AN ACCIDENTAL EXPOSURE TO IODINE 131

Maarit Muikku, Jussi Huikari, Helinä Korpela, Carita Lindholm, Wendla Paile, Teuvo Parviainen

STUK

On 28.2.2013, in a Finnish company manufacturing radiopharmaceuticals, a worker was heavily contaminated with I-131.

She was cleaning the device for producing capsules with I-131 for cancer therapy. The activity in one capsule is ~ 3.7 GBq.

She wore two pairs of protecting gloves, frequently changing the outer pair. The outer pair was of latex and the inner of nitrile.

When changing gloves she noticed a rupture in the right inner glove but not in the outer glove. She changed both pairs, but did not check for contamination.

3 – 4 h later, when she left the production area, routine monitoring revealed heavy contamination of the right hand, monitor reading 2400 cps, and also slightly contaminated left hand.

Decontamination was performed on site with 0,1 M KI and 70% etanol.

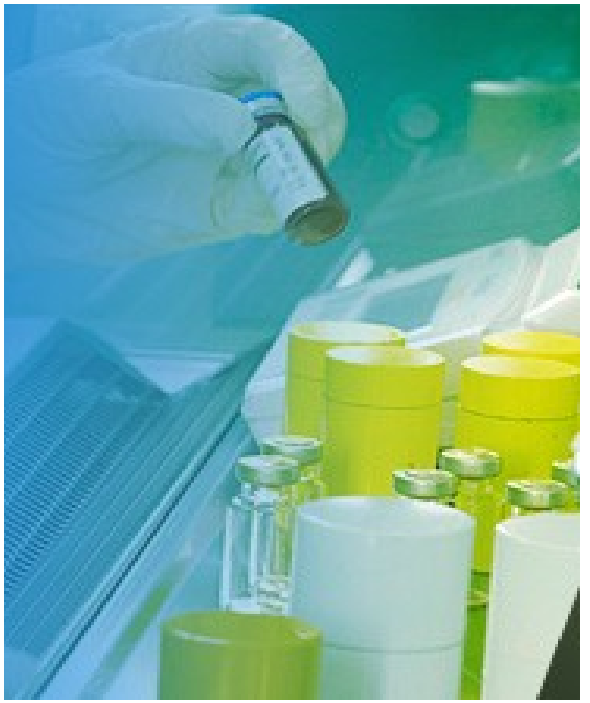
After decontamination the monitor reading was 1200 cps. Repeated washing had no further effect.

She was told to wear gloves at home to protect home surroundings, and to change gloves and wash hands frequently.

Stable iodine was not given.

Next morning after washing, the monitor reading was 500 cps. Now, activity was also noticed in the thyroid with a NaI-scintillationdetector.

STUK was alarmed and she arrived at STUK on Friday afternoon, 29.2.2013.



Iodine is absorbed through intact skin.

Of the iodine that enters the blood, 20-30% is rapidly uptaken by the thyroid gland.

The rest is excreted in the urine.

Physical half-life for I-131 is 8.02 days.

Biological half-life in blood is ~ 6 h

Biological half-life in the thyroid gland is ~ 80 days.

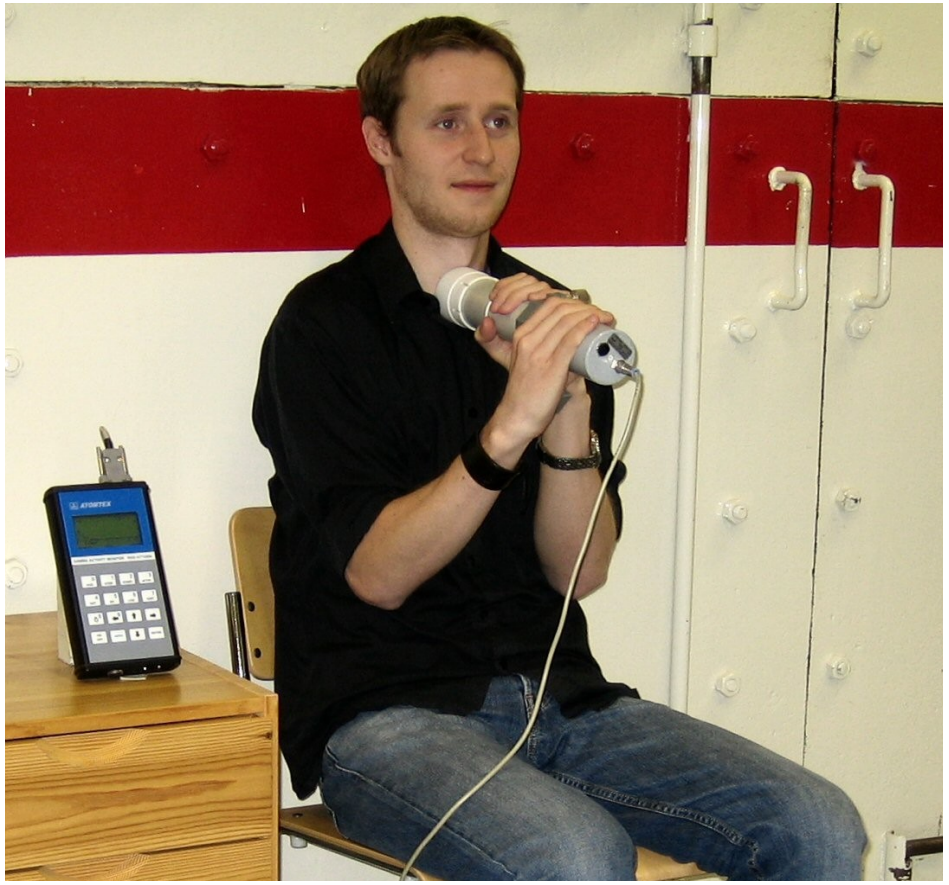
I-131 in the thyroid stays there until decay.

