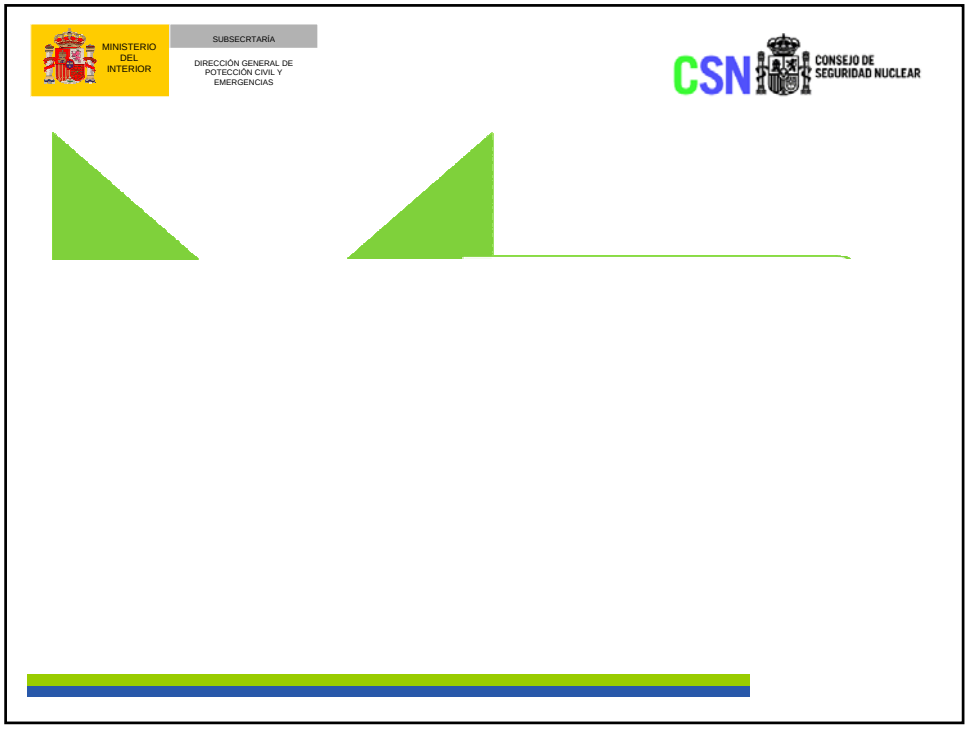
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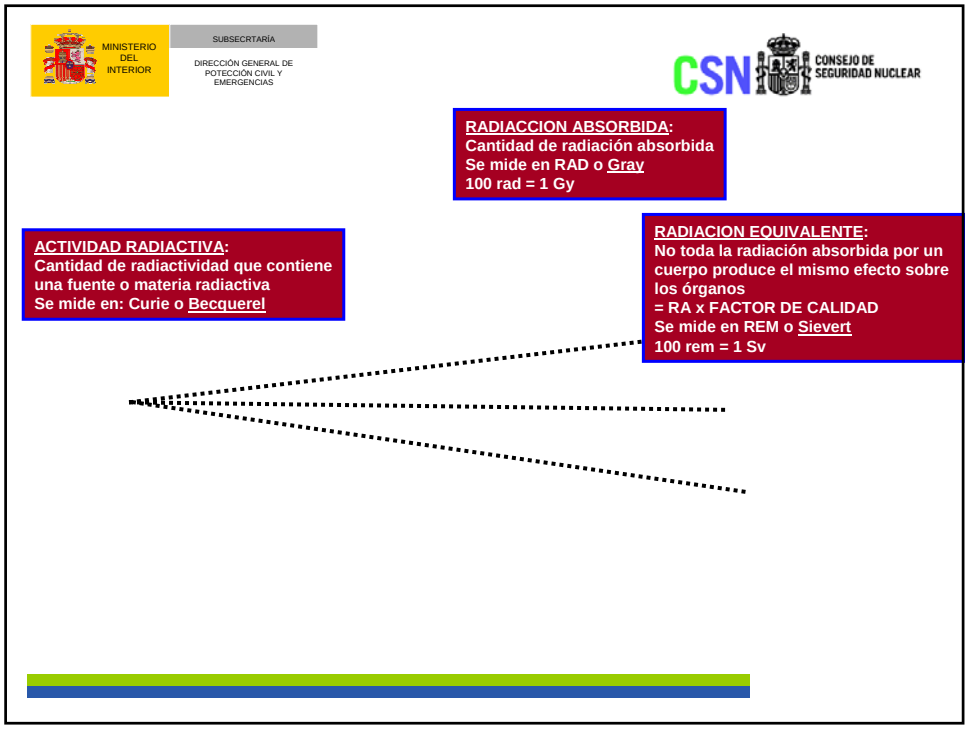
CSN
CONSEJO DE SEGURIDAD NUCLEAR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SUBSECRTARÍA
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RADIACCION ABSORBIDA:
Cantidad de radiación absorbida
Se mide en RAD o Grav
100 rad = 1 Gy
ACTIVIDAD RADIACTIVA:
Cantidad de radiactividad que contiene una fuente o materia radiactiva
Se mide en: Curie o Becquerel
RADIACION EQUIVALENTE:
No toda la radiación absorbida por un cuerpo produce el mismo efecto sobre los órganos
= RA x FACTOR DE CALIDAD
Se mide en REM o Sievert
100 rem = 1 Sv

