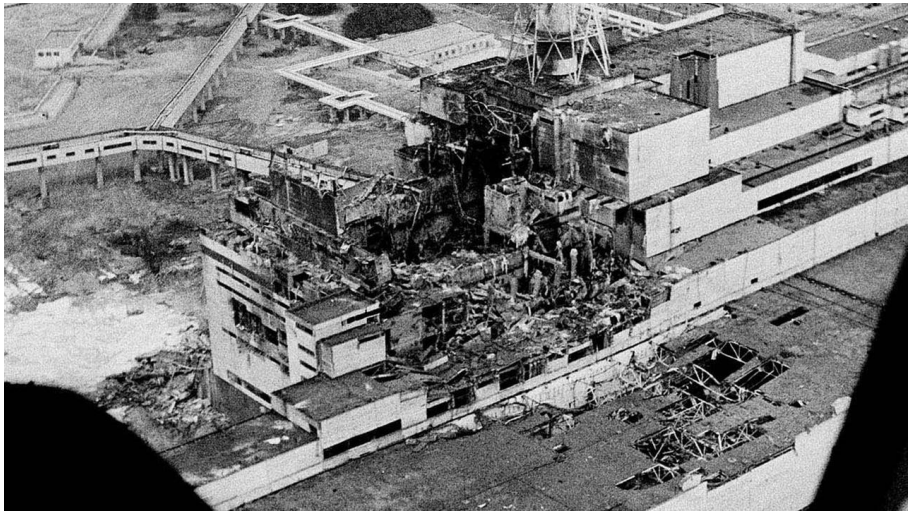
USZ Universitäts Spital Zürich

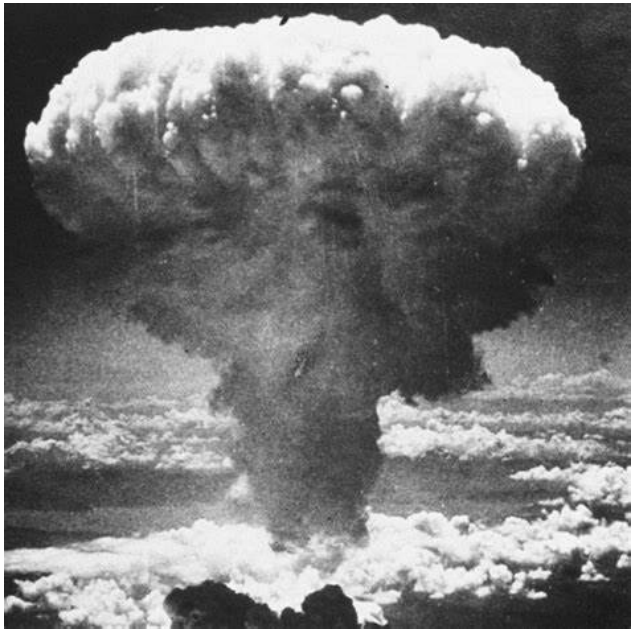
BAG OFSP UFSP

Strahlenunfälle und nukleare Katastrophen: Grundlagen und medizinische Behandlung

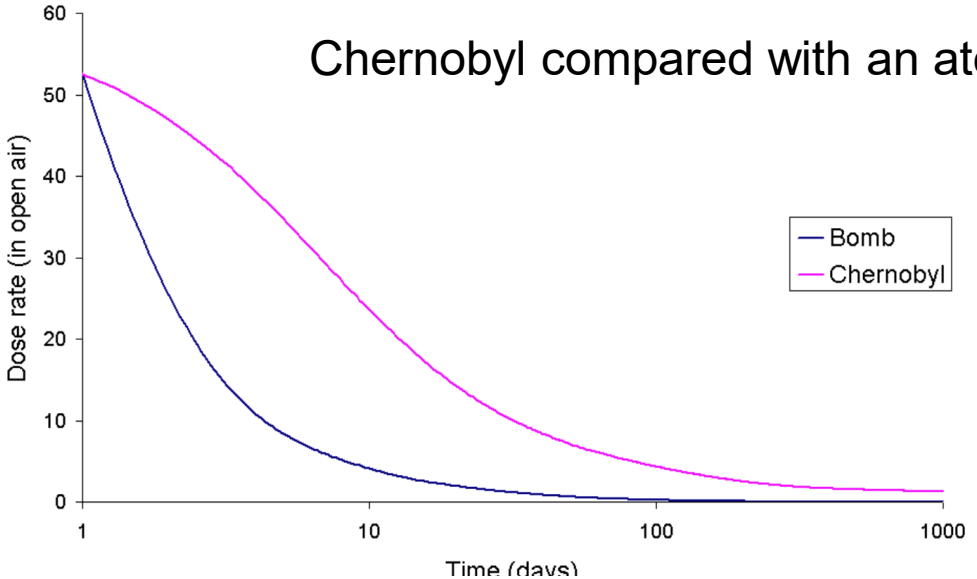
Urs Schanz

Netzwerkanlass BAG Bern, 11.11.2022





Chernobyl compared with an atomic bomb



Isotope	Ratio between the release due to the bomb and the Chernobyl accident
^{90}Sr	1:87
^{137}Cs	1:890
^{131}I	1:25
^{133}Xe	1:31

Some comments have been made in which the radioactive release of the Chernobyl event is claimed to be 300 or 400 times that of the bomb dropped on Hiroshima. The work of SCOPE suggests that the two events can not be simply compared with a number suggesting that *one was XX times larger than the other*.

Kernkraftwerk Störungen und Unfälle

Nuclear power plant accidents and incidents
with multiple fatalities and/or more than US$100 million in property damage, 1952-2011[10][24][26]

Date	Location of accident	Description of accident or incident	Dead
July 26, 1957	Simi Valley, California, United States	Partial core meltdown at Santa Susana Field Laboratory's Sodium Reactor Experiment.	0
September 29, 1957	Mayak, Kyshtym, Russia	The Kyshtym disaster was a radiation contamination incident that occurred at Mayak, a Nuclear fuel reprocessing plant in the Soviet Union.	
October 10, 1957	Sellafield aka Windscale fire, Cumberland, United Kingdom	A fire at the British atomic bomb project destroyed the core and released an estimated 740 terabecquerels of iodine-131 into the environment. A rudimentary smoke filter constructed over the main outlet chimney successfully prevented a far worse radiation leak and ensured minimal damage.	0
January 3, 1961	Idaho Falls, Idaho, United States	Explosion at SL-1 prototype at the National Reactor Testing Station. All 3 operators were killed when a control rod was removed too far.	3
October 5, 1966	Frenchtown Charter Township, Michigan, United States	Partial core meltdown of the Fermi 1 Reactor at the Enrico Fermi Nuclear Generating Station. No radiation leakage into the environment.	0
January 21, 1969	Lucens reactor, Vaud, Switzerland	On January 21, 1969, it suffered a loss-of-coolant accident, leading to a partial core meltdown and massive radioactive contamination of the cavern, which was then sealed.	0
1975	Sosnovyi Bor, Leningrad Oblast, Russia	There was reportedly a partial nuclear meltdown in Leningrad nuclear power plant reactor unit 1.	
December 7, 1975	Greifswald, East Germany	Electrical error in Greifswald Nuclear Power Plant causes fire in the main trough that destroys control lines and five main coolant pumps	0
January 5, 1976	Jaslovské Bohunice, Czechoslovakia	Malfunction during fuel replacement. Fuel rod ejected from reactor into the reactor hall by coolant (CO_2).[29]	2
February 22, 1977	Jaslovské Bohunice, Czechoslovakia	Severe corrosion of reactor and release of radioactivity into the plant area, necessitating total decommission	0
March 28, 1979	Three Mile Island, Pennsylvania, United States	Loss of coolant and partial core meltdown due to operator errors. There is a small release of radioactive gases. See also Three Mile Island accident health effects.	0
September 15, 1984	Athens, Alabama, United States	Safety violations, operator error, and design problems force a six-year outage at Browns Ferry Unit 2.	0
March 9, 1985	Athens, Alabama, United States	Instrumentation systems malfunction during startup, which led to suspension of operations at all three Browns Ferry Units	0
April 11, 1986	Plymouth, Massachusetts, United States	Recurring equipment problems force emergency shutdown of Boston Edison's Pilgrim Nuclear Power Plant	0
April 26, 1986	Chernobyl, Chernobyl Raion (Now Ivankiv Raion), Kiev Oblast, Ukraininan SSR, Soviet Union	A flawed reactor design and inadequately trained personnel led to a failed backup generator test. This test led to a power surge which overheated the fuel rods of reactor no. 4 of the Chernobyl power plant, causing an explosion and meltdown, necessitating the evacuation of 300,000 people from Chernobyl and dispersing radioactive material across Europe (see Effects of the Chernobyl disaster). Around 5% (5200 PBq) of the core was released into the atmosphere and downwind.	28 direct, 19 not entirely related and 15 minors due to thyroid cancer, as of 2008.[30][31]
May 4, 1986	Hamm-Uentrop, West Germany	Experimental THTR-300 reactor releases small amounts of fission products (0.1 GBq Co-60, Cs-137, Pa-233) to surrounding area	0
March 31, 1987	Delta, Pennsylvania, United States	Peach Bottom units 2 and 3 shutdown due to cooling malfunctions and unexplained equipment problems	0
December 19, 1987	Lycoming, New York, United States	Malfunctions force Niagara Mohawk Power Corporation to shut down Nine Mile Point Unit 1	0
March 17, 1989	Lusby, Maryland, United States	Inspections at Calvert Cliff Units 1 and 2 reveal cracks at pressurized heater sleeves, forcing extended shutdowns	0
March 1992	Sosnovyi Bor, Leningrad Oblast, Russia	An accident at the Sosnovy Bor nuclear plant leaked radioactive gases and iodine into the air through a ruptured fuel channel.	
February 20, 1996	Waterford, Connecticut, United States	Leaking valve forces shutdown Millstone Nuclear Power Plant Units 1 and 2, multiple equipment failures found	0
September 2, 1996	Crystal River, Florida, United States	Balance-of-plant equipment malfunction forces shutdown and extensive repairs at Crystal River Unit 3	0
September 30, 1999	Ibaraki Prefecture, Japan	Tokaimura nuclear accident killed two workers, and exposed one more to radiation levels above permissible limits.	2
February 16, 2002	Oak Harbor, Ohio, United States	Severe corrosion of control rod forces 24-month outage of Davis-Besse reactor	0
April 10, 2003	Paks, Hungary	Collapse of fuel rods at Paks Nuclear Power Plant unit 2 during its corrosion cleaning led to leakage of radioactive gases. It remained inactive for 18 months.	0
August 9, 2004	Fukui Prefecture, Japan	Steam explosion at Mihama Nuclear Power Plant kills 4 workers and injures 7 more	4
July 25, 2006	Forsmark, Sweden	An electrical fault at Forsmark Nuclear Power Plant caused one reactor to be shut down	0
March 11, 2011	Fukushima, Japan	A tsunami flooded and damaged the plant's 5 active reactors, drowning two workers. Loss of backup electrical power led to overheating, meltdowns, and evacuations.[32] One man died suddenly while carrying equipment during the clean-up.[33] The plant's 6th reactor was inactive at the time.	2+
September 12, 2011	Marcoule, France	One person was killed and four injured, one seriously, in a blast at the Marcoule Nuclear Site. The explosion took place in a furnace used to melt metallic waste.	1

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WIKIPEDIA
The Free Encyclopedia

with multiple fatalities and/or more than US$100 million in pro

Als in der Schweiz ein Atomreaktor explodierte

Michael Fischer / 8.01.2019 **Vor 50 Jahren entging die Schweiz haarscharf einer Atomkatastrophe, als es im Versuchs-Reaktor Lucens zu einer Kernschmelze kam.**

