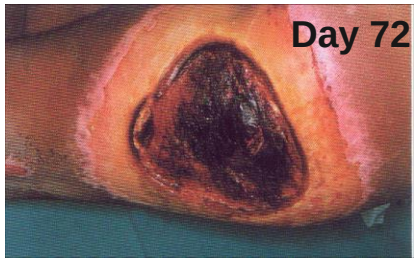
Hospitalization in France

Cutaneaous Radiation Syndrome
right leg

day 3

day 9





Hospitalization in France (on Day 101) in the Burn Treatment Department (HIA Percy), 1 June 1999.

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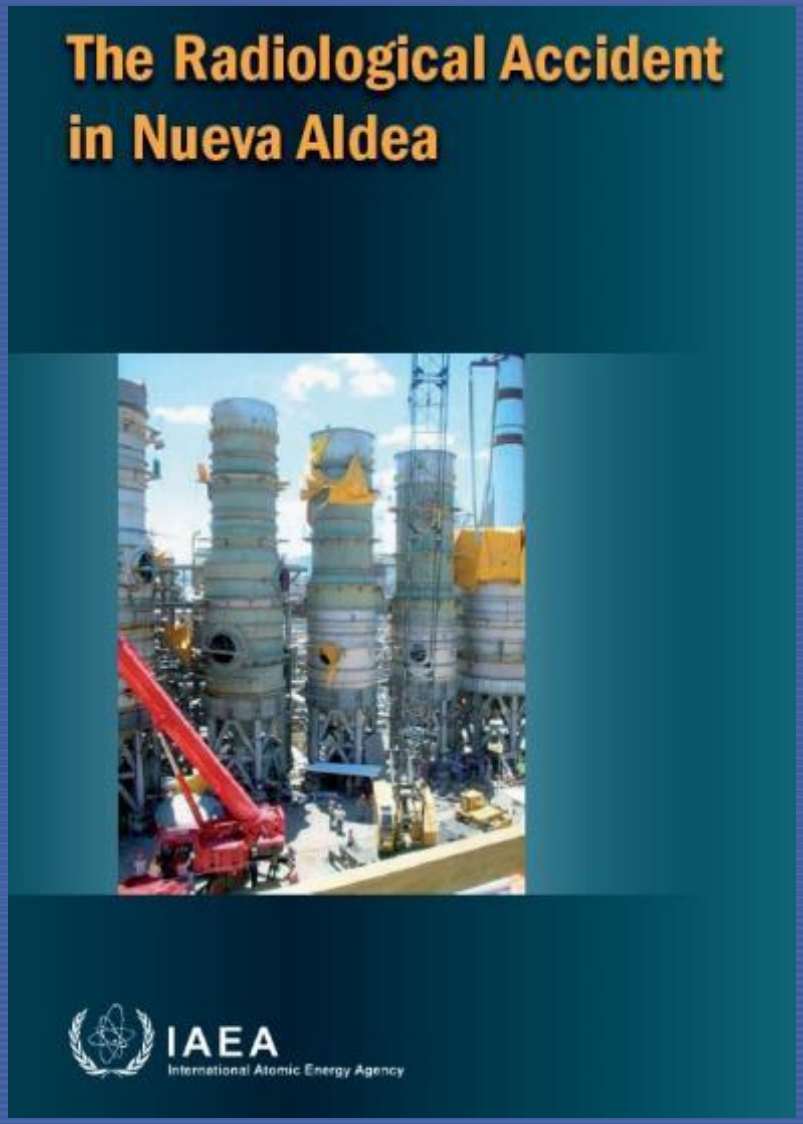
Courtesy: IRSN – HIA Percy (France)

Clinical Evolution After Return of Patient to Peru

Day > 240

Photo Credita: Dr. Oscar Barriga (INEN, Peru)

Chile 2005



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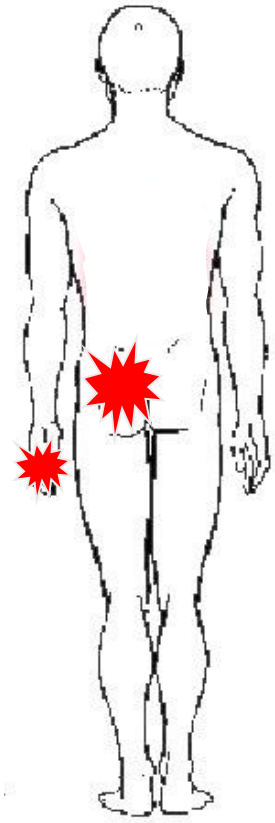
Clinical Symptoms (1)

