Can we attribute health effects to medical radiation exposure?

Wolfgang-Ulrich Müller

(Lead writer for the UNSCEAR Attribution report)

United Nations Scientific Committee on the Effects of Atomic Radiation

Content

- Introduction
- Basic aspects
- Deterministic (tissue) effects
- Stochastic effects
- Conclusions

Introduction

Mandate by the United Nations General Assembly:

On 10 December 2009, the General Assembly encouraged „the Scientific Committee at its earliest convenience to submit the report on the attribution of health effects due to radiation exposure".

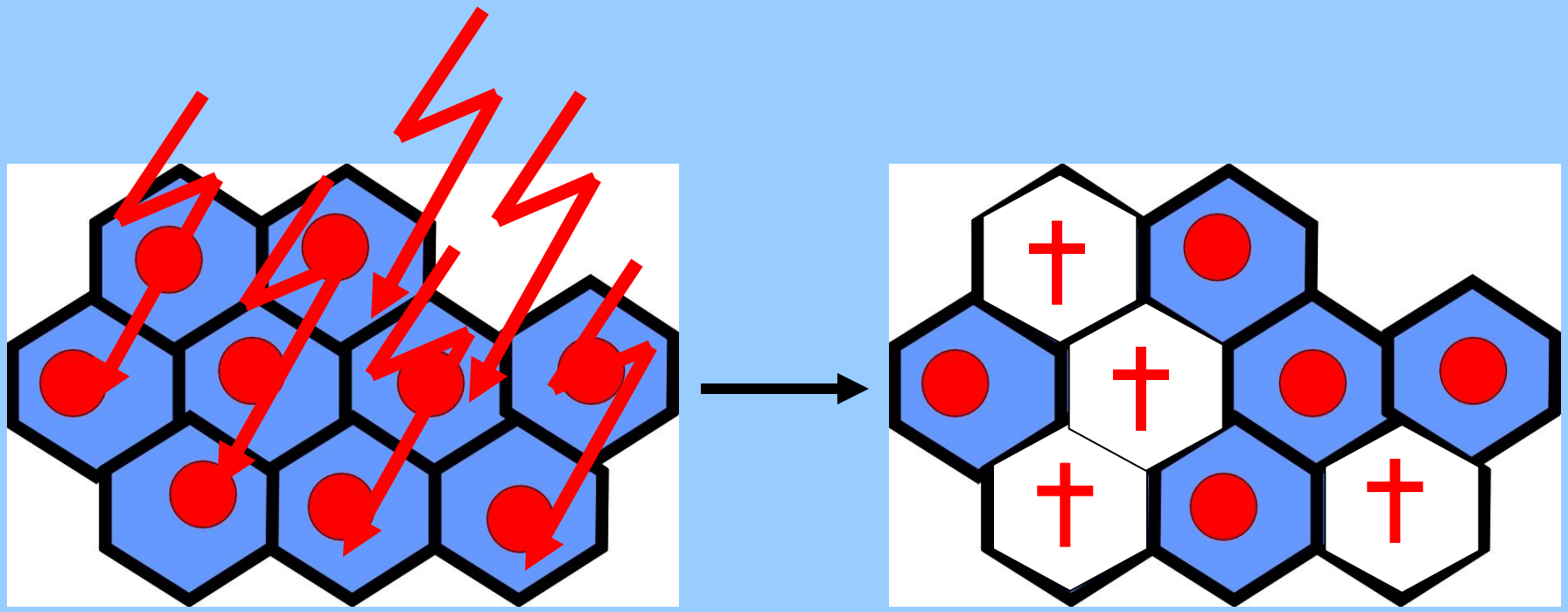
Why does UNSCEAR address attribution?

- The primary task of UNSCEAR is to collect worldwide data on radiation sources and radiation effects.
- It turned out that quite a number of UNSCEAR's data were mis-used.
- The reason: UNSCEAR never stated what can be done with the data and what should not be done.
- Therefore, two documents were prepared and will be published soon:
  - One document on uncertainties
  - One document on attribution.

Some basic aspects

- First of all, one has to be very careful to distinguish „health effect" (something that is actually observed) and „health risk" (something that is expected).
- In general, health effects are related to the past and health risks to the future.
- It makes a difference to attribute in the individual case or in the case of a population.