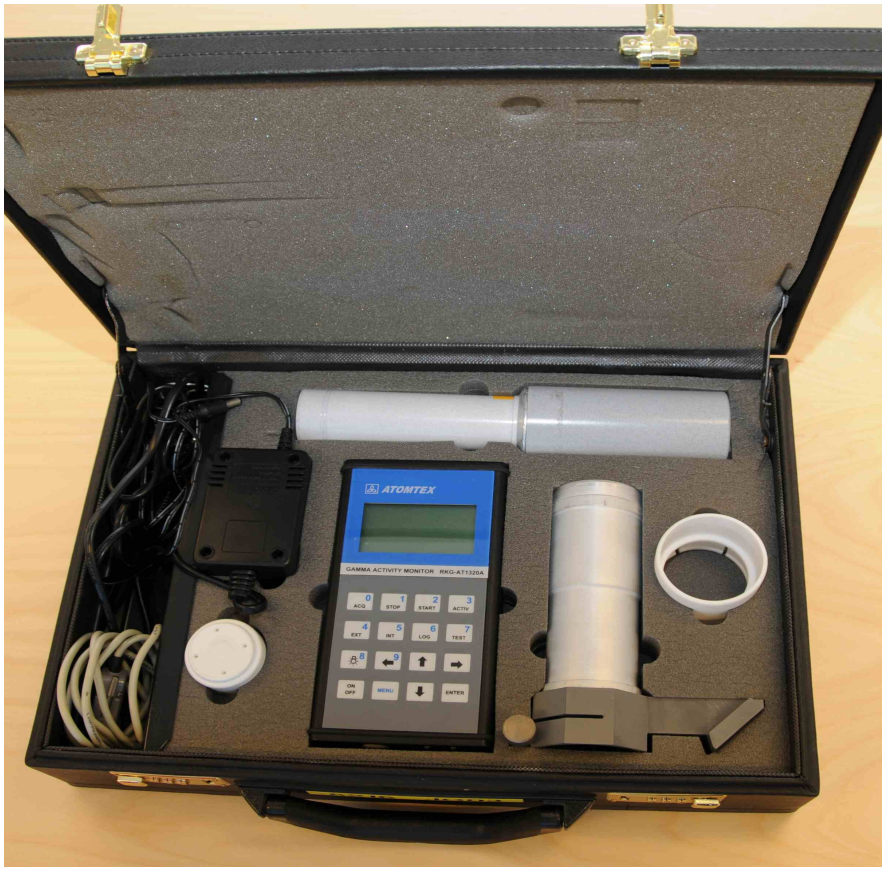
I-131 emits beta-particles with a maximum energy of 0.81 MeV.

Most of the energy is absorbed within 0,1 mm.

The basal cell layer of the skin is affected.

Negligible contribution of gamma rays to the skin dose.