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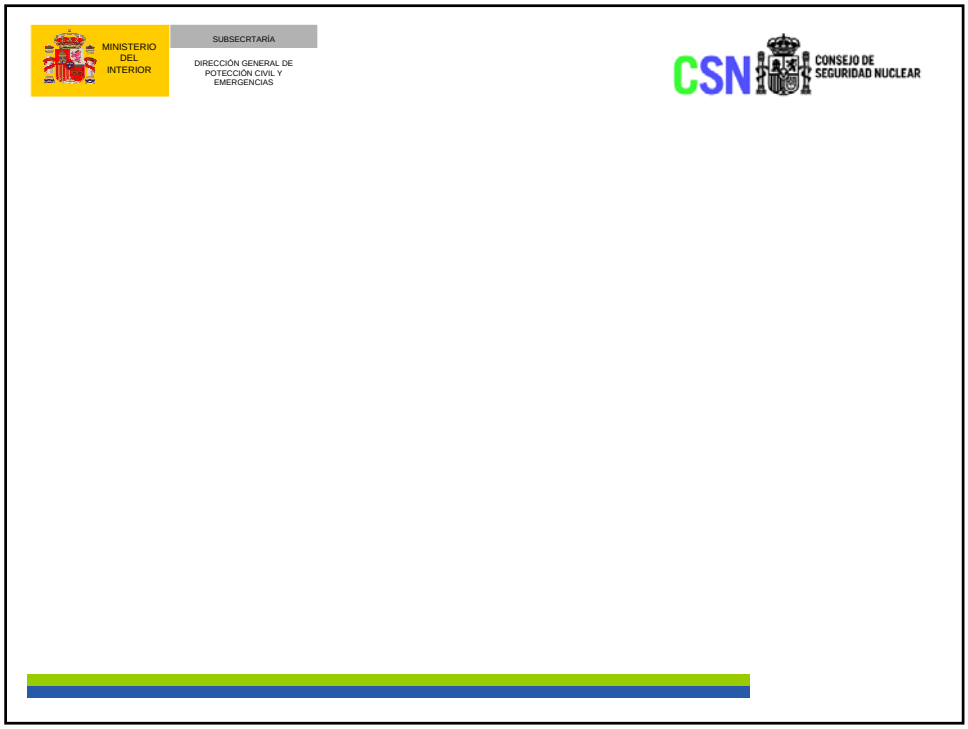
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR
FORMAS DE CONTAMINACION
• EXPOSICION
• INHALACION
• ABSORCION
• INGESTION
CONTAMINACION
INT NA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CSN CONSEJO DE SEGURIDAD NUCLEAR

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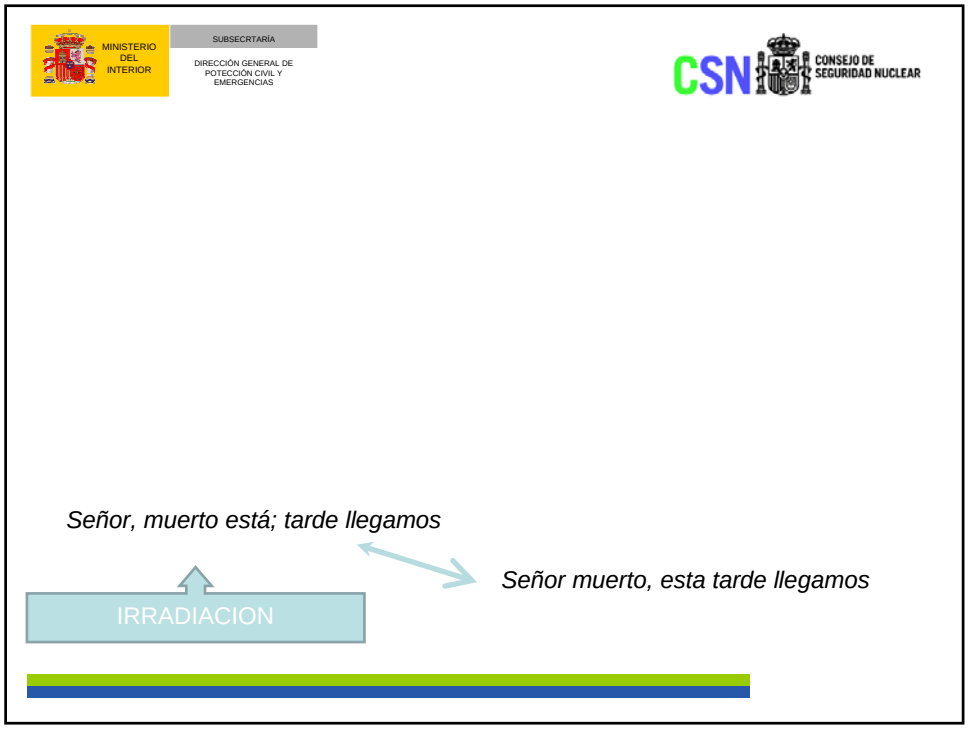
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR
IRRADIACION
EFECTO ESTOCASTICO
EFECTO DETERMINISTICO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DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR
Señor, muerto está; tarde llegamos
Señor muerto, esta tarde llegamos
IRRADIACION