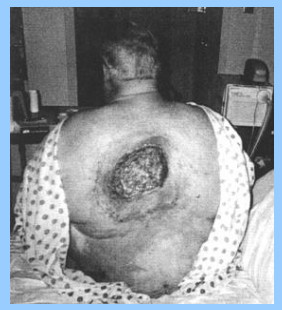
First, let's have a look at deterministic (tissue) effects



Skin burn after interventional cardiology procedure

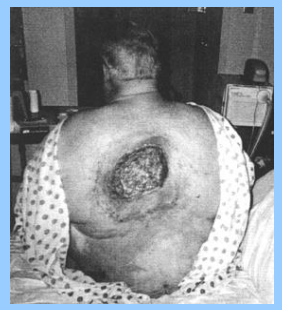
United Nations Scientific Committee on the Effects of Atomic Radiation

Background



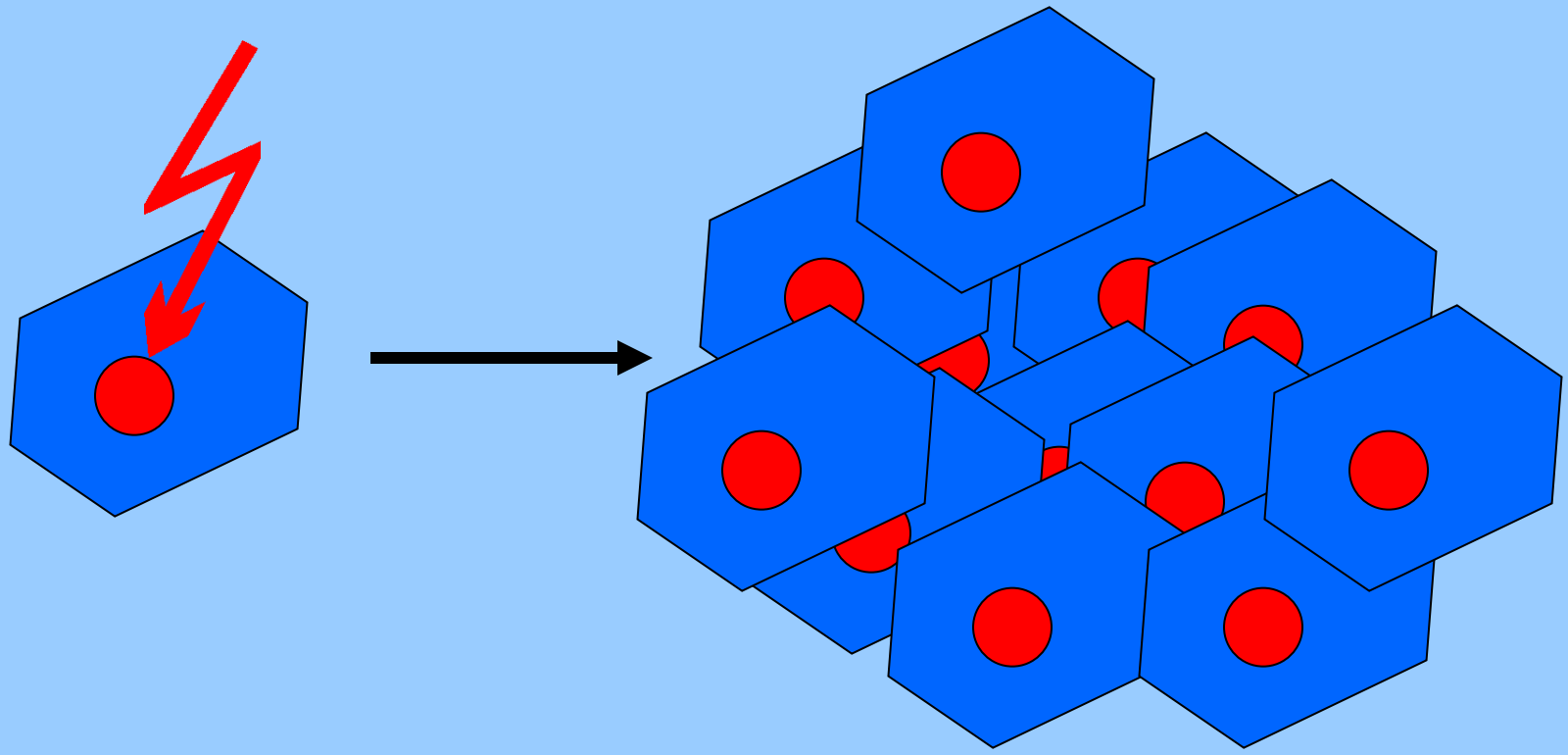
- 69 year old patient with a long-standing heart-disease;
- a diagnostic nuclear medicine myocardial imaging study showed severe ischaemia in the distribution of the left anterior descending coronary artery;
- he underwent a cardiac catheterization that included several attempts at coronary angioplasty (dilatation) and stenting. The fluoroscopy time was recorded as 34 minutes. There were 50 cine runs with a total of about 6,200 frames.