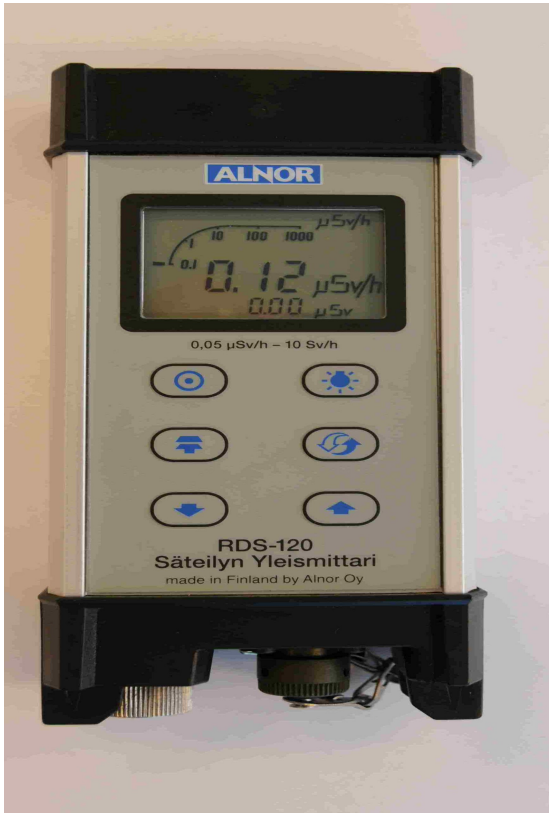




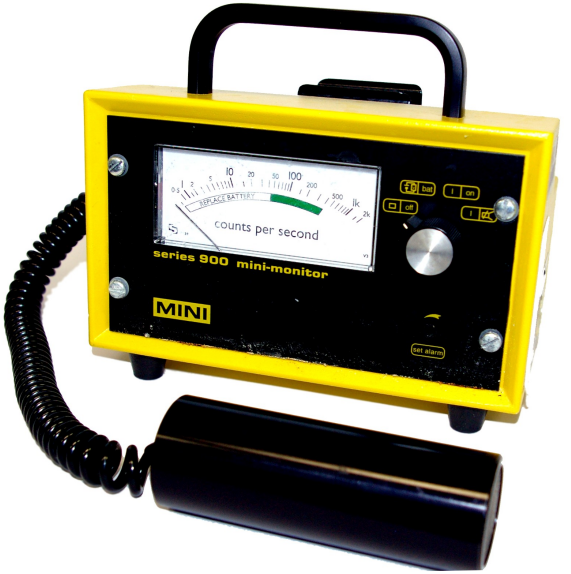
At STUK, a thyroid monitor Atomtex RGK AT 1320 (Minsk, Belarus) was used to monitor the hand (at 20 cm distance) and the thyroid (at 7 cm).

In 1991, STUK received 20 of these as a payoff of Soviet Union's trade depth to Finland. They have been placed in central hospitals around the country.

STUK's mobile whole body counter with HPGe-detector was used



Alnor dose rate-monitor



Mini-monitor 900 with NaI-probe (cps)

Measurement results, hand

Time	Atomex RGK AT1320	HPGe-detector	Alnor dose rate monitor, max.	Mini-monitor 900 with NaI-probe (cps)
29-30 h	2 MBq	1.7 MBq	36 µSv/h	10 (on 100 cm distance)
4 d	100 kBq	180 kBq	2.6 µSv/h	800-900 (2 cm distance)
11 d	< 2300 Bq		0.19 µSv/h	10
15 d	< 2100 Bq			4-5

An autoradiography of the right hand was made on day 4 by holding the dorsal side for 20 minutes against a Kodak PQ phosphor screen.

A lead weight was kept in the palm to ensure immobilization.

A rough estimate of the contaminated area:
10 cm2

Measurement results, thyroid

Time	Atomex RGK AT1320	HPGe-detector	Alnor dos rate monitor, max.
29-30 h	150 kBq	134 kBq	3.7 µSv/h
4 d	200 kBq	220 kBq	3.8 – 4.2 µSv/h
11 d	107 kBq	115 kBq	2 µSv/h
15 d		83 kBq	
3 mo		0.57 kBq	

Estimation of skin dose:

2 MBq at 30 h. Extrapolation backwards and comparison with early monitor readings (cps) → initial contamination **12 MBq.**

Dose rate at 0.07 mm: 1.62 mGy/h per kBq/cm2.

Contaminated area around 10 cm2 → initial dose rate ~ 2 Gy/h for 4 h = 8 Gy.

After decontamination → half of the stuff left.

5 – 30 h: mean activity 3.8 MBq → 16 Gy.

31 to 96 h: mean activity 0.7 Mbq → 8 Gy.

Total superficial skin dose → **33 Gy absorbed dose**

Radiation damage to the skin?

Slight reddening of the right hand, but also some of the left hand. Vigorous, repeated washing? Irritation from gloves and sweat?

On day 11, slight dryness and desquamation of the right hand. On day 15, intact skin and no desquamation left.

After 3 months: no sign of damage.

Superficial skin dose 33 Gy. A threshold dose of 35 Gy has been assessed for serious skin damage (moist desquamation) for Tm-170, a slightly more energetic beta emitter. For late atrophy, the threshold is lower.