Date		accident or incide
July 26, 1957		Field Laboratory's Sc
September 29, 195		ccurred at Mayak, a
October 10, 1957		cquerels of iodine-1
		se radiation leak an
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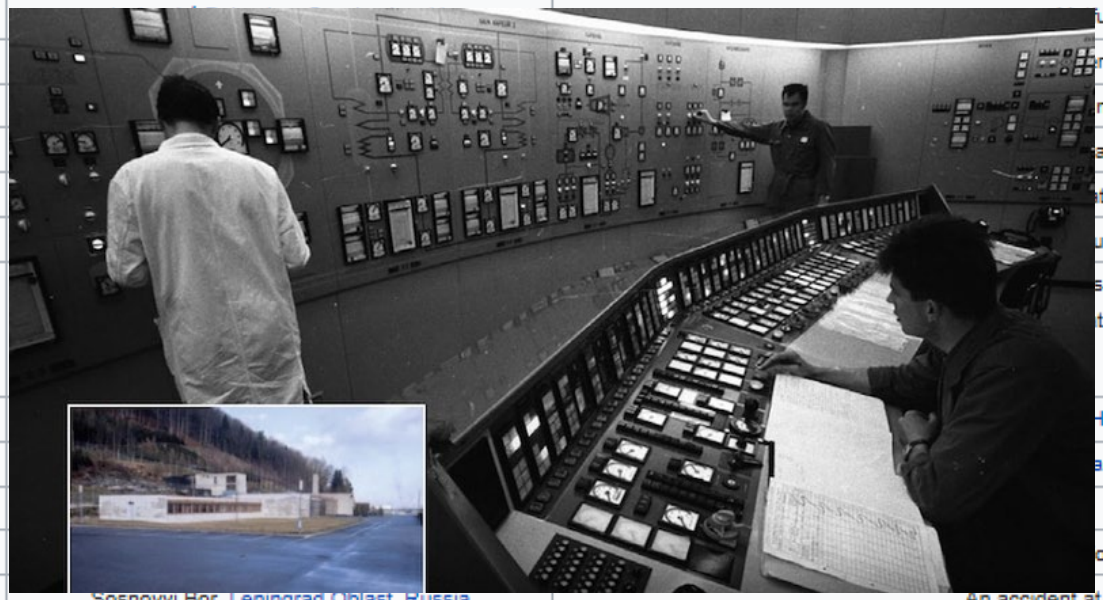
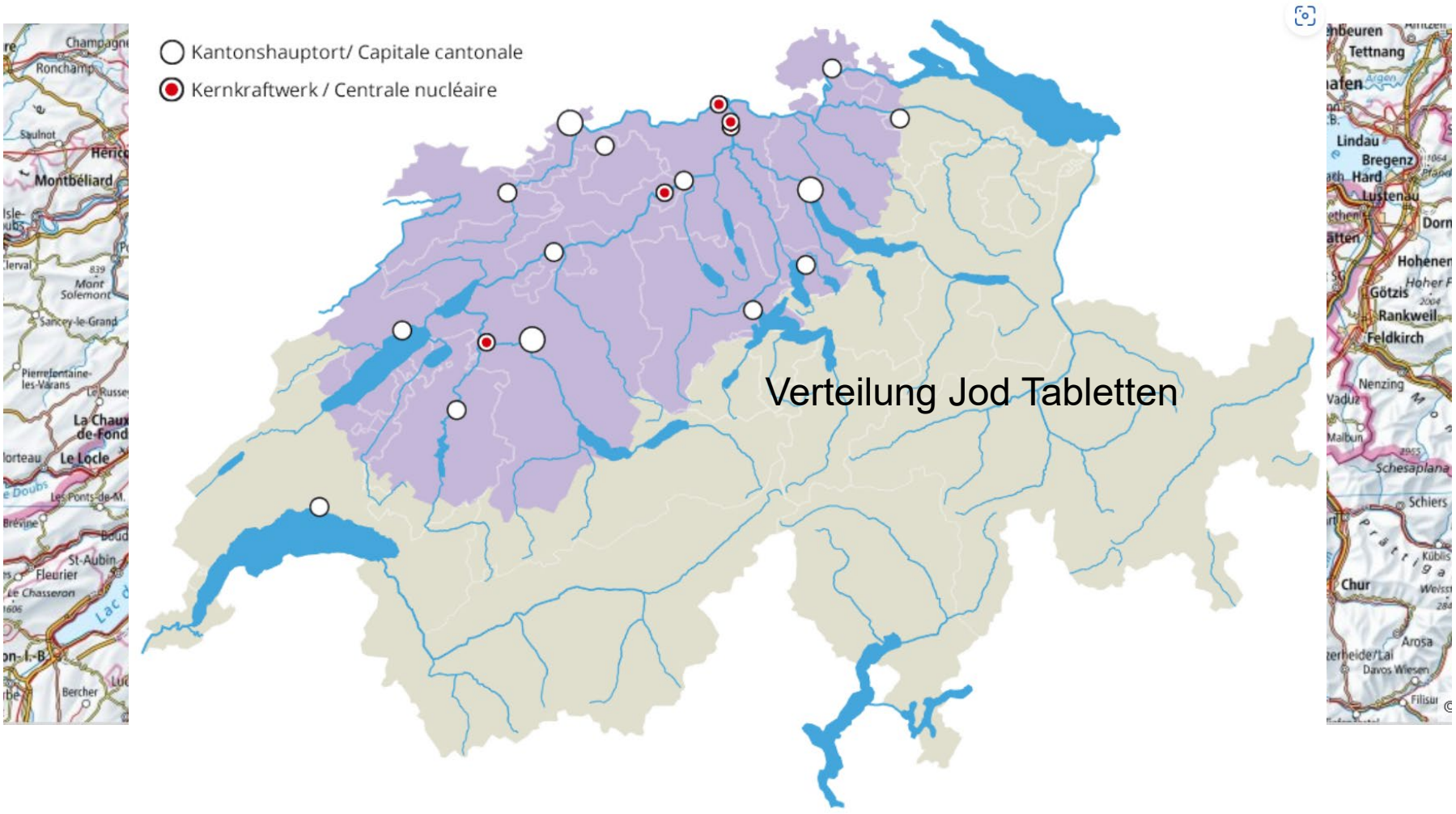


Lage der Kernreaktoren in der Schweiz

●=Kommerzielle Reaktoren ●=Stillgelegte Reaktoren ●=Forschung-/Versuchsreaktoren ●=geplante/verworfene Reaktoren

Notfallschutz und Zonenpläne des ENSI



ABC

Referenzszenarien

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Bevölkerungsschutz BABS
LABOR SPIEZ
Federal Office for Civil Protection FOCP
SPIEZ LABORATORY

4. Szenarien

A-Szenarien

- Kernkraftwerkunfall mit ungefilterter Freisetzung
- Radiologische Bombe
- Einsatz einer Kernwaffe in Grenznähe
- Anschlag auf einen Transport mit radioaktiven Abfällen

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Bevölkerungsschutz BABS
LABOR SPIEZ
Federal Office for Civil Protection FOCP
SPIEZ LABORATORY

Types of Radiation Emergencies

Español (Spanish)

Radiation emergencies may be intentional (e.g., caused by terrorists) or unintentional. Below are some examples of different types of radiation emergencies. Click on the icons to find out what to do if a radiation emergency happens in your area.

Nuclear Emergencies

- A nuclear emergency involves the explosion of a nuclear weapon or improvised nuclear device (IND).
- The explosion produces an intense pulse of heat, light, air pressure, and radiation.
- Nuclear explosions produce fallout (radioactive materials that can be carried long distances by the wind).

Learn more about nuclear emergencies

Dirty Bomb or Radiological Dispersal Device (RDD)

- A dirty bomb (also known as a radiological dispersal device) is a mix of explosives such as dynamite, with radioactive powder or pellets.
- A dirty bomb cannot create an atomic blast.
- When the explosives are set off, the blast carries radioactive material into the surrounding area.

Learn more about dirty bombs

Radiological Exposure Device (RED)

- A radiological exposure device (also called a hidden sealed source) is made of or contains radioactive material.
- REDs are hidden from sight to expose people to radiation without their knowledge.

Learn more about radiological exposure devices

Nuclear Power Plant Accident

- An accident at a nuclear power plant could release radiation over an area.
- Nuclear power plants have many safety and security procedures in place and are closely monitored by the Nuclear Regulatory Commission (NRC)

Learn more about nuclear power plant accidents

Transportation Accidents

- It is very unlikely that a transportation accident involving radiation would result in any radiation-related injuries or illnesses.
- Shipments involving significant amounts of radioactive material are required to have documentation, labels, and placards identifying their cargo as radioactive.

Learn more about transportation accidents

Occupational Accidents

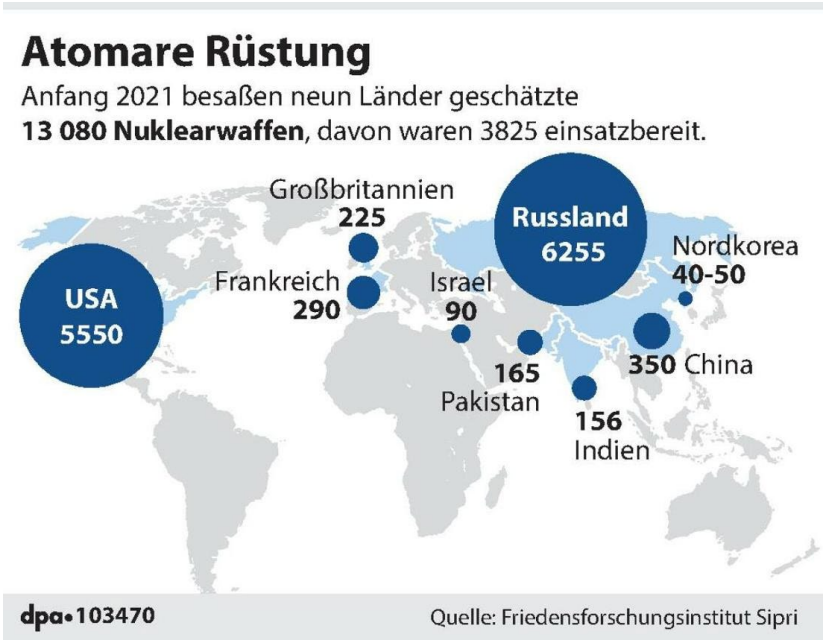
- Radiation sources are found in a wide range of settings such as health care facilities, research institutions, and manufacturing operations.
- Accidents can occur if the radiation source is used improperly, or if safety controls fail.

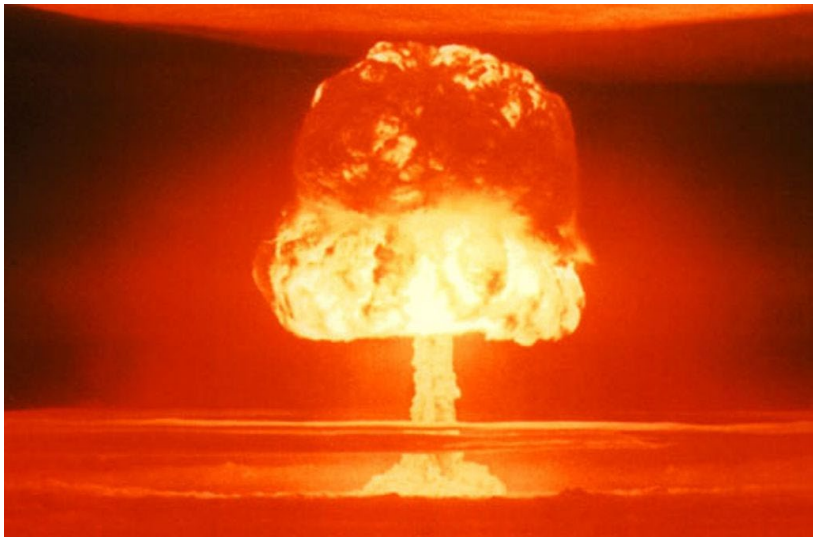
Learn more about occupational accidents

[Types of Radiation Emergencies | CDC](https://www.cdc.gov/nceh/radiation/emergencies/typesofemergencies.htm)