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR

ACTITUD INICIAL

- VALORACION SINTOMATICA ¿Qué nota o siente?
- DOSIMETRIA BIOLOGICA: MONITORIZACION ¿Cómo afecta a su cuerpo?
- DOSIMETRIA RADIOLOGICA: CORRELACION RADIACION EMITIDA-ABSORBIDA ¿hay relacion de causalidad?
- COINCIDENCIA LUGAR-DOSIS-SINTOMATOLOGIA.

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR

ACTITUD INICIAL

- VALORACION SINTOMATICA ¿Qué nota o siente?
- DOSIMETRIA BIOLOGICA: MONITORIZACION ¿Cómo afecta a su cuerpo?
- DOSIMETRIA RADIOLOGICA: CORRELACION RADIACION EMITIDA-ABSORBIDA ¿hay relacion de causalidad?
- COINCIDENCIA LUGAR-DOSIS-SINTOMATOLOGIA

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR

SINTOMAS Y SIGNOS			
< 1 SIEVERT	1 - 6 SIEVERT	6 - 20 SIEVERT	> 20 SIEVERT
Asintomático	Síndrome Hematopoyetico	Síndrome Gastrointestinal (GI)	Síndrome neurológico y vascular
Síntomas moderados o ausentes Episodio nauseas, vómitos en primeras 48 hs en 1 - 10% casos Depresión leucocitaria moderada a las 2 - 4 semanas Embarazadas y dosis efectiva > 100 milisievert riesgo fetal	Anorexia, nausea, vómitos, fatiga: 1 -4 hs post exposición relacionado con dosis y tiempo. Periodo de latencia 2 dias - 4 semanas Depresión medula ósea: leucopenia - infecciones; descenso plaquetas - hemorragias y hematomas 3 - 4 sieverts perdida de cabello en 2 -3 semanas DL 50/60 = 4-5 sievert sin tratamiento	Precoz nauseas, vómitos, diarrea, anorexia y fatiga Periodo de latencia horas - 1 semana Grave cuadro GI unido a depresión de medula ósea: fiebre, dolor abdominal, retortijones, diarrea liquida, hemorragia intestinal, alteraciones electrolíticas, deshidratación DL100 = 10 sievert sin tratamiento en 2 semanas	Inmediatamente vomitos en proyectil, diarrea explosiva sanguinolenta, cefalea, colapso, confusión, perdida de conocimiento, agitación, sensación de ardor en la piel Quizás intervalo lucido de horas Síntomas neurológicos y cardiovasculares predominantes: convulsiones, coma, hipotensión arterial y shock Muerte en 2-3 dias

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR

Table 2-N: Relative Radiosensitivity of Various Organs

Organs	Relative radiosensitivity	Chief mechanism of parenchymal hypoplasia
The hematopoietic and the gastrointestinal systems	High*	Destruction of parenchymal cells, especially the vegetative or differentiating cells
Skin; cornea & lens of eyes; gastrointestinal organs; cavity, esophagus, stomach, rectum	Fairy high	Destruction of vegetative and differentiating cells of the stratified epithelium
Growing cartilage; the vasculature; growing bones	Medium	Destruction of proliferating chondroblasts or osteoblasts; damage to the endothelium; destruction of connective tissue cells & chondroblasts or osteoblasts
Mature cartilage or bone; lungs; kidneys; liver; pancreas; adrenal gland; pituitary gland	Fairly low	Hypoplasia secondary damage to the fine vasculature and connective tissue elements
Muscle; brain; spinal cord	Low	Hypoplasia secondary damage to the fine vasculature and connective tissue elements, with little contribution by the direct effects on parenchymal tissues

*Embryonic tissue is also highly radiosensitive

Reference: Table 5-IV from FM 8-9 (Part I).