(For deep dose the threshold is much lower! 15 Gy → blisters)

Possibly the skin on the back of the hand may later become somewhat thin and sensitive.

Our dose assessment may be somewhat conservative.

Estimate of the thyroid dose:

Monitoring results, IMBA software.

Scenario: 4 acute intakes on consecutive days.

Result:

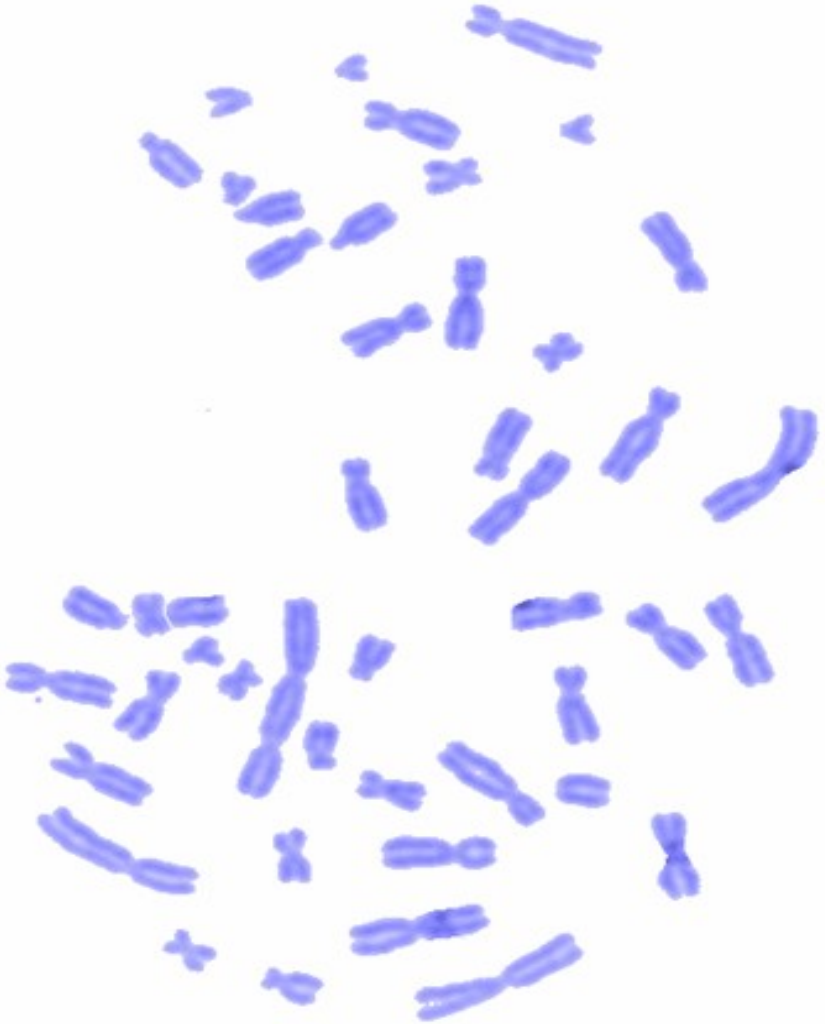
430 mGy absorbed thyroid dose

Threshold for hypothyreosis ~ 5 Gy.

Effective dose 17 mSv.

(Contribution from skin dose is negligible)

Further radiation work in 2013 was prohibited on the basis of the high local skin dose.



Chromosome analysis:
4 dicentric chromosomes in 2000 cells – a little more than normal background (1/1000) but not significantly so.
However, 2 of the 4 dicentrics were in one cell.
Non-Poisson distribution indicates non-homogeneous exposure.
11 acentric fragments – clearly over normal level.

Points to a small, partial exposure – in line with the incident.

Conclusions and lessons

Heavy skin contamination with I-131 can cause significant exposure of the skin and the thyroid, particularly if it goes unnoticed for hours and decontamination is delayed.

In this case, half of the stuff was removed by the first decontamination procedure.

After one day, 17% was left in the skin, and after four days, 1%.

However, the content in the thyroid was highest after 4 days.

Assuming that 30% of the iodine that entered the circulation was taken up by the thyroid, 9 % of the initial contamination found its way to the blood.

More lessons:

Latex gloves do not protect adequately. Iodine penetrates through latex! When there was a rupture in the inner, nitrile glove, I-131 penetrated to the skin

Monitoring when changing the ruptured glove would have revealed the contamination earlier.

Stable iodine would have reduced the thyroid dose even if given one day after the incident!

STUK made an inspection on site and gave instructions to evaluate risks, to use thicker gloves and to keep iodine tablets at hand.