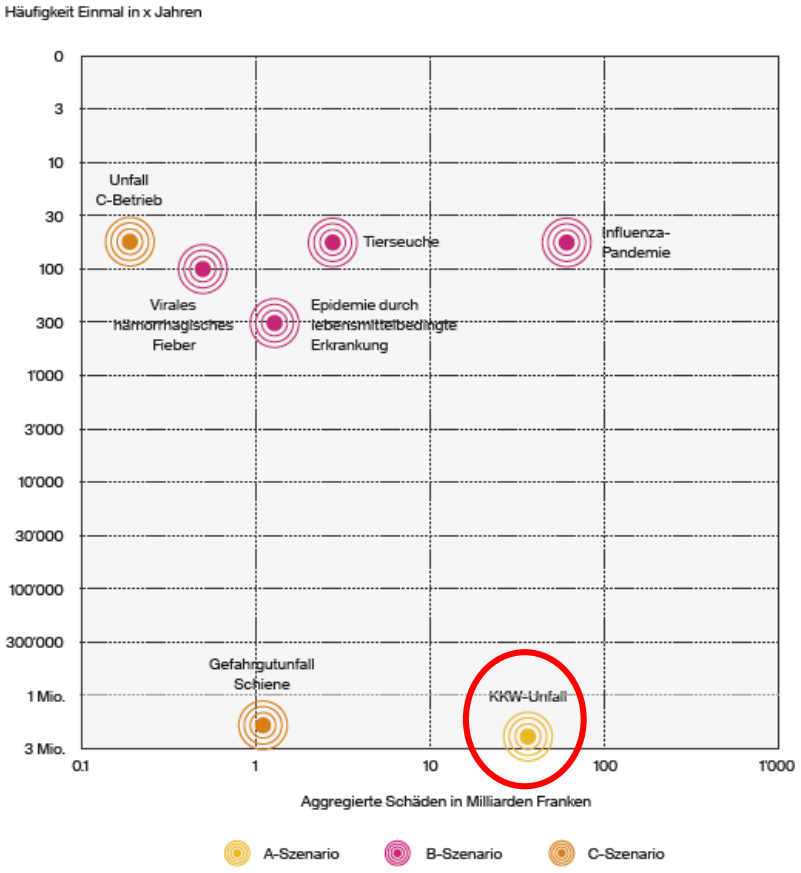
https://www.cdc.gov/nceh/radiation/emergencies/typesofemergencies.htm

24. February 2022

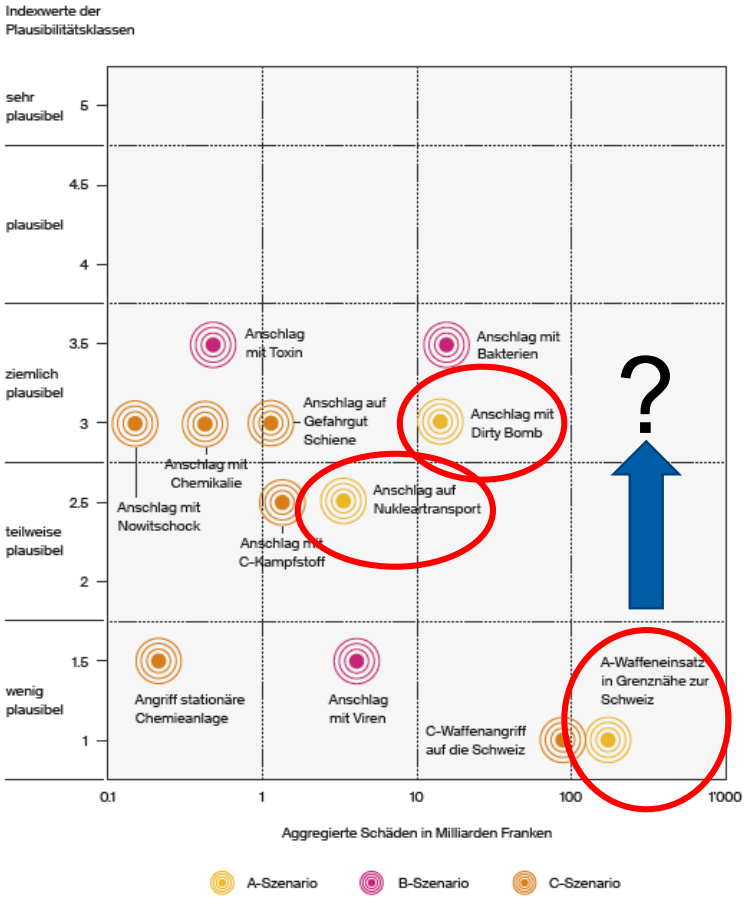




Risikodiagramm Unfälle/Katastrophen: Schäden und Häufigkeit



Risikodiagramm Anschläge und Angriffe: Schäden und Plausibilität

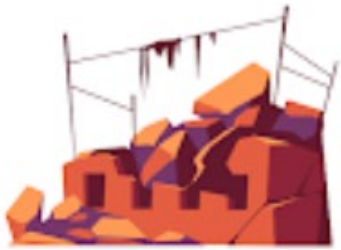


Nuclear Hazards

Fires

Radiation Sickness

Structural Damage



Nuclear Fallout

Environmental Damage

Radiation Injury

- External photon (γ-) irradiation
  (can result in radiation sickness)

- Contamination
  (results in tissue damage but not in radiation sickness)

  - External (skin)
  - Internal (by the airways, the GI-tract, wounds)
    - Incorperation

Radiation Injury - External Photon (γ) Irradiation

Single dose not fractionated as usually used in medicine

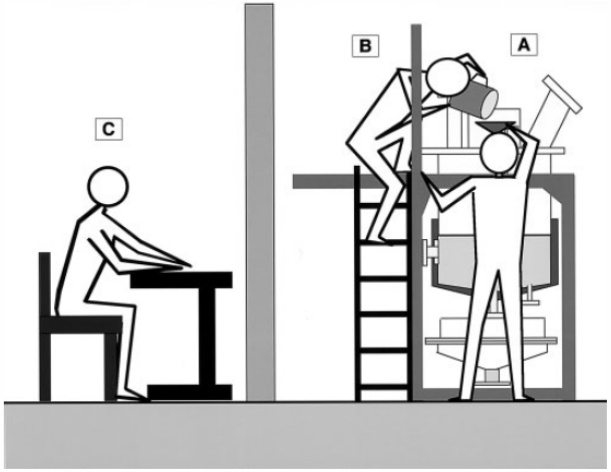
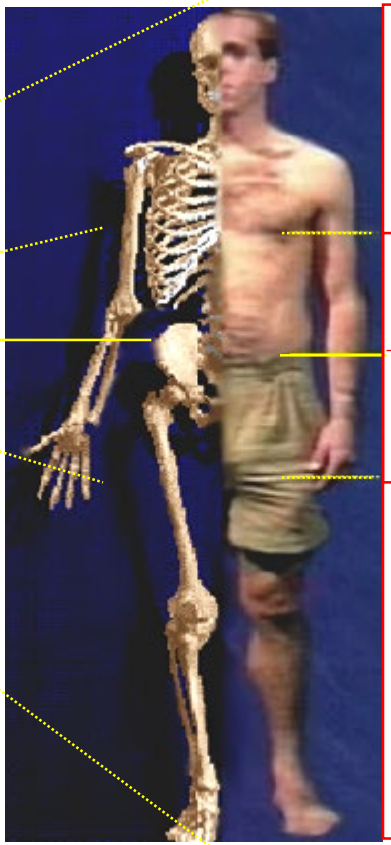


Figure 1. The positions and postures of the victims of the accident at the moment when criticality was triggered, reconstructed by interviewing Workers B and C.

The British Journal of Radiology, April 2003



Homogeneous / heterogeneous ?

Local **Partial Body**

Whole body

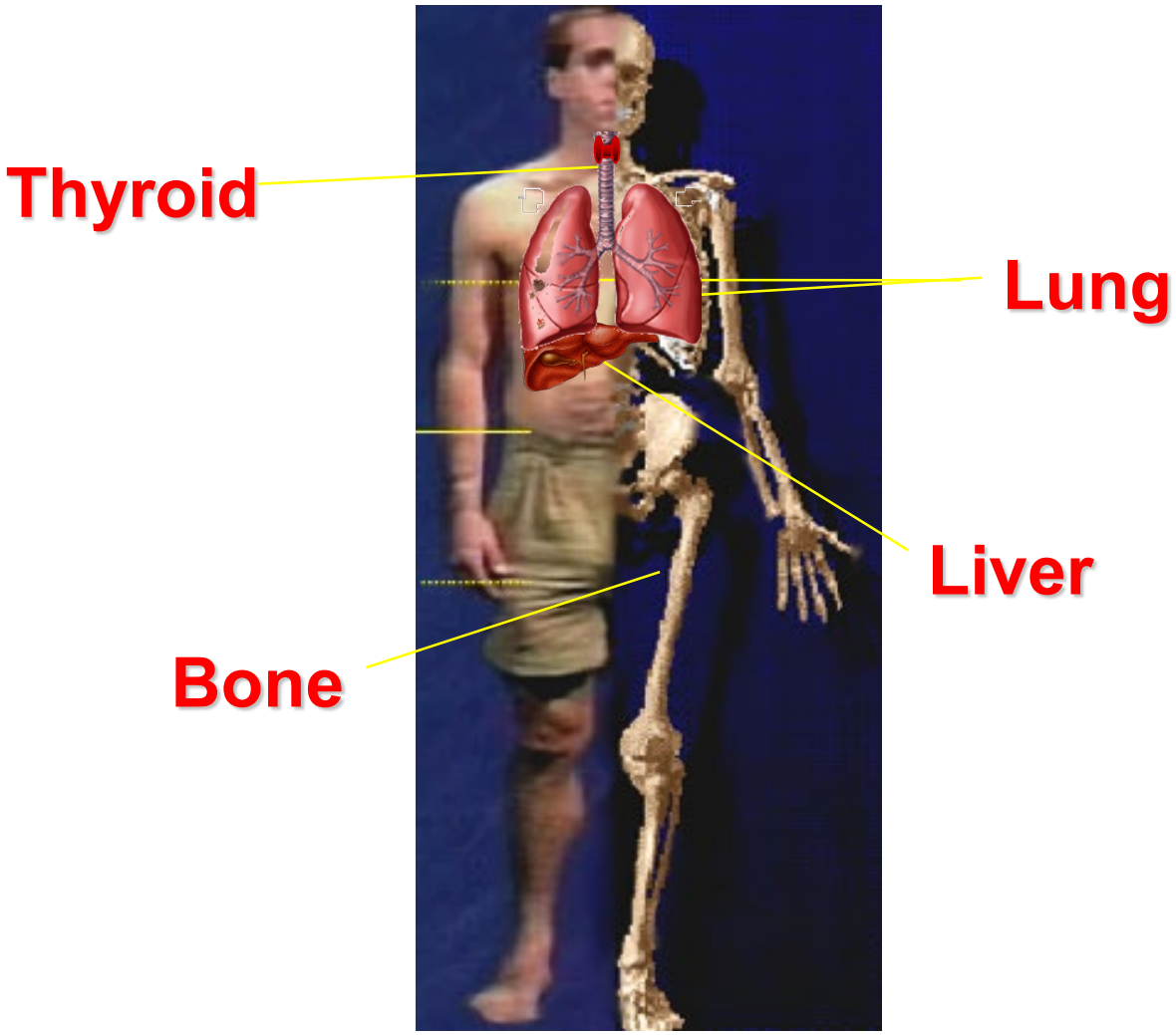
Dose? Dose rate ?

TBI for stem cell transplantation
6x2Gy, 0.05 – 0.15 Gy/min

Radiation Injury - Contamination

External Internal

Radiation Injury - Incorporation



Isotopes releases at the Chernobyl accident

Table 1. Estimated Releases of Isotopes during the Chernobyl Accident.*

Isotope	Half-Life	Type of Radiation	Estimated Release during Accident†
			PBq
Neptunium-239	58 hr	Beta, gamma	95
Molybdenum-99	67 hr	Beta, gamma	>168
Tellurium-132	78 hr	Beta, gamma	1150
Xenon-133	5 days	Beta, gamma	6500
Iodine-131	8 days	Beta, gamma	1760
Barium-140	13 days	Beta, gamma	240
Cerium-141	33 days	Beta, gamma	196
Ruthenium-103	40 days	Beta, gamma	>168
Strontium-89	52 days	Beta	115
Zirconium-95	65 days	Beta, gamma	196
Curium-242	163 days	Alpha	0.9
Cerium-144	285 days	Beta, gamma	116
Ruthenium-106	1 yr	Beta, gamma	>73
Cesium-134	2 yr	Beta	54
Plutonium-241	13 yr	Beta	6
Strontium-90	28 yr	Beta	10
Cesium-137	30 yr	Beta, gamma	85
Plutonium-238	86 yr	Alpha	0.035
Plutonium-240	6,850 yr	Alpha, gamma	0.042
Plutonium-239	24,400 yr	Alpha, gamma	0.030

* Data are from the Nuclear Energy Agency.[8]
† A petabecquerel (PBq) equals 10^{15} becquerels (decays per second).