Time of exposure: *40 min., including 10 min. with the radiation source in back pant pocket.*
Localized irradiation suspected : *buttock, hands, head and chest.*

Cutaneous radiation syndrome of the left hand



Radiological lesion of the buttock

Hospitalized in France on 26 December 2005, in the Burn Treatment Department of the Percy Hospital, for a cutaneous radiation syndrome

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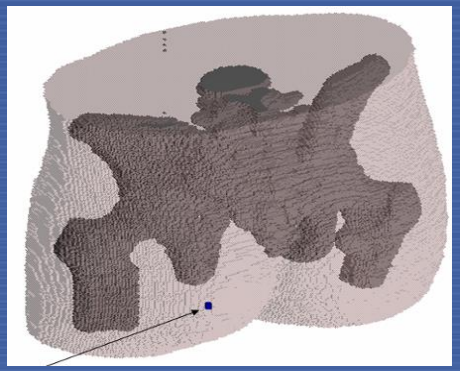
Courtesy: IRSN – HIA Percy (France)

New Approach by Dosimetry Guided Surgery

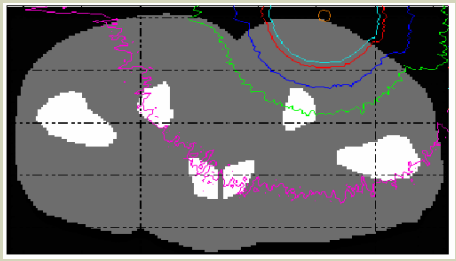
CT SCAN

FIRST EXERESIS (day 21)



Source

PHANTOM
VOXELIZATION



1900 Gy
25 Gy
20 Gy
10 Gy
5 Gy
1 Gy

DOSIMETRIC MAP

2000 Gy at skin surface
20 Gy at a depth of 5 cm

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Courtesy: IRSN – HIA Percy (France)

Buttock Lesion Evolution

109 days P.I.

162 days P.I.

204 days P.I.

Courtesy: IRSN – HIA Percy (France)

Evolution of Hand Lesion

1 month

2 months

3 months

Courtesy : IRSN - HIA Percy (France)

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September 2013 (6 years after accident)

Radiological Accident 2012 - 2013. Chilca, Peru.

- January 11-12, 2012 // January to September 2013.
- Industrial radiography company.
- 3 workers overexposed
- 3 formal requests for assistance were sent from Peruvian Authorities to the IAEA under the Assistance Convention.
  1. Dose reconstruction and medical advice (held in Peru - January 20, 2012).
  2. Medical treatment of the worker who had been most severely exposed during the accident (held in France - February 1, 2012).
  3. Medical treatment for recurrence of symptoms (held in Chile - May 18, 2013).
- Assessment by through RANET.

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Radiological Accident 2012-2013. Chilca, Peru.

TABLE 9. DOSE ESTIMATION BASED ON BIOLOGICAL DOSIMETRY (IRSN DATA)

Person	Whole body dose [Gy]	[Confidence Interval]	Partial body irradiation
Worker 1	1.86	[1.56 - 2.20]	Yes
Co-Worker 1	0.45	[0.23 - 0.75]	Could not be determined
Co-Worker 2	0.75	[0.50 - 1.06]	Could not be determined
RPO	Below detection limit	Not applicable	Could not be determined
Worker 2	Below detection limit	Not applicable	Could not be determined

Photos and table from "The Radiological Accident In Chilca, Peru. IAEA"

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6 days post accident


30 days post accident


33 days post accident
Moist desquamation

EPR

Photo courtesy IRSN- FRAMCE.
Photo and table from "The Radiological Accident In Chilca, Peru. IAEA"