The reasons for attributing this health effect to ionizing radiation

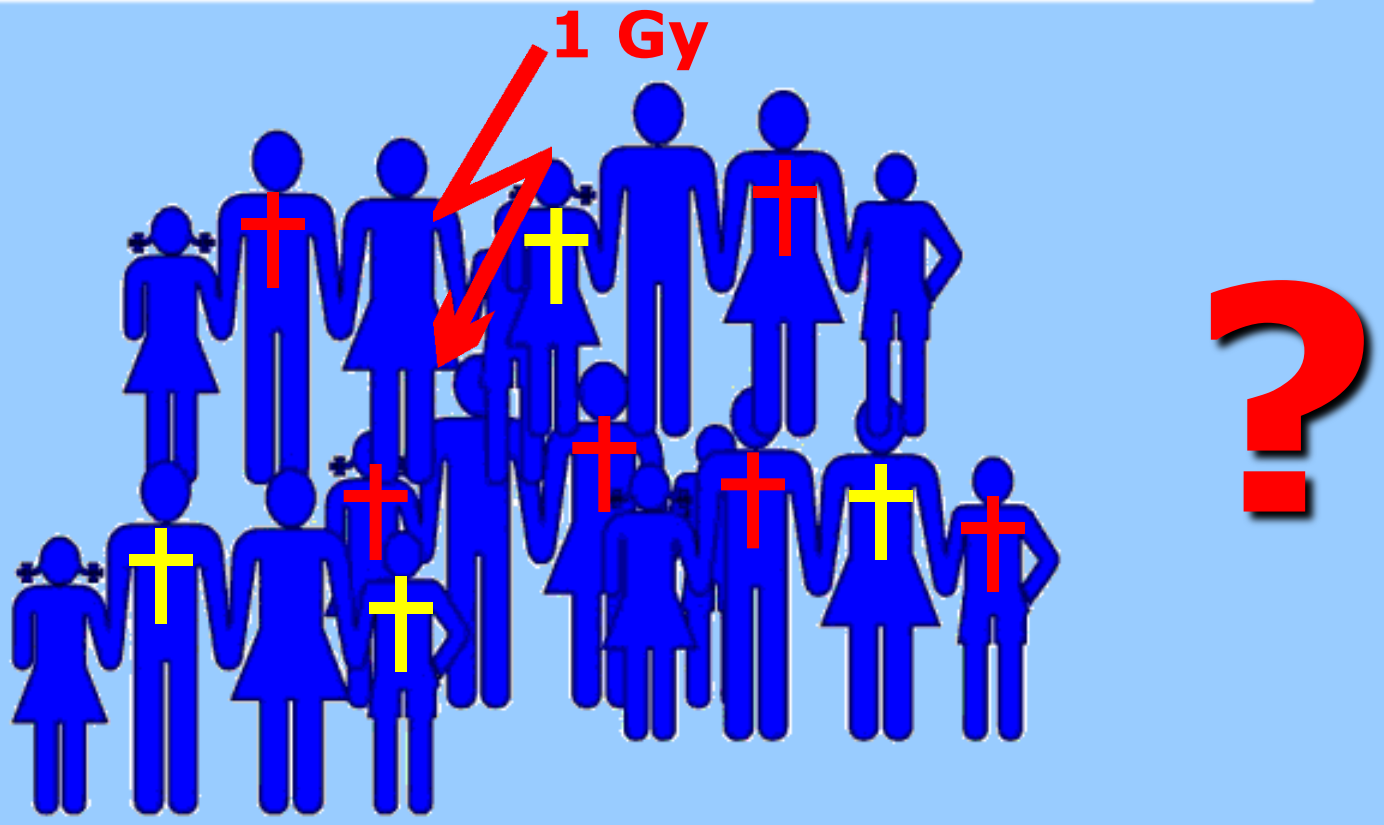


- The lesion appeared shortly after the intervention;
- the temporal sequence of the appearance of reddening, itching followed by skin breakdown within a few weeks and non-healing ulceration at about 6–12 months is characteristic of many radiation burns following high doses;
- the site of the lesion is consistent with a right anterior oblique projection that would be utilized for visualization of the left anterior descending coronary artery;
- a review of the actual images from the procedure showed an exact correlation with anatomical structures underlying this lesion;