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR

ACTITUD INICIAL

- VALORACION SINTOMATICA ¿Qué nota o siente?
- DOSIMETRIA BIOLOGICA: MONITORIZACION ¿Cómo afecta a su cuerpo?
- DOSIMETRIA RADIOLOGICA: CORRELACION RADIACION EMITIDA-ABSORBIDA ¿hay relacion de causalidad?
- COINCIDENCIA LUGAR-DOSIS-SINTOMATOLOGIA

MINISTERIO DEL INTERIOR
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CSN CONSEJO DE SEGURIDAD NUCLEAR

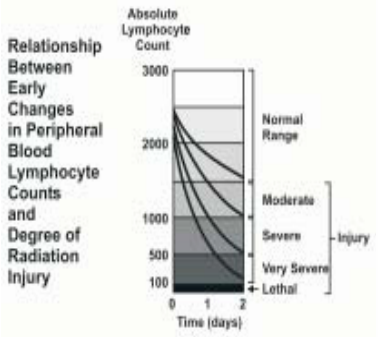
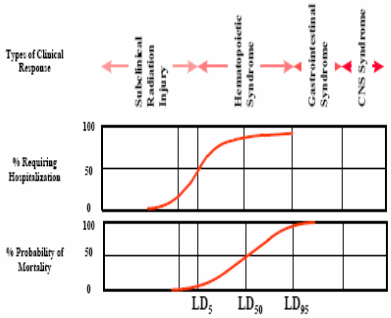


Figure 2-F: Clinical Effects of Whole Body Irradiation in Humans



Reference: Figure 6-V from FM 8-9 (Part I).

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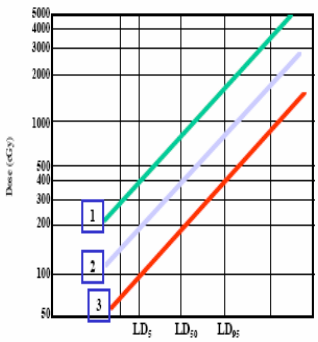
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR

Figure 2-G: Dose versus LD for Whole Body Irradiation



1 - Dose response for low dose rate exposures (fallout),
2 - Dose response for uncomplicated prompt exposure.
3 - Dose response for prompt exposure complicated by combined injury.

Reference: Figure 6-V from FM 8-9 (Part I).

Table 5. Radiation dermatitis.

Radiation	Dose	Effect
Acute	6–20 Sv	Erythema only
	20–40 Sv	Skin breakdown in 2 wk
	> 3000 Sv	Immediate skin blistering
Chronic	> 20 Sv	Dermatitis, with cancer risk

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR

Monitorizacion biologica

- Hematológica: Horas a días
  - Pancitopenia:
  - Depresión médula ósea
- Aparición enfermedades oportunistas — En días
- Fracaso multiorgánico — En días a semanas

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR

tratamiento

- Etiologico
- Sintomático
- paliativo

- Tratar isotopo
- Tratar sintomas
- Aminorar sufrimiento

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR

Tratamiento etiologico

- Irradiacion
- Absorcion
- Ingestion
- inhalacion

- Uso de antídotos en función de isótopo
- Aislamiento
- Descontamición
- Terapia sustitutiva/regenerativa
- Antibioterapia, antimicóticos, antivirales

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS

CSN CONSEJO DE SEGURIDAD NUCLEAR

Appendix B: Table of Internal Contaminant Radionuclides

Element	Respiratory absorption, deposition	GI absorption, deposition	Skin wound absorption	Primary toxicity	Treatment
^{241}Am	75% absorbed 10% retained	Minimal, usually insoluble	Rapid in first few days	Skeletal deposition Marrow suppression Hepatic deposition	Chelation with DTPA or EDTA
^{137}-^{134}Cs	Completely absorbed Follows potassium	Completely absorbed Follows potassium	Completely absorbed Follows potassium	Renal excretion Beta and gamma emissions	Ion exchange resins Prussian blue
^{60}Co	High absorption Limited retention	< 5% absorption	Unknown	Gamma emitter	Gastric lavage Penicillamine in severe cases
^{131}I	High absorption Limited retention	High absorption Limited retention	High absorption Limited retention	Thyroid ablation carcinoma	Iodine therapy
^{32}P	High absorption Limited retention	High absorption Limited retention	High absorption Limited retention	Bone, rapidly replicating cells	Lavage, Aluminum hydroxide Phosphates