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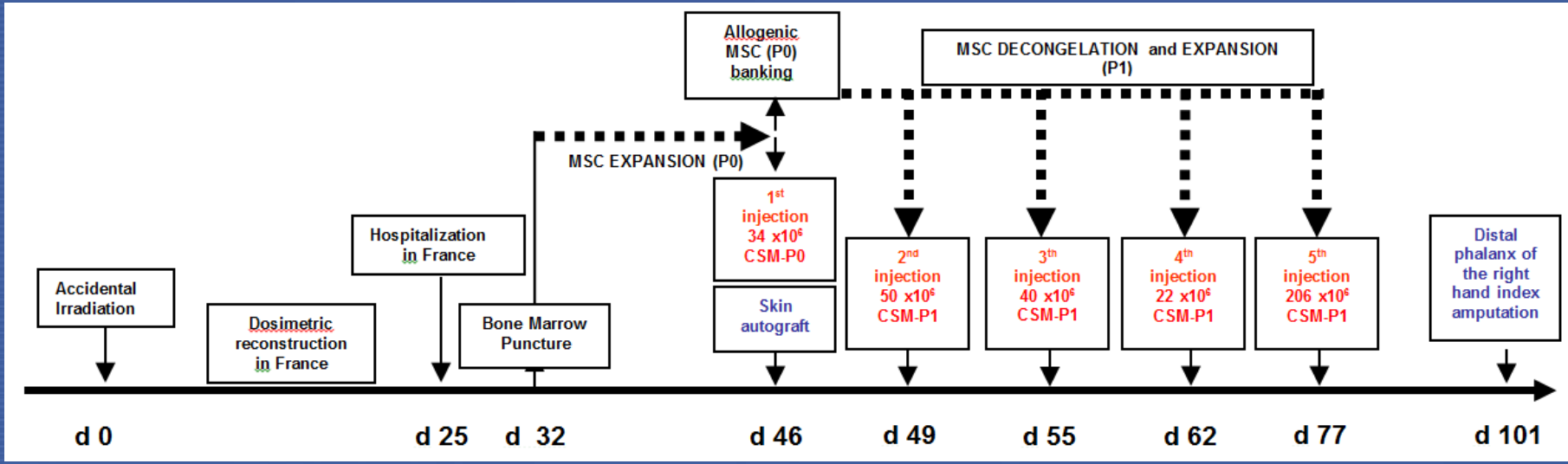
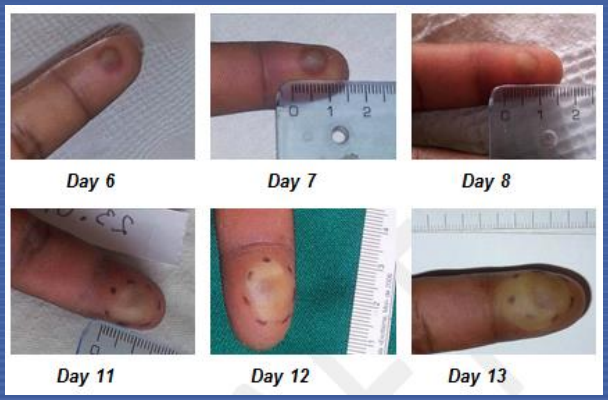
Radiological Accident 2012. Chilca, Peru.