N Engl J Med 2011;364:2334-4

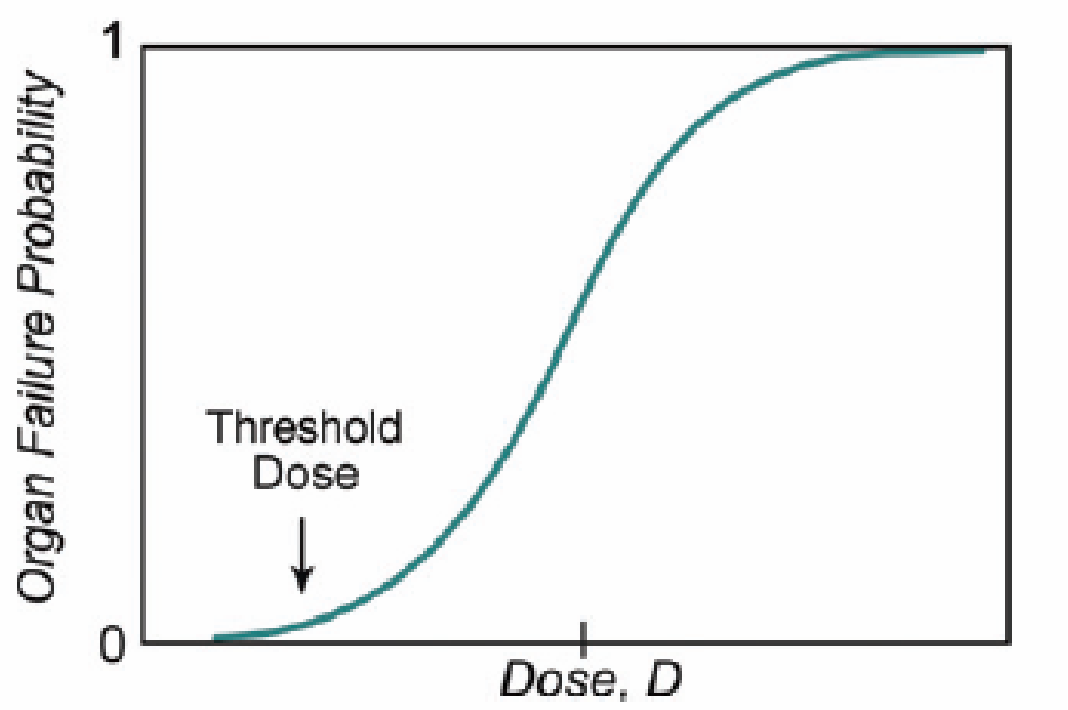
Consequences or effects of radiation injuries

- Deterministic effects

- Stochastic effects

Deterministic effects

There is a threshold dose for damaging effects



Deterministic effects

Early (prodromal) effects – erythema, decr
WBC count, vomiting

Latency period

Early serious effects – hematopoietic synd
GI syndrome, neuroovascular syndrome

- Acute radiation syndrome = ARS

- New: cutaneous manifestations are included into ARS

- H, N, C, G grading

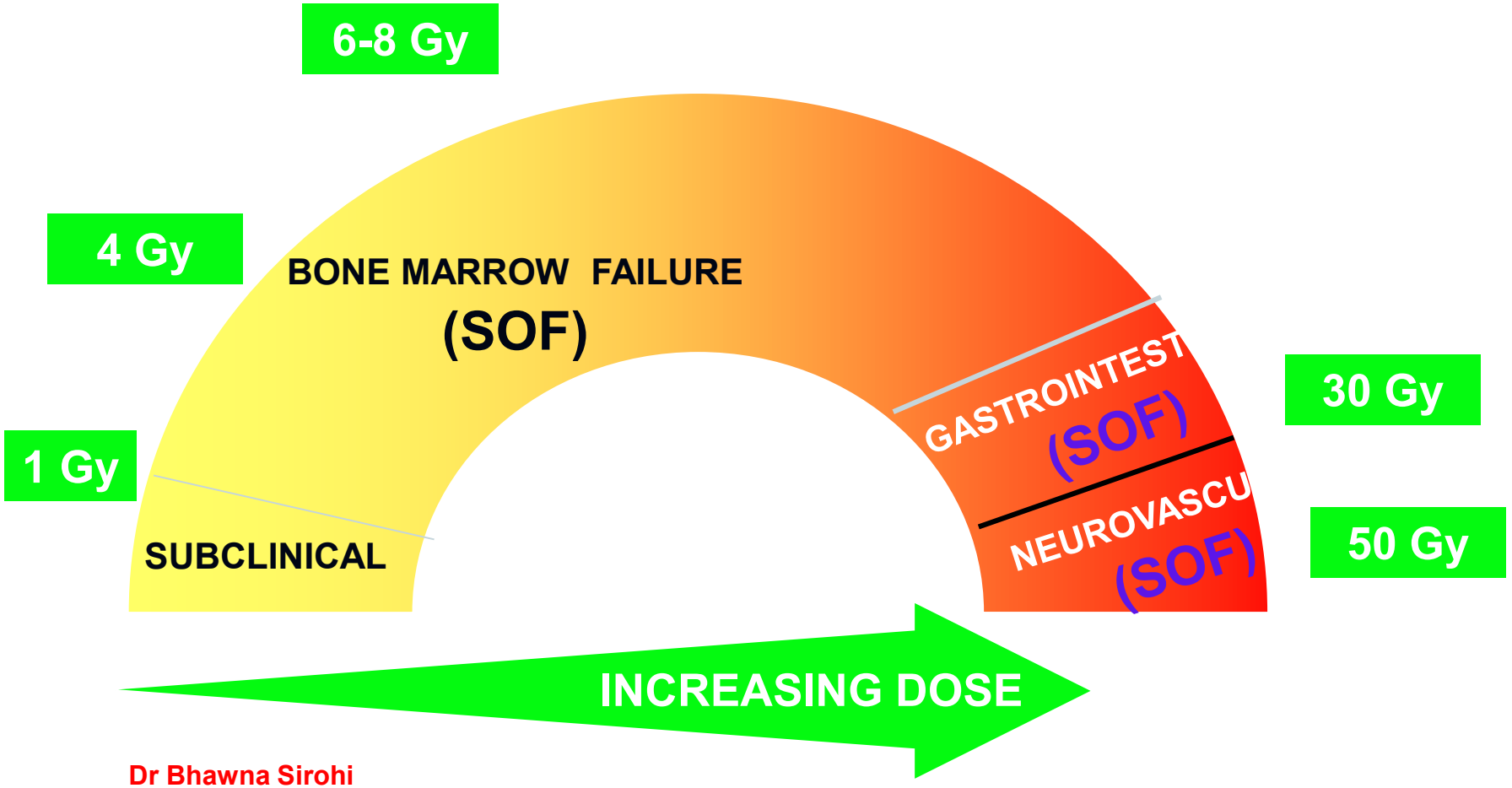
Figure 8. X-ray accident, 0 days post-incident. ▲

Figure 9. Twenty-four days post-incident. ▲

Figure 10. Thirty-three days post-incident. ▲

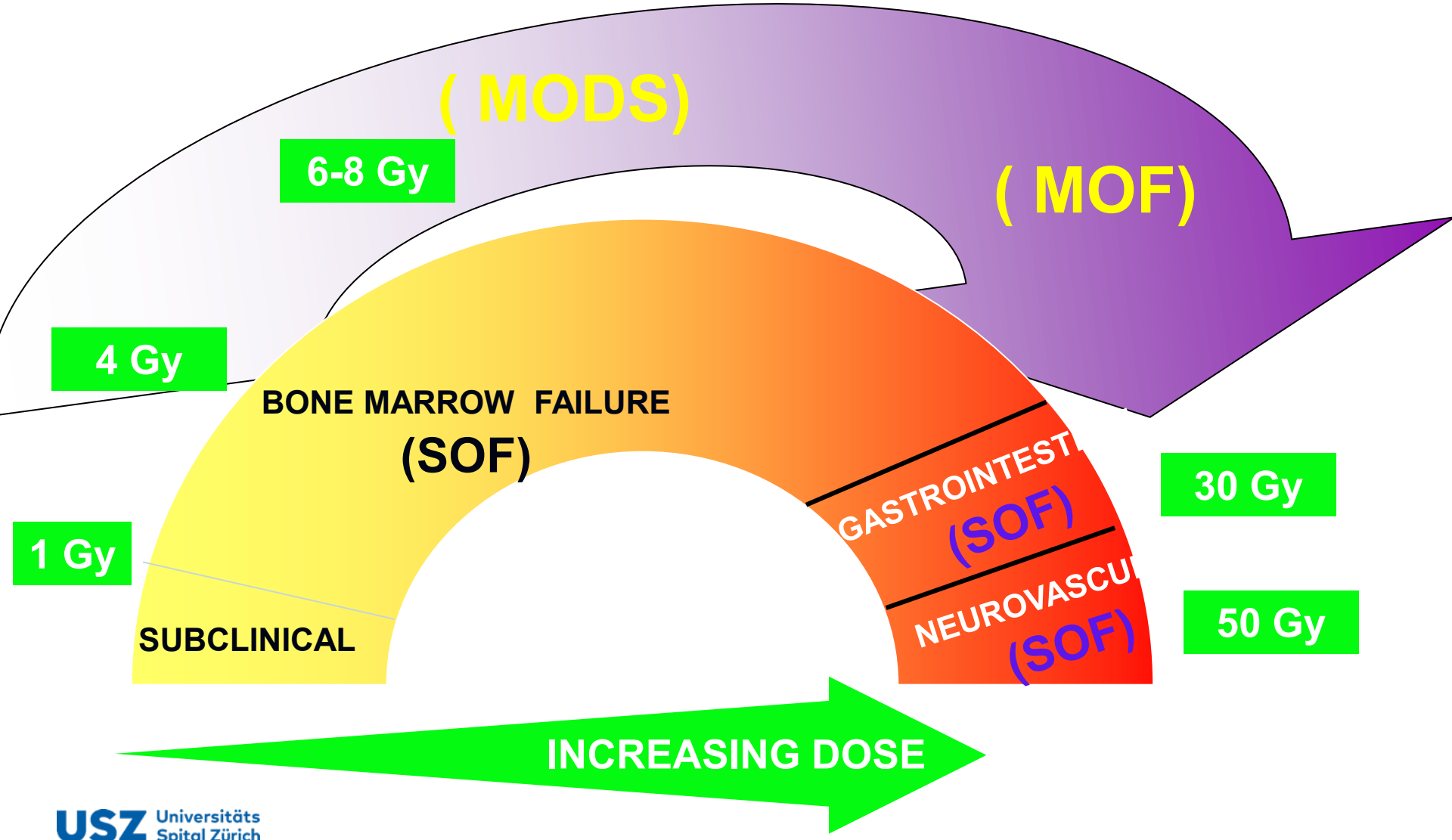
The Classical Paradigm of the ARS (Acute Radiation Syndrome)

The Single Organ Failure concept (SOF)



Dr Bhawna Sirohi
Secretary, EBMT Nuclear Accident Committee
USZ Universitäts Spital Zürich

The New Concept of the ARS



Acute radiation syndrome (ARS) = mutiorgan dysfunction syndrome (MODS)

- The multiorgan dysfunction syndrome includes the following organs
  - Skin — burn like lesions
  - Hematopoiesis — cytopenias and its sequalae i.e. infection and bleeding
  - Gastrointestinal tract — muccosal damage resulting in vomiting, diarrhea, cramps, bleeding, …….
  - CNS — headache, fever, fatigue, nausea, vomiting, neurological deficits, ….