- Tratamientos:
  - EDTA
  - AZUL PRUSIA
  - PENICILAMINA
  - IODURO POTASICO
  - QUELANTES Y ANTI ADSORBENTES

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS

CSN CONSEJO DE SEGURIDAD NUCLEAR

Element	Respiratory absorption, deposition	GI absorption, deposition	Skin wound absorption	Primary	
$^{238\text{-}239}$ metal or salt	High absorption Limited retention	Minimal, usually insoluble	Limited absorption May form nodules	Lung, bone, liver	Chelation with DTPA or EDTA
$^{238\text{-}239}Pu$ High-fired oxides	Limited absorption High retention	Minimal, usually insoluble	Limited absorption May form nodules	Local effects from retention in lung	Chelation with DTPA or EDTA Pulmonary lavage*
^{210}Po	Moderate absorption Moderate retention	Minimal	Moderate absorption	Spleen, kidney	Lavage Dimercaprol
^{226}Ra	Unknown	30% absorption, but 95% fecal excretion	Unknown	Skeletal deposition Marrow suppression Sarcoma	$MgSO_4$ lavage Ammonium chloride Calcium Alginates
^{90}Sr	Limited retention	Moderate absorption	Unknown	Bone – follows calcium	Strontium Calcium Ammonium chloride
Tritium (T or ^{3}H) Hydrogen-3 Tritiated water = HTO	HT – minimal HTO – complete	HT – minimal HTO – complete	HTO – complete	Panmyelocytopenia	Dilution with controlled water intake, Diuresis

- TRATAMIENTOS:
  - DTPA
  - DIMERCAPROL
  - SULFATO MAGNESICO
  - CALCIO
  - DIURESIS FORZADA

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS

CSN CONSEJO DE SEGURIDAD NUCLEAR

Element	Respiratory absorption, deposition	GI absorption, deposition	Skin wound absorption	Primary toxicity	Treatment
$^{238-235}U$ fluorides UO3, sulfates, carbonates	High absorption High retention	High absorption	High absorption Skin irritant	Renal, urinary excretion	Chelation with DTPA* or EDTA $NaHCO^3$
$^{238-235}U$ Some oxides, nitrates	Moderate absorption High retention	Moderate absorption	Unknown	Nephro-toxic Urinary excretion	Chelation with DTPA* or EDTA $NaHCO^3$
$^{238-235}U$ High oxides, hydrides, carbides, salvage ash	Minimal absorption Retention based on particle size	Minimal absorption High excretion	Unknown	Nephro-toxic Urinary excretion	Chelation with DTPA* or EDTA $NaHCO^3$
^{228}U Depleted uranium metal	Retention based on particle size	Minimal absorption High excretion	Forms pseudo-cysts with urinary excretion Limited absorption	Nephro-toxic Deposits in bone, kidney, brain	Particulate removal when possible

*Treatment is not approved by the Food and Drug Administration. Clinical investigations have not begun in the United States.

- TRATAMIENTOS :
  - BICARBONATO SODICO
  - EDTA

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS

CSN CONSEJO DE SEGURIDAD NUCLEAR

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR

Table 2. Recommendations for use of cytokines for patients expected to experience severe neutropenia.

Filgrastim (G–CSF)	2.5–5 µg/kg/d QD s.c. (100–200 µg/m^2/d)
Sargramostim (GM–CSF)	5–10 µg/kg/d QD s.c. (200–400 µg/m^2/d)
Pegfilgrastim (pegG-CSF)	6 mg once s.c.

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR

Antídotos

- Quelantes
  - DTPA
  - AZUL DE PRUSIA
  - IODURO POTÁSICO:
    - 130 mg aprox.

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR

Table 2-O: Preliminary Triage of Casualties with Possible Radiation Injuries

Symptoms	Possible category of radiation injury		
	Unlikely	Probable	Severe
Nausea	Absent	Excessive	Very Excessive
Vomiting	Absent	Present	Very Excessive
Diarrhea	Absent	Absent to Present	Absent to Very Excessive
Hyperthermia	Absent	Absent to Present	Present to Very Excessive
Hypothermia	Absent	Absent	Present to Very Excessive
Erythema	Absent	Absent	Absent to Excessive
CNS dysfunction	Absent	Absent	Absent to Excessive

Reference: Table 6-II from FM 8-9 (Part I).

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR

Table 2-P: Radiation Doses and Combined Injuries

Starting Triage Classifications	Final Triage Classifications		
	Less than 150 cGy	150-550 cGy	Over 550 cGy
Radiation Only	Minimal or duty	Delayed**	Delayed
Immediate	Immediate	Immediate or Expectant*	Expectant
Delayed	Delayed	Delayed or Expectant*	Expectant
Minimal	Minimal	Minimal**	Expectant
Expectant	Expectant	Expectant	Expectant

*Select Expectant in the case of full or partial thickness burns coverings more than 18 % of the body surface, or trauma which would either result in significant infection or be categorized as severe but not immediately life threatening, such as a fractured femur. This is a clinical decision and not necessarily subjectively reproducible.

**Includes the probable requirements for antibiotics and transfusion at a later time. So this classification does not suggest that the patient is not in need of treatment, but rather that he does not need immediate specialized care.

Reference: Table 4-2 from FM 8-10-7 and comments from AFRRI.