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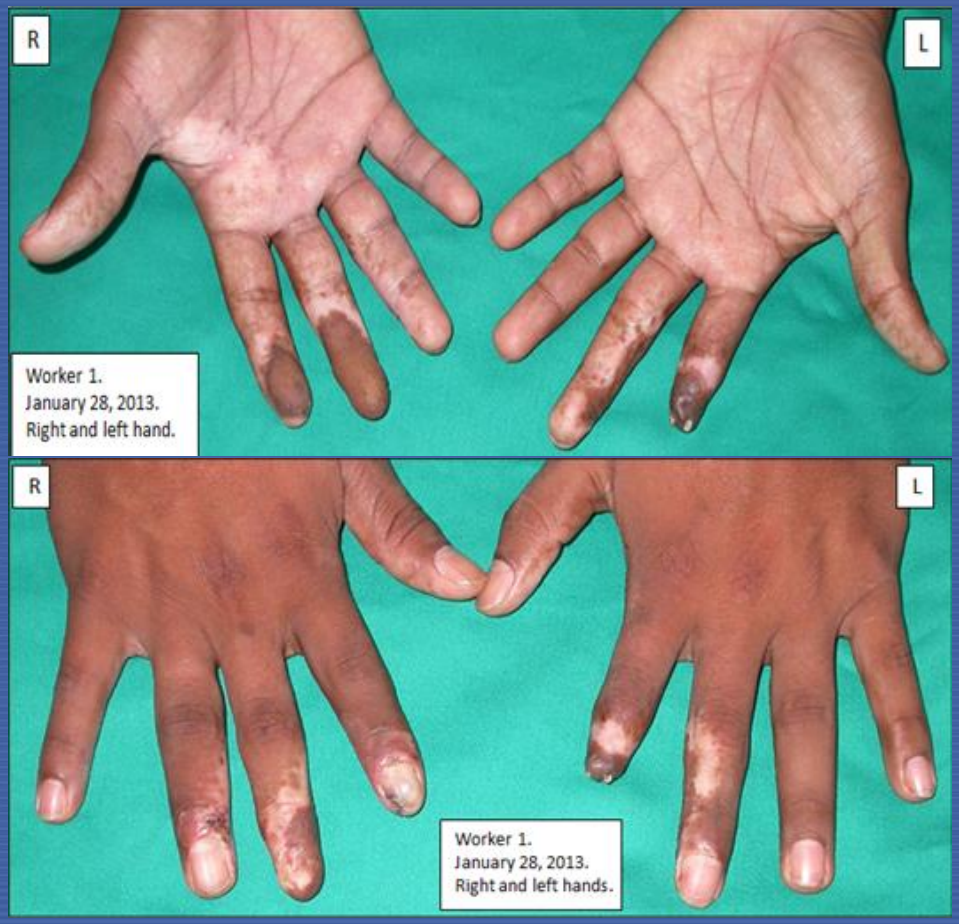
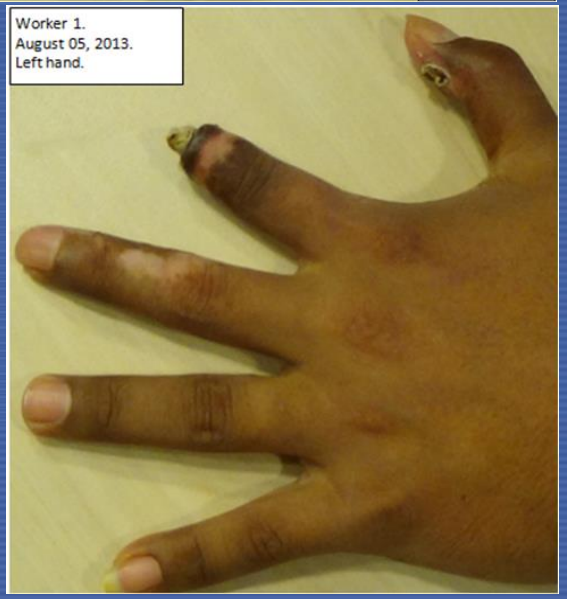
Photos and table from "The Radiological Accident In Chilca, Peru. IAEA"

Severe Recurrence Cutaneous Radiation syndrome 2013





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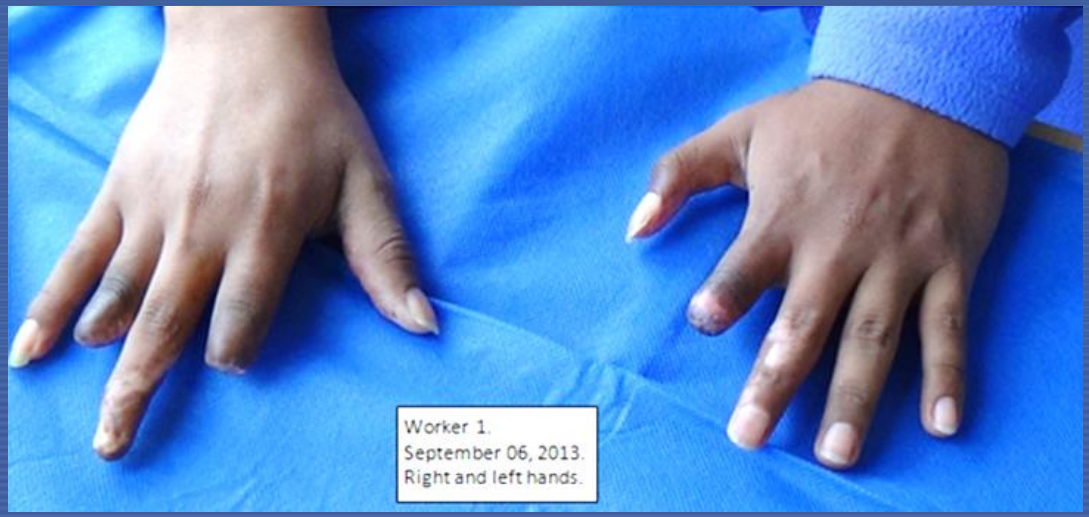
Treatment in Chile 2013



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Radiological Accident 2012-2013. Chilca, Peru.