- Symptoms similiar to those that are observed in allogeneic stem cell transplantation and therapy of acute leukemia

→ Therapy of MODS patients should be concentrated on large hematology centers

Deterministic effects

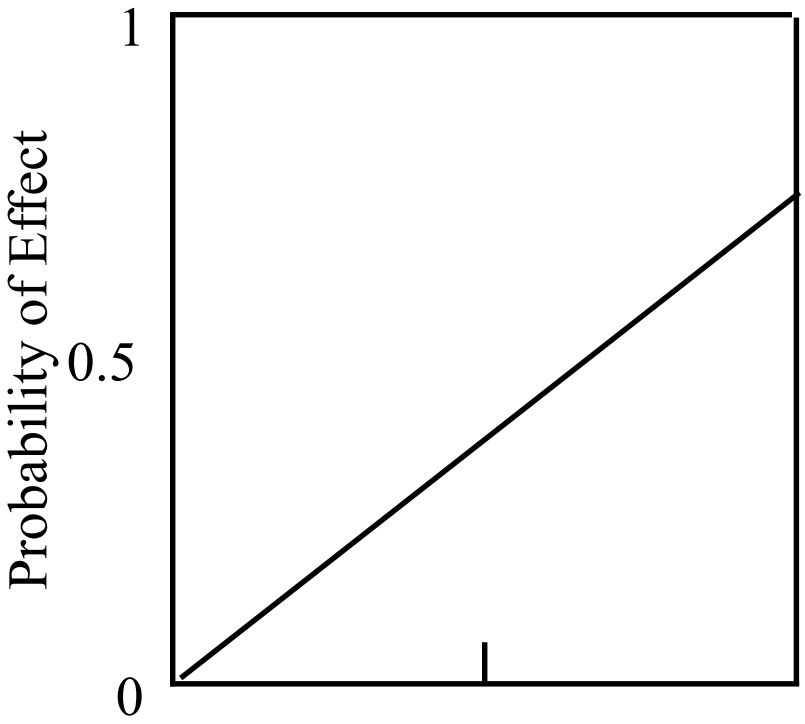
Late effects

- Cataracts
- Fibrosis
- Organ atrophy
- Reduced fertility
- Sterility

Stochastic Effects

Non-threshold, randomly dose dependently occurring effects

Includes cancer, and genetic effects



Unter stochastischen Strahlenschäden versteht man die Verursachung von Krebs und Veränderungen im Erbmaterial. Diese Schäden können bereits bei Dosen unter den Grenzwerten entstehen.

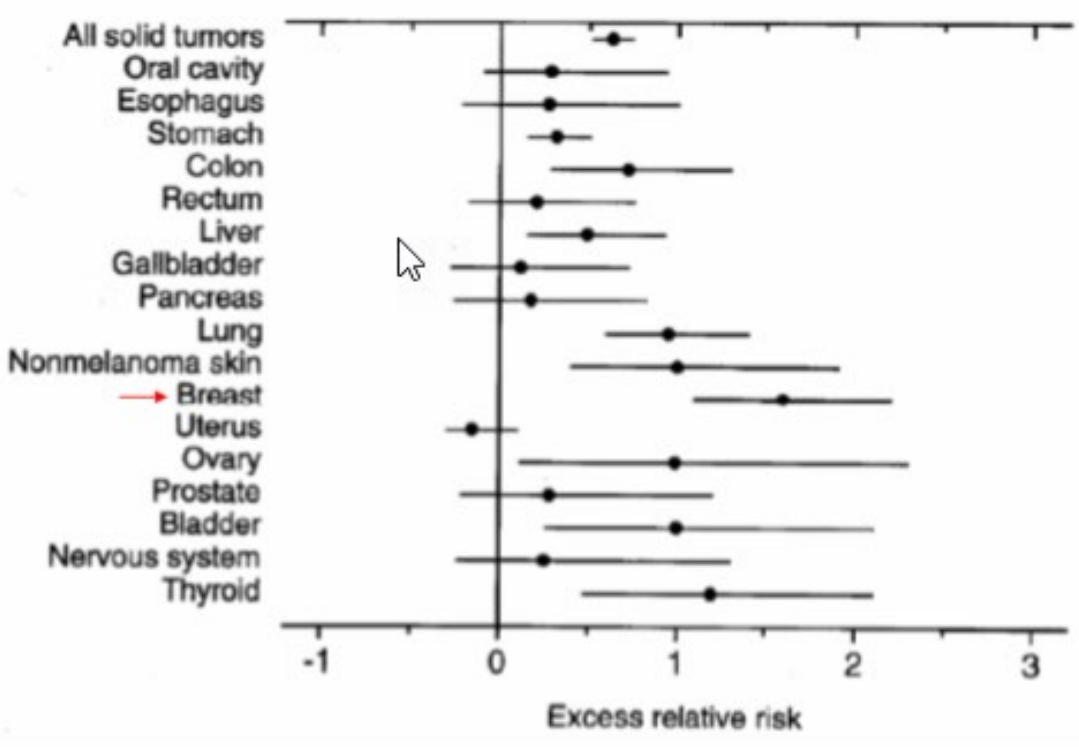
KSR in: Stellungnahme zur Anerkennung strahleninduzierter Berufskrankheiten in der Schweiz 2019

Effects of ionizing radiation, whereby the probability of their occurrence, but not their severity is a function of the dose without the existence of a threshold value.

ENS European nuclear society

Cancer risk 2)

- Different types of cancer has different radiation risk factors – ERR



Department of Physics
University of Oslo

Cancer risk 4)

- The influence of age at exposition:

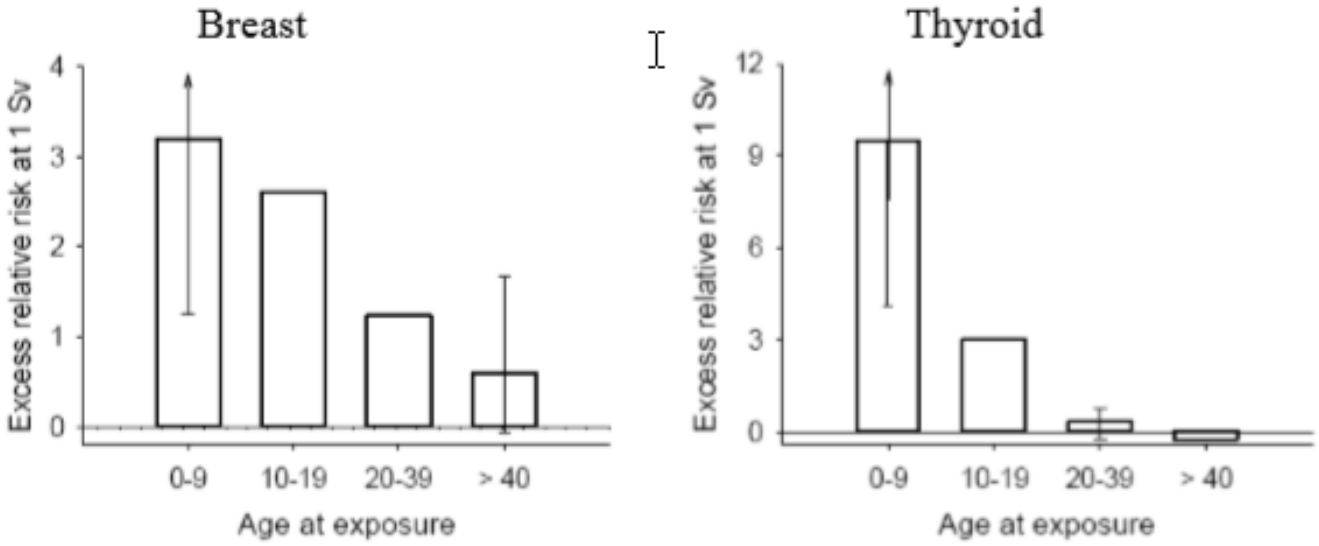
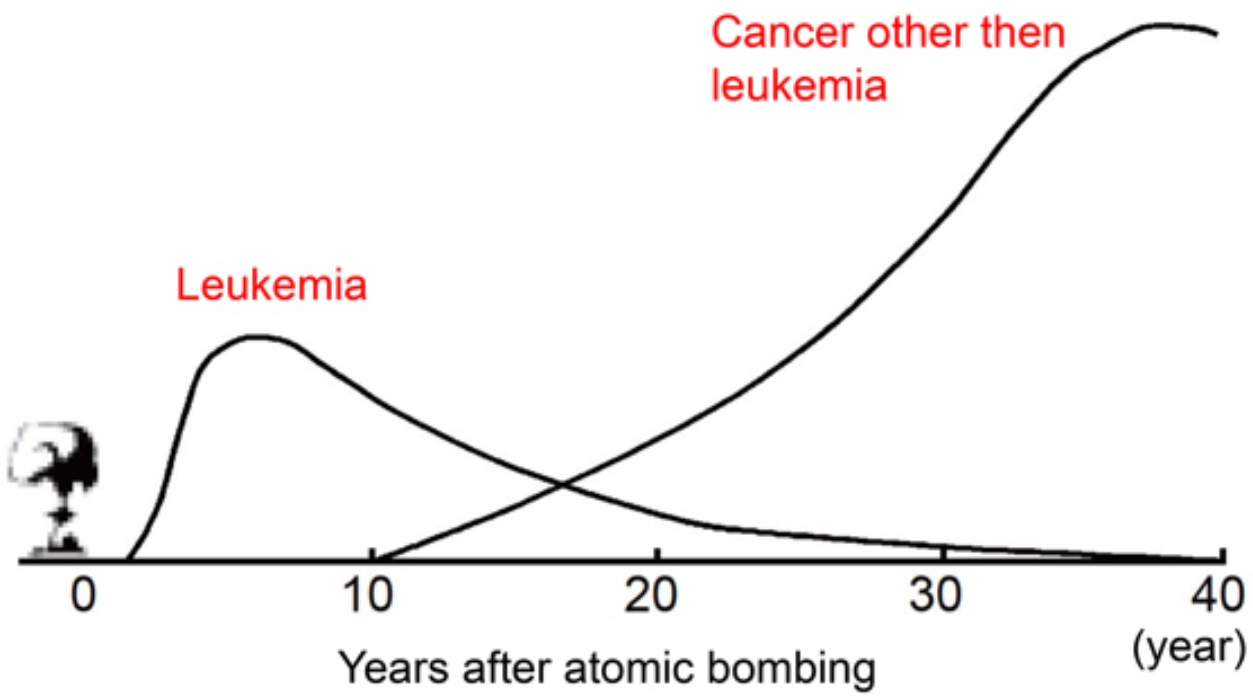
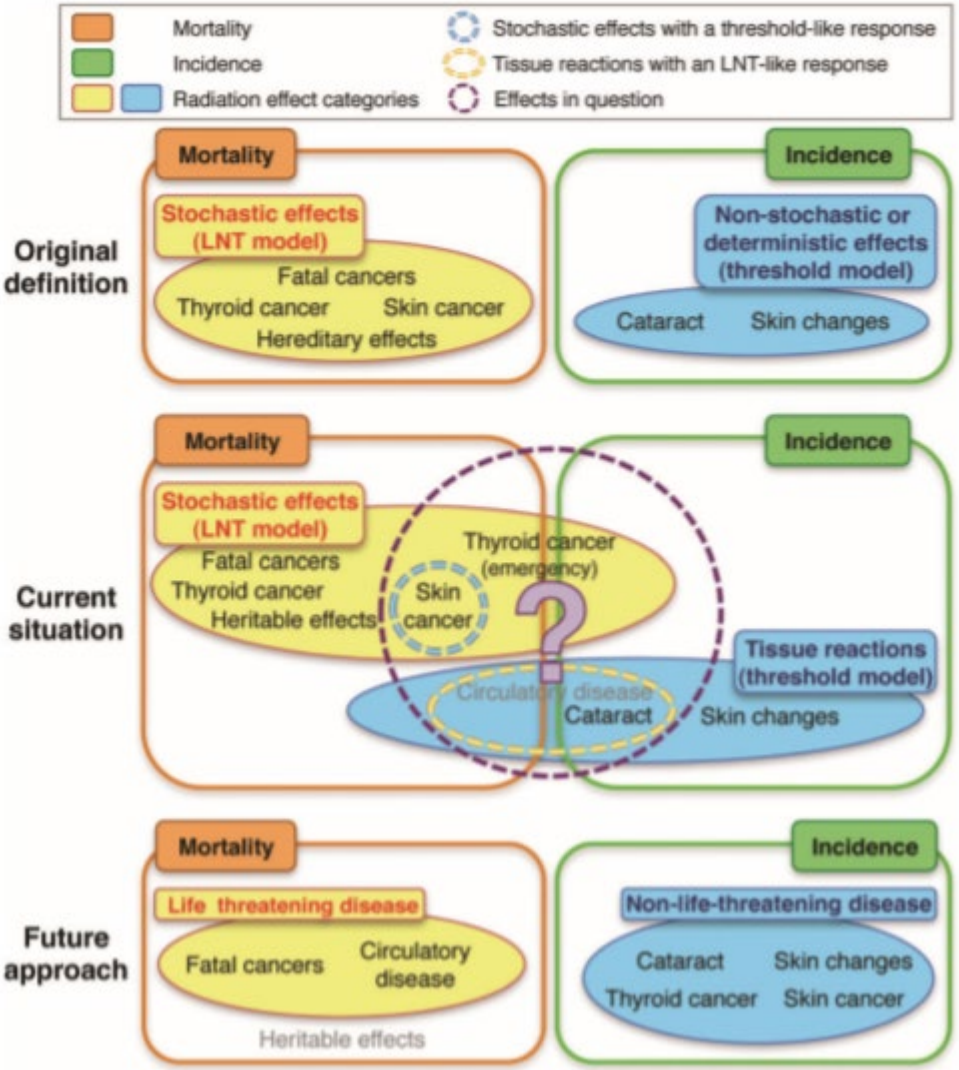


Fig.2 Leukemia and solid tumors induced by atomic bomb radiation



"The effects of radiation on the human body“ March 2017
by Dr. Shinya Matsuura
Director, Research Institute for Radiation Biology and Medicine,
Hiroshima University

Stochastic versus deterministic: differentiation not so clear-cut?