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR

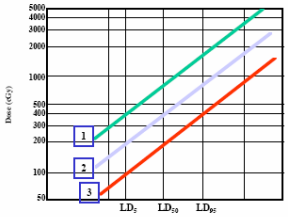
Table 2-Q (Part 1): Medical Response to Nuclear Radiation

Dose range (cGy free in air)	Onset and duration of initial symptoms
0 to 70	From 6 to 12 hours: none to slight incidence of transient headache and nausea; vomiting in up to 5 percent of personnel in upper part of dose range.
70 to 150	From 2 to 20 hours: transient mild nausea and vomiting in 5 to 30 percent of personnel.
150 to 300	From 2 hours to 3 days: transient to moderate nausea and vomiting in 20 to 70 percent; mild to moderate fatigability and weakness in 25 to 60 percent of personnel.
300 to 530	From 2 hours to 3 days: transient nausea and vomiting in 50 to 90 percent; moderate fatigability in 50 to 90 percent of personnel.
530 to 830	From 2 hours to 2 days: moderate to severe nausea and vomiting in 80 to 100 percent of personnel. From 2 hours to 6 weeks: moderate to severe fatigability and weakness in 90 to 100 percent of personnel.
830 to 3000	From 30 minutes to 2 days: severe nausea, vomiting, fatigability, weakness, dizziness, and disorientation; moderate to severe fluid imbalance and headache.
3000 to 8000	From 30 minutes to 5 days: severe nausea, vomiting, fatigability, weakness, dizziness, disorientation, fluid imbalance, and headache.
Greater than 8000	From 30 minutes to 1 day: severe and prolonged nausea, vomiting, fatigability, weakness, dizziness, disorientation, fluid imbalance, and headache.

Reference: Table 7-I from FM 8-9, Table 4-1 from FM 8-10-7, Table 4-10 from FM 3-7.

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR

Figure 2-G: Dose versus LD for Whole Body Irradiation



1 - Dose response for low dose rate exposures (fallout).
2 - Dose response for uncomplicated prompt exposure.
3 - Dose response for prompt exposure complicated by combined injury.

Reference: Figure 6-V from FM 8-9 (Part I).

Table 3-A: Background Radiation Levels (external)

Location	Levels (cGy/yr)
New York City	0.091
Denver	0.172
Guarapari, Brazil	0.640

Reference: ACALA's *Radioactive Material Handling Safety*

MINISTERIO DEL INTERIOR

SUBSECRTARÍA

DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS

CSN CONSEJO DE SEGURIDAD NUCLEAR

Table 3-B: Radiation exposure pathways from nuclear plants

Radionuclide	Effluent	Exposure Pathway	Critical Organ
Iodine	Airborne	Ground deposition (external)	Whole body
		Air inhalation	Thyroid
		Grass →cow → milk	Thyroid
		Leafy vegetables	Thyroid
	Liquid	Drinking water	Thyroid
		Fish (and shellfish consumption)	Thyroid
Tritium	Airborne	Submersion (external)	Skin
		Air inhalation	Whole body
	Liquid	Drinking water	Whole body
		Food consumption	Whole body
Cesium	Airborne	Ground deposition (external)	Whole body
		Grass →cow →milk or meat	Whole body
		Inhalation	Whole body
	Liquid	Sediments (external)	Whole body
		Drinking water	Whole body
		Fish consumption	Whole body
Metals (iron, cobalt, nickel, zinc, manganese)	Liquid	Drinking water	GI tract
		Fish consumption	GI tract
Direct radiation from plant		External	Whole body

Reference: USACHPPM's TG 238.

Table 3-C: Industrial Sources of Radiation

Locations and Materials	Radiation Sources	Source Strength	Comments
Gauges, Sources, Static Eliminators	Iridium-192, Cesium-137, Cobalt-60, Radium-226, neutrons, Americium-241, Polonium-210	Greater than about 4 TBq	Sealed sources, and if leaking, surface contamination.
X-ray Machine Sterilizers, Processors, and Particle Accelerators	X-rays, protons, deuterons, electrons, gammas, Cesium-137, Cobalt-60	~4 TBq to ~ 40PBq	Anywhere in an industrial area. Be aware of possible activation products.
Mineral Extraction and Processing – including phosphate fertilizers, oil, natural gas, and coal.	Naturally Occurring Radioactive Materials - Uranium, Thorium, and progeny	Generally low level with external exposures from background to about 0.01mSv (1 mrem)	Dispersed low level material and scale buildup in piping. Also, gauges as noted above. It is possible for radon to be of concern.
Power Sources	Plutonium-238, Strontium-90	Plutonium-238: up to 4 GBq Strontium-90: up to 1 TBq	In equipment in isolated areas.
Radioluminescent Materials	Promethium-147, Tritium, Radium-226	Up to tens of TBq	Various areas, and if leaking, surface contamination.

Reference: Shleien 83, Shleien 92.