- First combined treatment applied in Latin-America (Surgery and Mesenchymal Stem Cells).
- IEC in coordination with 9 Institutions in 3 different countries (Peru-France and Chile). More than 40 professionals involved in the treatment.
- Participation of experts through RANET.
- The patient is under medical follow-up in Peru. No new recurrences have been reported.

Radiological Accident 2014. Ventanilla - Callao, Peru.

- February 14, 2014
- Industrial radiography company
- One worker overexposed
- Peruvian Government requested assistance under Convention Assistance to the IAEA
- Two Assistance Missions were conducted
  - Medical assessment, held in Lima (April - May, 2014).
  - Medical treatment, held in Brazil at three stages (July - November, 2014).

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Peru: Evolution of the patient

From IPEN report "Reconstruccion del accidente". 2014

Dr. Eduardo Herrera Reyes - IEC

Dr. Eduardo Herrera Reyes – IEC

Day 3

Day 12

Day 27

Photos Dr. Alberto Lachos - Peru

First IAEA Assistance Mission in Peru

Dr. Eduardo Herrera Reyes - IEC

Patient SCCJ, 76 days after exposure, lesion in the left upper thigh and inguinal area (April 30, 2014).

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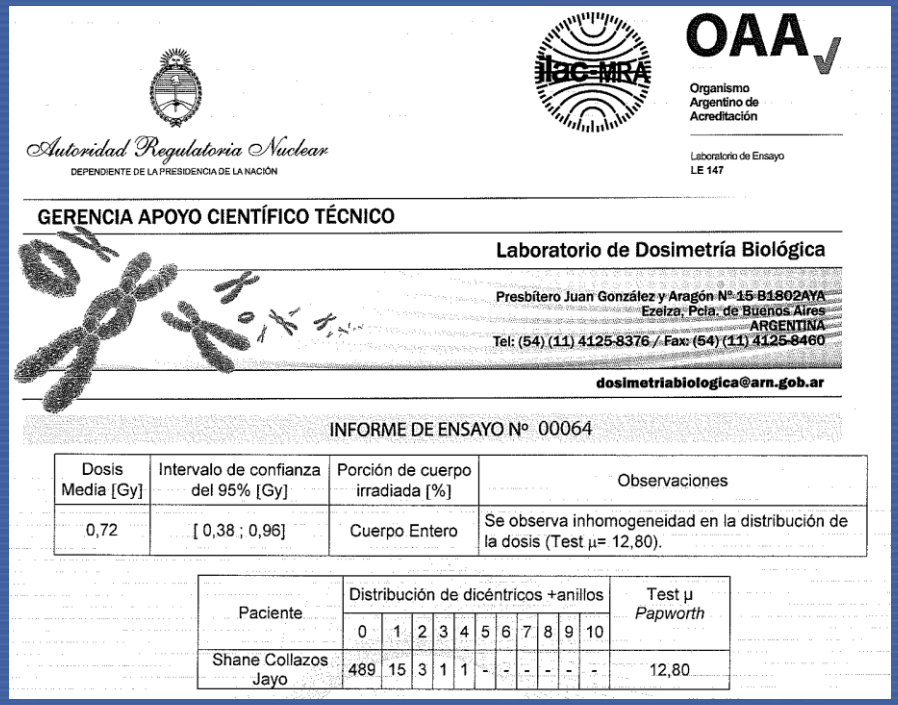
RANET: Biodosimetry LBDNet – ARN Argentina



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DEPENDIENTE DE LA PRESIDENCIA DE LA NACIÓN

OAA
Organismo Argentino de Acreditación
Laboratorio de Ensayo LE 147

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INFORME DE ENSAYO Nº 00064

Dosis Media [Gy]	Intervalo de confianza del 95% [Gy]	Porción de cuerpo irradiada [%]	Observaciones
0,72	[0,38 ; 0,96]	Cuerpo Entero	Se observa inhomogeneidad en la distribución de la dosis (Test μ= 12,80).