Journal of Radiation Research,2014,55, 629–640

BMJ

RESEARCH

Radiation exposure and circulatory disease risk: Hiroshima and Nagasaki atomic bomb survivor data, 1950-2003

BMJ 2010;340:b5349

Table 2 | Summary excess relative risks (ERR)* per Gy and excess additive risks per 10^4 person year Gy† (EAR/10^4 PY-Gy) for types of circulatory disease mortality

Circulatory disease	Indicated as underlying cause of death				Underlying or contributing cause of death	
	Deaths	P value	% ERR/Gy (95% CI)	EAR/10^4 PY-Gy (95% CI)†	Deaths	% ERR/Gy (95% CI)
Total	19 054	<0.001	11 (5 to 17)	5.5 (2.7 to 8.4)	25 113	15 (10 to 20)
Stroke	9 622	0.02	9 (1 to 17)	2.3 (0.4 to 4.4)	12 139	12 (5 to 19)
Heart disease	8 463	<0.001	14 (6 to 23)	3.2 (1.3 to 5.2)	14 018	18 (11 to 25)
Other	969	>0.5	2 (−18 to 29)	0.1 (−0.4 to 0.7)	5 846	58 (45 to 72)

*Estimates based on linear model, adjusted for city, sex, age at exposure, and attained age.
†Average EARs calculated directly from fitted ERR models.

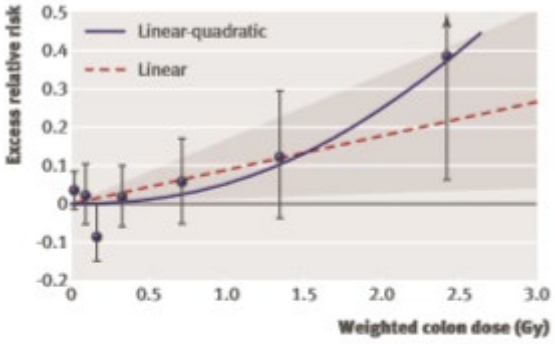


Fig 1| Radiation dose-response relation (excess relative risk per Gy) for death from stroke, showing linear and linear-quadratic functions. Shaded area is 95% confidence region for fitted linear line. Vertical lines are 95% confidence intervals for specific dose category risks. Point estimates of risk for each dose category are indicated by circles

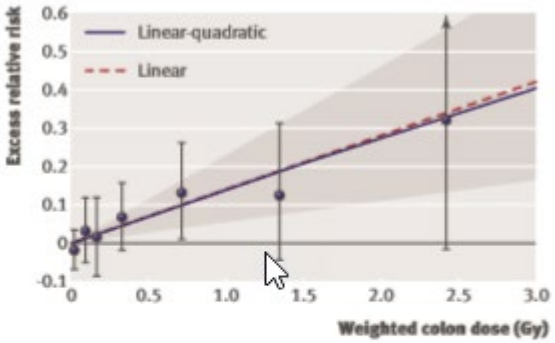


Fig 2| Radiation dose-response relation (excess relative risk) for death from heart disease, showing linear and linear-quadratic functions. Shaded area is 95% confidence region for fitted linear line. Vertical lines are 95% confidence intervals for specific dose category risks. Point estimates of risk for each dose category are indicated by circles

A radiation accident has happened

Medical treatment: What shall we do??????????

THERAPEUTICAL MANAGEMENT

According to the European consensus conference « *European approach for the medical management of mass radiation exposure* » updated in October 2017

Beyond the first 48 hrs, a second patient scoring is done by organs (Haematopoietic, Gastrointestinal, Cutaneous, Neurovascular) according to the METREPOL document for therapeutical management and Multiple Organ Failure (MOF) prediction.

Cytokines

Score I: Monitoring. No cytokine

- Outpatient clinical monitoring.
- Blood count day 1 - 2 and then once a week for 2 months.

Score II: Cytokines (curative)

- G-CSF (Pegylated or not) should be used within 48 hrs or as soon as possible until neutrophil recovery (ANC > 0.5 x 10^9/L). EPO and TPO agnoists can be used if needed. Routine marrow failure support with antibiotics, blood products as per routine haemato-oncology care.
- Symptomatic treatment of gastrointestinal damage.
- If severe aplasia → Protected environment.
- Accidental radiation exposure is generally heterogeneous. Some under-exposed/protected regions of bone marrow can give rise to endogenous haematopoietic recovery.

Score III: Cytokines (until reappraisal of score)

- Patients to be treated as score II until it is clear that they are score III.
- Palliative and end of Life care to be initiated.
- Re-evaluation of score during the first week based on laboratory or clinical symptoms revealing irreversible organ damage or MOF.

ALL BLOOD PRODUCTS SHOULD BE IRRADIATED.

SEVERE RADIATION SKIN LESIONS HAVE A PECULIAR EVOLUTION. CONSIDER MESENCHYMAL STEM CELLS AT SPECIALIST CENTRES.

References:
- Gorin NC *et al* – *Ann Hematol*, 85 : 671-679, 2006.
- Fliedner TM *et al* – Medical Management of Radiation Accidents - Manual of the acute radiation syndrome, published by BIR, 2001.
- Powles R *et al* – *Health Phys*, 98 : 810-814, 2010.

Haematopoietic stem cell (HSC) transplantation

Background

- HSC transplantation is not an emergency.
- It is crucial to avoid GVHD in order not to compromise an endogenous recovery.
- If severe aplasia persists under cytokines for more than 14 days, the possibility of an haematopoietic stem cell (HSC) transplantation is discussed (as below).

Criteria to transplant

- Severe marrow aplasia persisting 14 - 21 days despite cytokines.
- No residual haematopoiesis on bone marrow biopsy.
- No other irreversible organ damage.
- Treated or controlled infection, if present

Graft

- Type of graft:
  - Bone marrow.
  - Peripheral blood HSC (depleted or not).
  - Cord blood.
- Donor in the following order of priority (as per current transplant criteria):
  - HLA-identical sibling.
  - HLA-identical unrelated donor.
  - Cord blood > 4/6 matched.
  - Haplo-identical.
- Doses of cells to be grafted:
  At least:
  - 2x10^6 CD34 cells. kg^{-1} (peripheral blood).
  - 2x10^8 nucleated cells.kg^{-1} (bone marrow).
  - 3x10^7 nucleated cells (cord blood).

Conditioning and GVHD prevention (as per current transplant criteria):

- Reduced intensity conditioning.
- No Methotrexate.

EUROPEAN APPROACH

FOR THE MEDICAL MANAGEMENT OF MASS RADIATION EXPOSURE

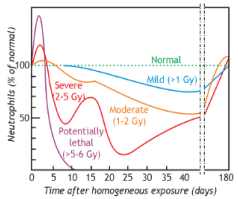
THERAPEUTICAL MANAGEMENT

EBMT European Society for Blood and Marrow Transplantation — IRSN Institut de radioprotection et de sûreté nucléaire

What can the European Blood and Marrow Transplant Group (EBMT) offer ?

Advice on :

1. Secondary Triage and Treatment
2. Ongoing feedback from experts on how the clinical scenario is evolving
3. Optimizing care outside of national borders
4. Skilled network of 500 BMT Centres
5. Generating prospective database of event



The amount of energy absorbed by the organs of the body is measured in Gray (Gy); the effects of this radiation is given by the equivalent dose which is measured in Sievert (Sv).
For x-rays, gamma rays, and beta particles 1 Gray ≈ 1 Sievert.

Contacts

M Benderitter (France): marc.benderitter@irsn.fr
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N C Gorin (France): gorinclaude@gmail
M Port (Germany): matthiasport@bun
R Powles (United Kingdom): myeloma
B Sirohi (United Kingdom): bhawna.sir
L Stenke (Sweden): leif.stenke@ki.se

October 2017

EBMT
Nuclear Accident Committee
Pocket Guide

THE FIRST 48 HOURS

Decontamination after stabilisation.
Life-threatening wounds and burns should be treated first.
Radiation dose review comes later – Irradiation is not contamination – An irradiated person is not a source of radiation.

Acute Radiation Injury

The severity of prodromal clinical features is indicative of probable significant injury.

- Extensive and immediate erythema.
- Early Transient Incapacitation Syndrome (temporary loss of consciousness).
- High fever.
- Hypotension; Early Vomiting.
- Immediate diarrhoea.

Accident Characterisation

- Inquiry: circumstances of the accident (is irradiation +/-contamination present; use contamination monitoring device), source characteristics, source-victim geometry, duration of exposure, shielding, homogeneous / heterogeneous irradiation.
- Labelling and storage of personal belongings and clothes, biological material (hair, nails).

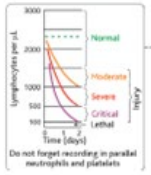
Urgent sampling

- Blood cell counts (+ differentials) every 4-8 hours for the 1st 24 hours, 12-24 h every day after.
- Red cell group typing
- Standard biochemistry + amylasemia.
- Urine and faeces if radionuclide contamination is suspected
- Store serum and cells or DNA for further analyses including HLA typing.
- Chromosome aberrations on blood lymphocytes (biodosimetry) (15 ml + heparin). Seek advice from national / international biodosimetry networks as soon as possible.