- the size of the lesion was consistent with the diameter of the radiation beam used for this procedure.

Second, what about stochastic effects?



Problem: lack of a biomarker



20% spontaneous cancer deaths
10% additional cancer deaths due to 1 Gy

United Nations Scientific Committee on the Effects of Atomic Radiation

A problem in population studies: Dose

- A serious problem in population studies is to overcome the statistical fluctuations.
- With decreasing dose uncertainty increases (not linearly, but to the square!).
- Thus, it is not surprising that for adults a statistically significant increase in radiation-induced cancer deaths is seen only from about 100 mSv upwards.

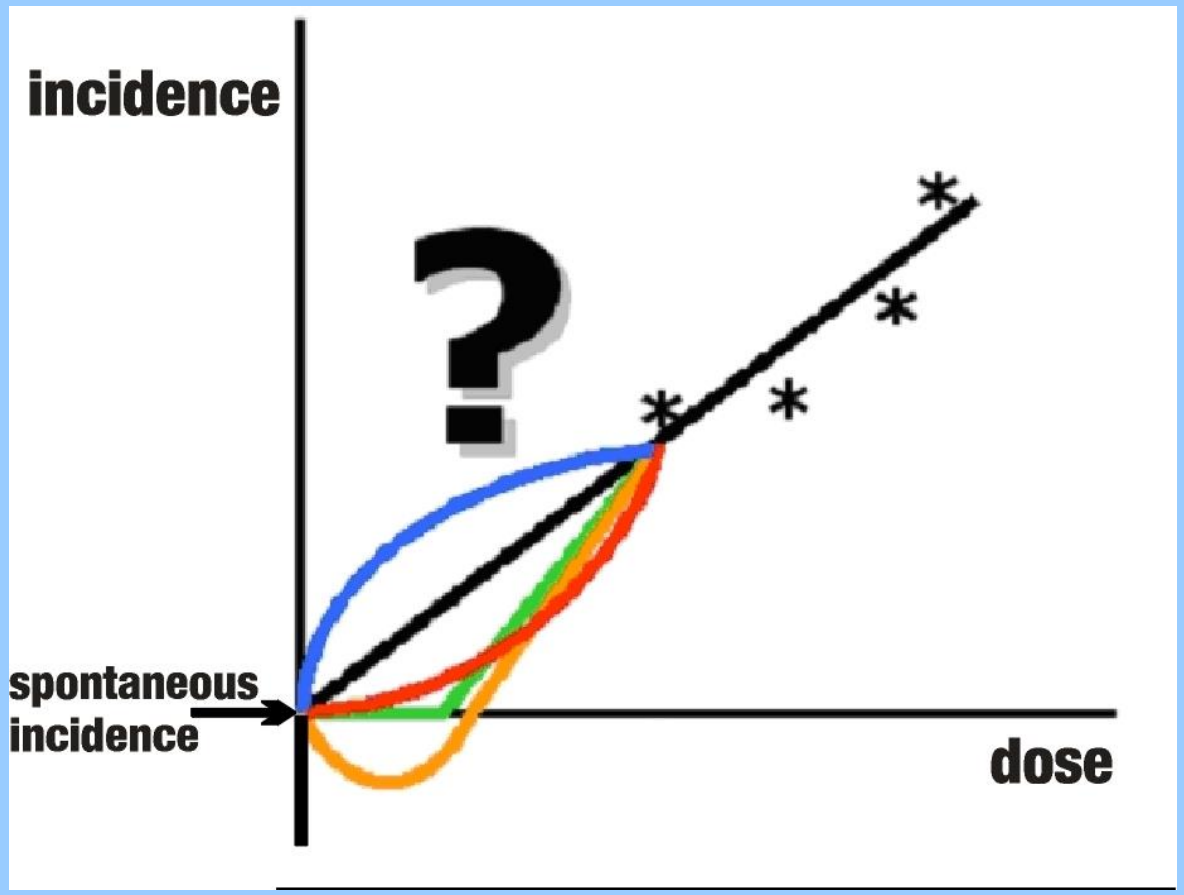
Definition of very low, low, moderate and high doses