Paciente	Distribución de dicéntricos +anillos										Test μ *Papworth*
	0	1	2	3	4	5	6	7	8	9	10	
Shane Collazos Jayo	489	15	3	1	1	-	-	-	-	-	-	12,80

- 509 cells were analysed, absorbed dose estimated 0,72Gy to whole body [0,38 - 0,96].
- May 15, 2014

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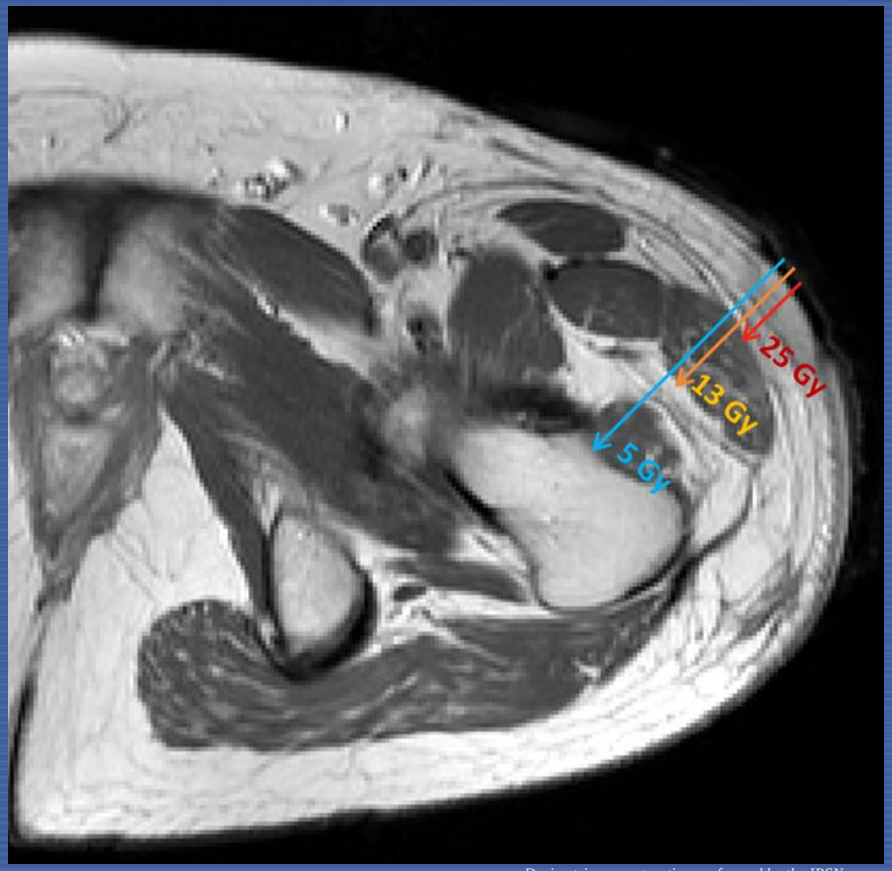
RANET: Dose Reconstruction – IRSN, France



Dosimetric reconstruction performed by the IRSN

- The estimated absorbed dose at the necrosis area 50 Gy.
- 2 cm in depth, 20-25 Gy.
- The absorbed dose to the muscle next to the lesion is estimated between 25 Gy (entrance) and 13 Gy (back part).
- The absorbed dose estimated to the adjacent bone (femur) 5 Gy.

Second IAEA Assistance Mission in Brazil

- Combined protocol: Surgery and Mesenchymal Stem Cells injections (4)
- RANET activation: Assessment by French and other experts
- Assistance provided in 3 stages
- Treatment performed in Brazil (July to November 2014)
- Patient currently under medical follow-up in Peru.
- More than 30 professionals, 9 institutions in 4 countries, coordinated by the IEC
- 2nd Inter-regional treatment applied in Latin-America

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Example

- Fire in the abracadabra company (11am)
- 2 industrial radiography teams in place working during the day (3 persons each)
- 30 persons working during starting of fire
- 10 persons injured
- 1 person heart attack
- 3 persons present skin burns from the radiograph company
- Medical team do not want to treat patient for the risk of “radiation”

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Conclusions

- Life is a priority.
- Multidisciplinary team should be prepared.
- Consider international cooperation through your national authorities.

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Thank you !

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