Primary scoring

Record all clinical symptoms on a date and hour-stamped chart

Average delay before symptoms appear	Score I: Less than 12 hours	Score II: Less than 5 hours	Score III: Less than 30 minutes
Cutaneous erythema	0	+/-	+++ ; before 3rd hour
Asthenia /Weakness	+	++	+++
Nausea	+	+++	(-)
Vomiting per 24 hrs	Maximum 1	1 to 10	Above 10; intractable
Diarrhea / Number of stools per 20 hrs	Maximum 2 - 3; bulky	2 - 9; soft	Above 10; watery
Abdominal pain	Minimal	Intense	Excruciating
Headaches	0	++	Excruciating; Signs of intra-cranial HT
Temperature	Below 38°C	38 - 40°C	Above 40°C
Blood pressure	Normal	Normal - Possible temporary decrease	Systolic below 80
Temporary loss of consciousness	0	0	+ / Coma



Do not forget recording in parallel neutrophils and platelets

Depletion of blood lymphocytes

	Score I	Score II	Score III
At 24 hours	Above 1 500 / µL	Below 1 500 / µL	Below 500 / µL
At 48 hours	Above 1 500 / µL	Below 1 500 / µL	Below 100 / µL
	Outpatient monitoring	Hospitalisation for curative treatment	Hospitalisation (MOF predicted) Multiple Organ failure (MOF)

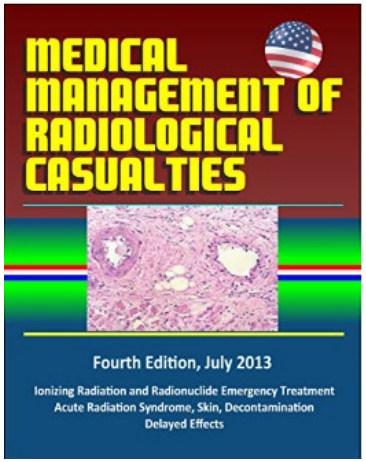
WARNING: the symptoms and values indicated above are reliable only in case the whole body or large parts of the body have been externally exposed to a high radiation dose delivered within few minutes or few hours. Fill and fax EBMT MED A to : (+33)1 71 97 04 88
To download EBMT MED A: www.ebmt.org in Data-Management/Registry structure/data collection forms & manuals

MEDICAL MANAGEMENT OF RADIOLOGICAL CASUALTIES

Fourth Edition – July 2013

Military Medical Operations
Armed Forces Radiobiology Research Institute
Bethesda, Maryland 20889-5603
www.usuhs.edu/afrri

Index



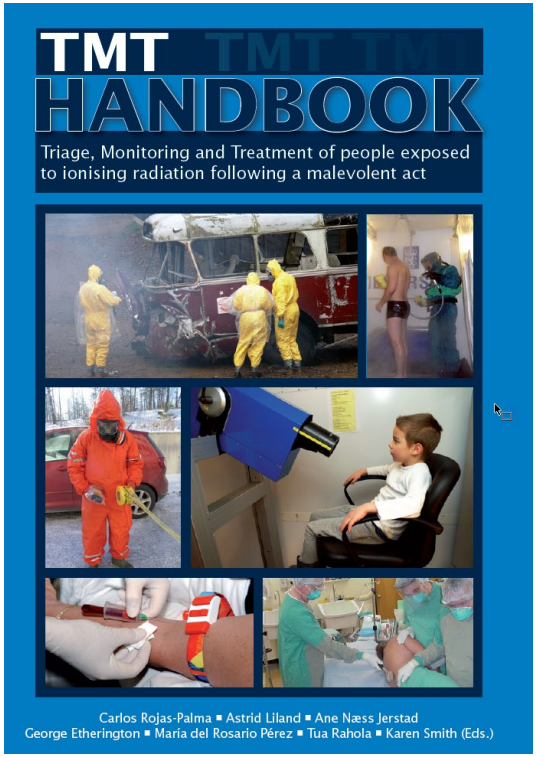
*"Radiological and nuclear accidents or incidents remain real threats, and understanding the medical radiobiology of such events represents a major gap in most emergency preparedness. This manual serves as an informative yet practical instrument in preparing

Ann Hematol (2006) 85: 671–679
DOI 10.1007/s00277-006-0153-x

CONFERENCE REPORT

N.-C. Gorin · T. M. Fliedner · P. Gourmelon ·
A. Ganser · V. Meineke · B. Sirohi
R. Powles · J. Apperley

Consensus conference on European preparedness for haematological and other medical management of mass radiation accidents



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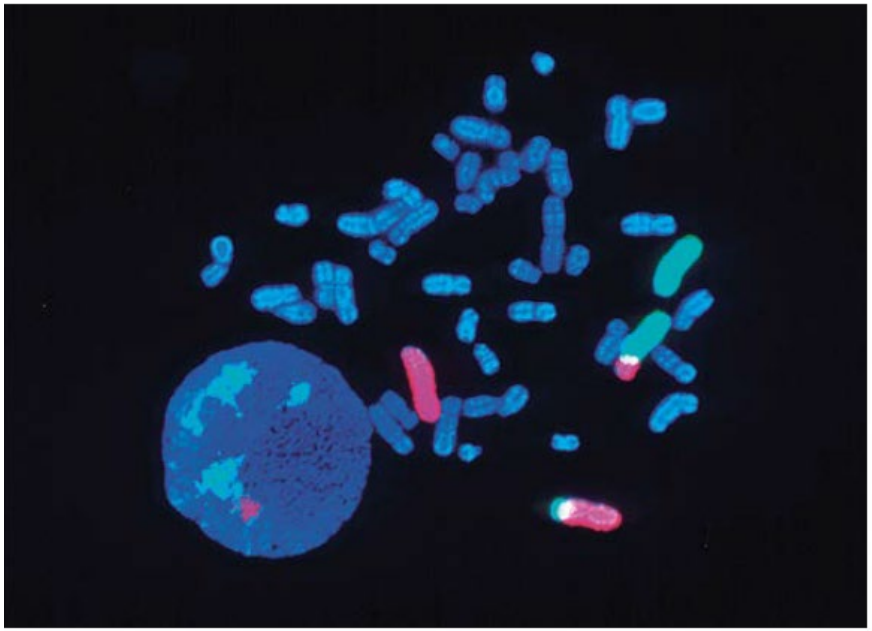

Suva
Arbeitsmedizin
Postfach, 6002 Luzern

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Bestellungen
www.suva.ch
Tel. 041 419 58 51
Fax 041 419 59 17

Titel
Der Strahlenunfall
Was ist zu tun?

[Der Strahlenunfall. Was ist zu tun? (suva.ch)]

Verfasser
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Dr. med. Klaus Ernst Stadtmüller, Bereich Fachärztinnen und Fachärzte Arbeitsmedizin

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2869/21.d

Der Strahlenunfall
Was ist zu tun?

Behörde	Aufgabe	Kontakt
Nationale Alarmzentrale (NAZ)	Fachstelle des Bundes für ausserordentliche Ereignisse (u. a. auch für Ereignisse mit erhöhter Radioaktivität), Anlaufstelle für alle bevölkerungsschutzrelevanten Meldungen; Anordnung von Sofortmassnahmen zum Schutz der Bevölkerung, Orientierung der Behörden	Nationale Alarmzentrale Postfach 8044 Zürich Tel: 0848 840 080 Fax: +41 58 466 49 03
Alarmstelle der NAZ ASNAZ (24h/365 Tage)	Eingangsstelle der Alarmmeldungen für die NAZ	Die Alarmnummer ist einschlägigen Institutionen und Notfallorganisationen bekannt.
Bundesamt für Gesundheit (BAG) Aufsichtsbehörde für Medizin, Forschung und Lehre	Erteilung von Bewilligungen für den Umgang mit ionisierender Strahlung (Medizin, Industrie, Forschung und Lehre); Strahlenschutz von Personal und Bevölkerung; Überwachung der Konformität der Einrichtungen und der Sicherheit der in diesem Bereich tätigen Personen; Durchführung von Messungen der Umweltradioaktivität; REMPAN Collaborative Center	Bundesamt für Gesundheit Abteilung Strahlenschutz 3003 Bern Tel: +41 58 462 96 14 Fax: +41 58 462 83 83 str@bag.admin.ch
Eidgenössisches Nuklear-Sicherheitsinspektorat (ENSI) Aufsichtsbehörde für Kernanlagen	Beaufsichtigung der schweizerischen Kernanlagen (Kernkraftwerke, Zwischenlager für radioaktive Abfälle, nukleare Forschungseinrichtungen); Strahlenschutz von Personal und Bevölkerung; Sicherung (Schutz vor Sabotage und Terrorismus). Überwachung von Transporten radioaktiver Stoffe von und zu den Kernanlagen.	Eidgenössisches Nuklear-Sicherheitsinspektorat Industriestrasse 19 5200 Brugg Tel: +41 56 460 84 00 Fax: +41 56 460 84 99 info@ensi.ch
Suva Aufsichtsbehörde für Industrie	Beaufsichtigung der Industrie- und Gewerbebetriebe; Überwachung der Konformität der Einrichtungen und der Sicherheit der in diesem Bereich tätigen Personen; Durchführung von radiologischen Messungen.	Suva Bereich Physik Postfach 4258 6002 Luzern Tel: +41 41 419 61 33 Fax: +41 41 419 62 13 physik@suva.ch
Suva Arbeitsmedizin	Aufzeigen der beruflichen Tätigkeiten, die ein erhöhtes Risiko für Unfälle, Berufskrankheiten und arbeitsplatzassoziierte Gesundheitsprobleme darstellen; Unterstützung bei der Organisation einer biologischen Dosimetrie	Suva Abteilung Arbeitsmedizin Postfach 4358 6002 Luzern Tel: +41 41 419 52 78 Fax: +41 41 419 62 05 arbeitsmedizin@suva.ch

suvapro
Sicher arbeiten

8 Die üblichen hygienischen Schutzmassnahmen bilden für den Helfenden einen ausreichenden Schutz vor Kontamination durch anhaftende radioaktive Stoffe.

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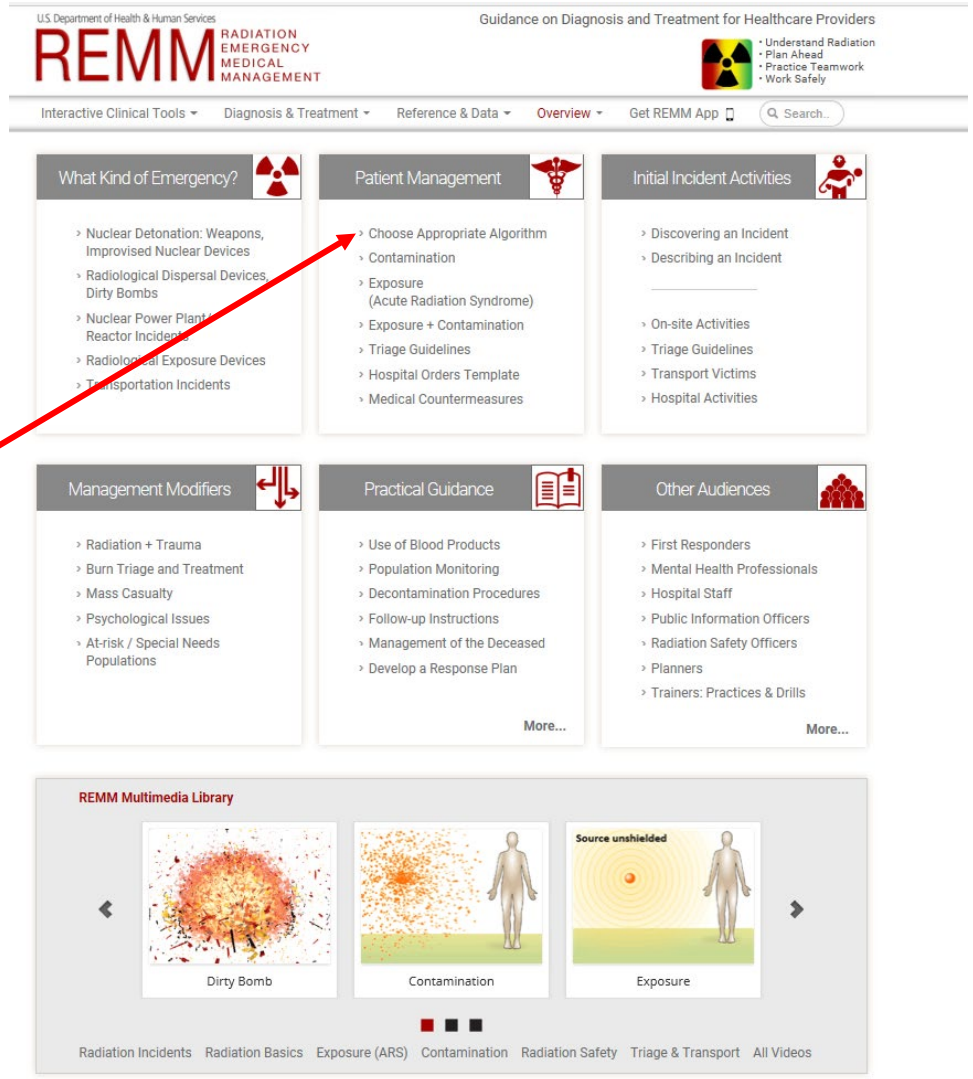
https://remm.hhs.gov/



US Department of Health and Human Services, Administration for Strategic Preparedness and Response

U.S. Department of Health & Human Services

REMM RADIATION EMERGENCY MEDICAL MANAGEMENT

Guidance on Diagnosis and Treatment for Healthcare Providers

- Understand Radiation
- Plan Ahead
- Practice Teamwork
- Work Safely

Interactive Clinical Tools | Diagnosis & Treatment | Reference & Data | Overview | Get REMM App | Search..