Dose category	Range of absorbed dose (for low-LET radiation)
High dose	> 1 Gy
Moderate dose	100 mGy – 1 Gy
Low dose	10 mGy – 100 mGy
Very low dose	< 10 mGy

What can be done in the individual stochastic case?

- One can try to calculate probabilities.
- „Assigned share" (frequently called „Probabilty of causation") can be estimated based upon individual characteristics (type of cancer, gender, age at exposure, age at diagnosis, dose ...).
- Using this concept, you never can be sure that the specific individual cancer was indeed caused by radiation, meaning that you cannot attribute with certainty.
- This is particularly true in the low dose range (i.e. below about 100 mGy).

Various possibilities of extrapolation from the moderate into the low and very low dose range



United Nations Scientific Committee on the Effects of Atomic Radiation

Calculation of low dose risk for comparison reasons

- Scientific knowledge can be applied to compare the potential benefits and risks of various types of imaging procedures used in medicine.
- The specific task may be to estimate the potential future impact in terms of cancer risk from the population exposure due to CT scanning in a specific year in a particular country.
- The current use of CT scanning in the United States may result in a future increase of about 1.8% (95% CI: 0.9%, 2.7%) above the current cancer rate.
- This estimate can be used to compare it with the potential impact on health effects by alternative diagnostic procedures.
- It is, however, not clear that this increase will actually happen or could be observed.

Conclusions (1)

- An observed health effect in an individual could be unequivocally attributed to radiation exposure if the individual were to experience tissue reactions (often referred to as "deterministic" effects), and differential pathological diagnosis were achievable that eliminated possible alternative causes.
- Other health effects in an individual that are known to be associated with radiation exposure — such as radiation-inducible malignancies (so-called "stochastic" effects) — cannot be unequivocally attributed to radiation exposure, because
  - radiation exposure is not the only possible cause and
  - there are at present no generally available biomarkers that are specific to radiation exposure.

Conclusions (2)

- An increased incidence of stochastic effects in a population could be attributed to radiation exposure through epidemiological analysis — provided that, inter alia,
  - the increased incidence of cases of the stochastic effect were sufficient to overcome the inherent statistical uncertainties.
- Although demonstrated in animal studies, an increase in the incidence of hereditary effects in human populations can not presently be attributed to radiation exposure; one reason for this is the large fluctuation in the spontaneous incidence of these effects.

Conclusions (3)

- In general, increases in the incidence of health effects in populations cannot be attributed reliably to chronic exposure to radiation at levels that are typical of the global average background levels of radiation.
- The reasons are:
  - the uncertainties associated with the assessment of risks at low doses,
  - the current absence of radiation-specific biomarkers for health effects and
  - the insufficient statistical power of epidemiological studies.
- Therefore, the Scientific Committee does not recommend multiplying very low doses by large numbers of individuals to estimate numbers of radiation-induced health effects within a population exposed to incremental doses at levels equivalent to or lower than natural background levels.

Conclusions (4)

- The Scientific Committee notes that public health bodies need to allocate resources appropriately, and that this may involve making projections of numbers of health effects for comparative purposes.
- This method, though based upon reasonable but untestable assumptions, could be useful for such purposes provided that
  - it were applied consistently,
  - the uncertainties in the assessments were taken fully into account, and
  - it were not inferred that the projected health effects were other than notional.