MINISTERIO DEL INTERIOR

SUBSECRTARÍA

DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS

CSN CONSEJO DE SEGURIDAD NUCLEAR

Table 3-C: Industrial Sources of Radiation

Locations and Materials	Radiation Sources	Source Strength	Comments
Gauges, Sources, Static Eliminators	Iridium-192, Cesium-137, Cobalt-60, Radium-226, neutrons, Americium-241, Polonium-210	Greater than about 4 TBq	Sealed sources, and if leaking, surface contamination.
X-ray Machine Sterilizers, Processors, and Particle Accelerators	X-rays, protons, deuterons, electrons, gammas, Cesium-137, Cobalt-60	~4 TBq to ~ 40PBq	Anywhere in an industrial area. Be aware of possible activation products.
Mineral Extraction and Processing – including phosphate fertilizers, oil, natural gas, and coal.	Naturally Occurring Radioactive Materials - Uranium, Thorium, and progeny	Generally low level with external exposures from background to about 0.01mSv (1 mrem)	Dispersed low level material and scale buildup in piping. Also, gauges as noted above. It is possible for radon to be of concern.
Power Sources	Plutonium-238, Strontium-90	Plutonium-238: up to 4 GBq Strontium-90: up to 1 TBq	In equipment in isolated areas.
Radioluminescent Materials	Promethium-147, Tritium, Radium-226	Up to tens of TBq	Various areas, and if leaking, surface contamination.

Reference: Shleien 83, Shleien 92.

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR

Table 3-D: Medical and Research Sources of Radiation

Locations and Materials	Radiation Sources	Source Strength	Comments
Cancer Treatment Areas	Cobalt-60 and Cesium-137	~1 to several 10 Gy over several hours at about one meter if the source is exposed.	Found in therapy rooms.
Sources and Applicators	Cesium-137, Iridium-192, Radium-226, Phosphorous-32, Stronium-90, Iodine-125	Tens of MBq	Therapy and nuclear medicine areas.
Radiopharma-ceuticals	Iodine-131, Iodine-123, Technetium-99^{m}, Thalium-201, Xenon-133	Tens of MBq	Storage, nuclear medicine areas and transportation.
X-ray Machines and Accelerators	X-rays and Electrons	~0.01 Gy min^{-1} at the source	Radiology or therapy rooms.
Various Sources and Devices	Tritium, Carbon-14, Sodium-22, Sodium-24, Sulfur-35, Calcium-45, Cobalt-60	Up to tens of TBq	Various areas, and if leaking, surface contamination.
Particle Accelerators	X-rays, alphas, protons, deuterons, electrons, gammas	~4 TBq to ~ 40PBq	Anywhere in an industrial area. Be aware of possible activation products.
Experimental Reactors and Critical Assemblies	Fission products, neutrons, fissile and fissionable material, transuranics	Up to tens of TBq	Various areas, up to square kilometers in the case of widespread contamination.

Reference: Shleien 83, Shleien 92.

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR

Table 3-P: Spectrum of Radiation Limits (CentiGray)

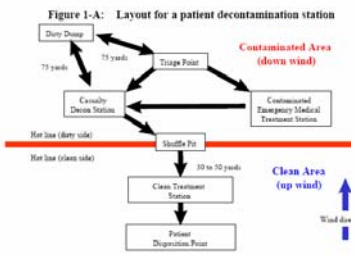
Dose	Function	Dose	Function
500	LD 50/60 with supportive care	10	Protection valuable prop; EPA
350	LD 50/60 without supportive care	5.0	Occupational annual limit; 10 CFR
300	Early erythema	5.0	Public organ dose limit; 10 CFR
200	Threshold for cataract	0.5	Average all X-ray procedures; NCRP
150	Emergency risk; STANAG 2083	0.5	Public, annual, infrequent; NCRP
100	Urgent action, accident; ICRP 63	0.30	Naturally occurring annual dose, US; NCRP
70	Moderate risk; STANAG 2083	0.10	Public, annual, continuous exposure; NCRP
50	Negligible risk; STANAG 2083	0.10	Public; 10 CFR
50	Emergency limit; ICRP	0.015	Annual Public limit for decontamination; EPA
25	Life saving; EPA	0.001	Insignificant dose; NCRP

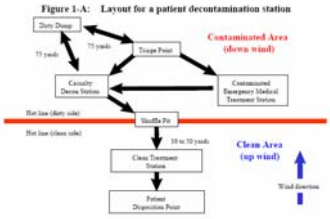
MINISTERIO DEL INTERIOR

SUBSECRTARÍA

DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS

CSN CONSEJO DE SEGURIDAD NUCLEAR





MINISTERIO DEL INTERIOR

SUBSECRTARÍA

DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS

CSN CONSEJO DE SEGURIDAD NUCLEAR

Monitorización biológica /hematológica

Table 1. Biological dosimetry assays and operational parameters.