Home > Managing Acute Radiation Syndrome (ARS)

Managing Acute Radiation Syndrome (ARS)

Tool Overview

Hematopoietic (H)

Gastrointestinal (G)

Cutaneous (C)

Neurovascular (N)

Response Category

Overview - How to Use This Tool

Read this information first

- Click through each ARS Subsyndrome tab on the left.
- For each clinical parameter, check "degree of severity": 1 (least) to 4 (most).
- Click **"View Treatments to Consider"**, based on severity inputs. [Print result.]
- Click **"View Response Category (RC)"** to assist with venue referral based on your inputs.
- Click **"Start Over"** to clear all previous inputs.

Disclaimers | References for Tool

Last updated Thu Jun 27 2019

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View/Print as PDF

Choose Appropriate Algorithm: Evaluate for Radiation Contamination and/or Exposure

Last updated Thu Jun 27 2019

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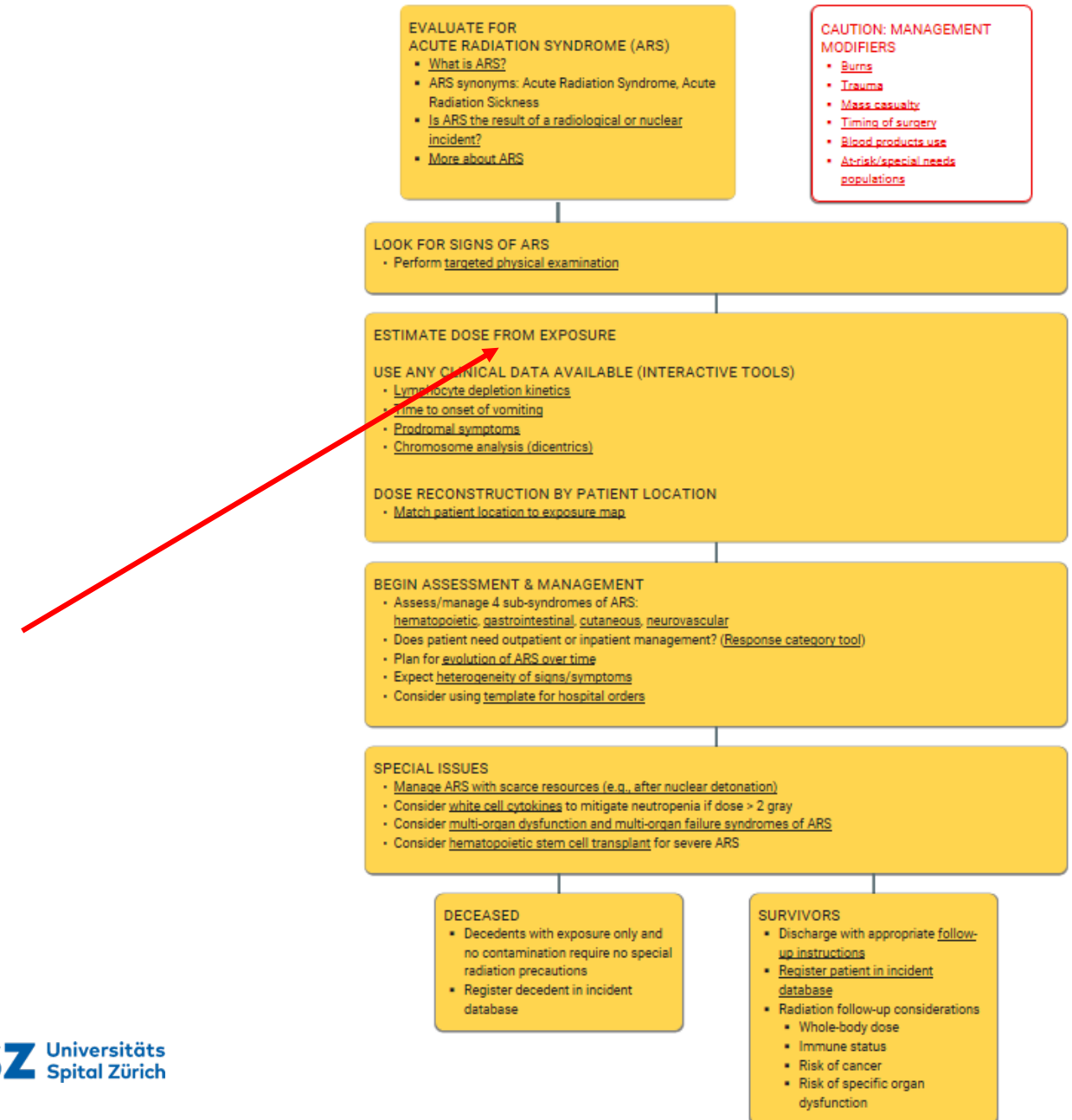
Radiation Exposure: Diagnose and Manage Acute Radiation Syndrome (ARS)



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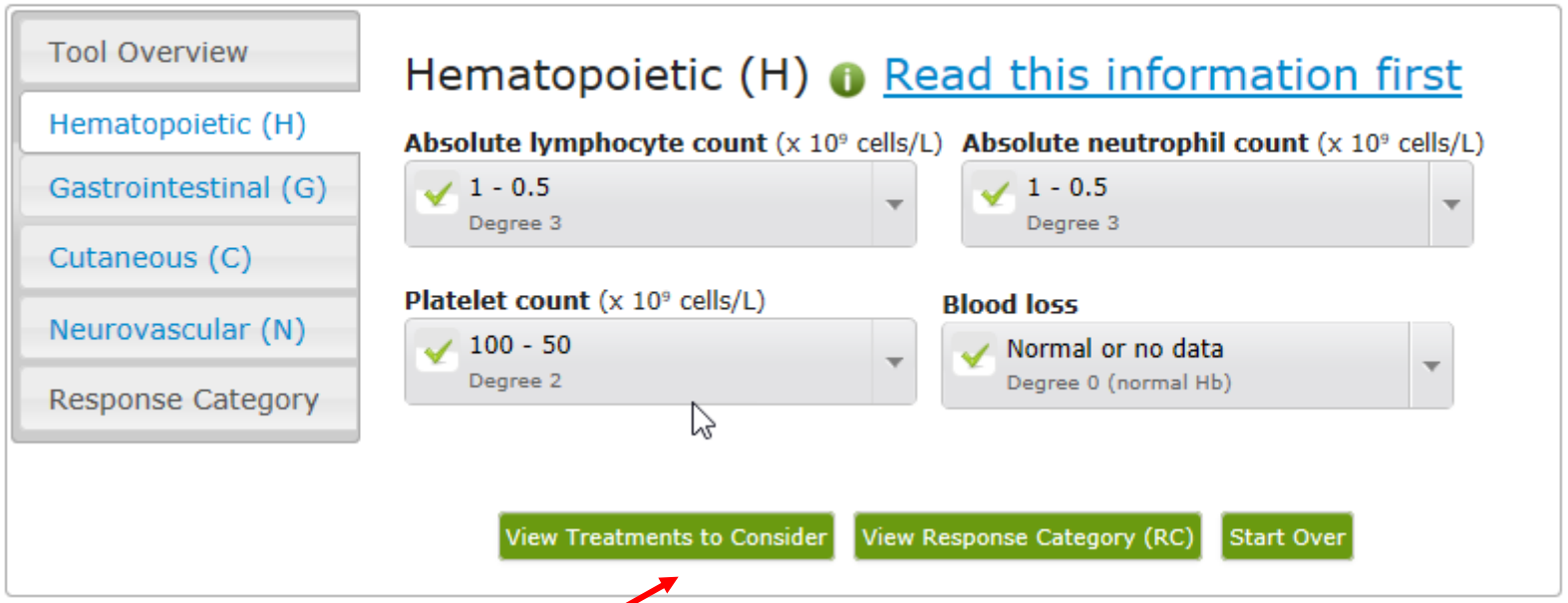
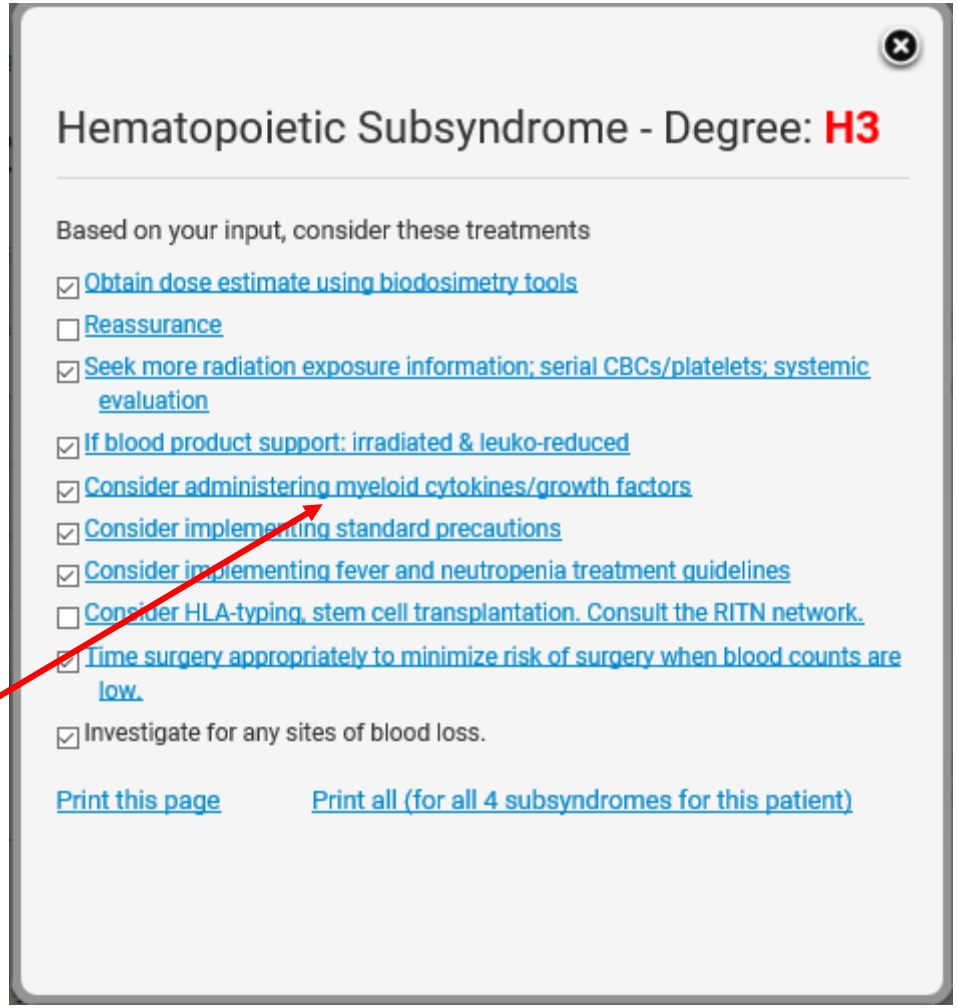
Managing Acute Radiation Syndrome (ARS)




Hematopoietic Subsyndrome - Degree: H3
Based on your input, consider these treatments
Obtain dose estimate using biodosimetry tools
Reassurance
Seek more radiation exposure information; serial CBCs/platelets; systemic evaluation
If blood product support: irradiated & leuko-reduced
Consider administering myeloid cytokines/growth factors
Consider implementing standard precautions
Consider implementing fever and neutropenia treatment guidelines
Consider HLA-typing, stem cell transplantation. Consult the RITN network.
Time surgery appropriately to minimize risk of surgery when blood counts are low.
Investigate for any sites of blood loss.
Print this page
Print all (for all 4 subsyndromes for this patient)

[Strahlenunfall – Universitätsspital Zürich (usz.ch)](www.usz.ch/strahlenunfall)

www.usz.ch/strahlenunfall

Strahlenunfall- Einführung und medizinisches Management 286 KB

DE: Vereinfachter Leitfaden nach der REMM-Webseite zur Betreuung von Strahlenopfern 355 KB

EN: Simplified guide to the online REMM tool for management of radiation incident victims 309 KB

FR: Guide simplifié concernant l'outil en ligne REMM pour le traitement des personnes fortement irradiées 316 KB

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Vielen Dank für Ihre Aufmerksamkeit