Class of biomarker	Assay	Time window	Operating dose window (Gy, acute photon-equivalent)
Prodromal signs and symptoms	Onset of vomiting	< 12 hours	2–20
Hematological	Depletion of peripheral blood lymphocytes	< 1.5 weeks	2–8
Cytological	Lympyocyte-metaphase spread dicentric	< several months*	0.2–5
	Lymphocyte-premature chromosome condensation	< several months*	0.2–20

*Generally, blood is sampled 24 hours after radiation exposure for cytological chromosome aberration analysis of dose.

MINISTERIO DEL INTERIOR

SUBSECRTARÍA

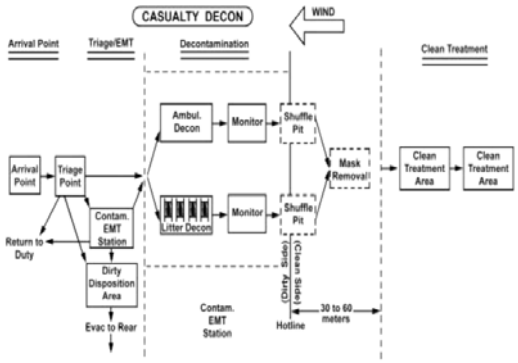
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS

CSN CONSEJO DE SEGURIDAD NUCLEAR

Descontaminación

Key Principles

- Wind direction
- Security of the decontamination site
- Area control of the decontamination site
- Litter patient decontamination
- Ambulatory patient decontamination



MINISTERIO DEL INTERIOR

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DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS

CSN CONSEJO DE SEGURIDAD NUCLEAR

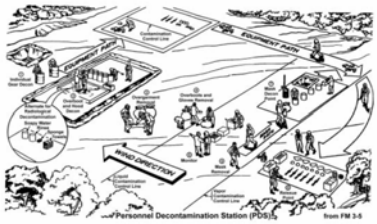

Table F1. Acute radiation syndrome.

Phase of syndrome	Feature	Effects of whole-body irradiation, from external radiation or internal absorption, by dose range in rad (1 rad = 0.01 Gy; 100 rad = 1 Gy)					
		0-100	100-200	200-600	600-800	800-3000	> 3000
Prodromal	Nausea, vomiting	None	5-50%	50-100%	75-100%	90-100%	100%
	Time of onset		3-6 h	2-4 h	1-2 h	< 1 h	Minutes
	Duration		< 24 h	< 24 h	< 48 h	< 48 h	N/A
	Lymphocyte count	Unaffected	Minimally decreased	↑ 1000 at 24 h	↑ 500 at 24 h	Decreases within hours	Decreases within hours
	CNS function	No impairment	No impairment	Routine task performance Cognitive impairment for 6-20 h	Simple, routine task performance Cognitive impairment for > 24 h	Rapid incapacitation May have a lucid interval of several hours	
Latent	No symptoms	< 2 wk	7-15 d	0-7 d	0-2 d	None	
Manifest illness	Signs, symptoms	None	Moderate leukopenia	Severe leukopenia, purpura, hemorrhage, pneumonitis, hair loss after 300 rad		Diarrhea, fever, electrolyte disturbance	Convulsions, ataxia, lassitude, tethargy
	Time of onset		< 2 wk	2 d - 2 wk		1-2 d	
	Critical period		None	4-6 wk; prompt supportive medical intervention		2-14 d	1-48 h
	Organ system	None		Hematopoietic, respiratory (mucosal) systems		GI tract Mucosal systems	CNS
	Hospitalization	0%	< 5 %	90%	100%	100%	100%
	Duration		45-60 d	60-90 d	90+ d	Weeks to months	Days to weeks
	Mortality	None	Minimal	Low with aggressive therapy	High	Very high, significant neurological symptoms indicate lethal dose	

Table F2. Symptom clusters as delayed effects after radiation exposure.

	Headache Fatigue Weakness	Anorexia Nausea Vomiting Diarrhea	Partial and full thickness skin damage Epilation (hair loss) Ulceration	Lymphopenia Neutropenia Thrombocytopenia Purpura Opportunistic infections

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR

Aislamiento y soporte general avanzado

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR

Tratamiento sintomático

- Dolor
- Fiebre
- Nauseas y vómitos
- Recursos medicina paliativa
- Escalera analgésica
  - Analgésicos AINES, mórficos y coadyuvantes
- Antipiréticos
- antieméticos

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR

Tratamiento paliativo

- Sedación
- Analgesia
- Comfort

- Morficos
- Hipnoticos
- Sedantes
- hidratacion

MINISTERIO DEL INTERIOR
SUBSECRTARÍA
DIRECCIÓN GENERAL DE POTECCIÓN CIVIL Y EMERGENCIAS
CSN CONSEJO DE SEGURIDAD NUCLEAR

Fin de la segunda parte