RADON DYNAMICS IN UNDERWATER THERMAL RADON THERAPY

H. Lettner[1], W. Hofmann[1], R. Rolle[1,2], R. Winkler[1] and W. Foisner[3]

[1]*Institute of Physics and Biophysics, Unversity of Salzburg, Hellbrunnestrasse 34, A-5020 Salzburg*
[2]*Grimm Labortechnik GmbH & Co KG, Dorfstraße 9, D-83404 Ainring / Germany*
[3]*Thermalkurhaus, A-5630 Bad Hofgastein*

1. Methods

The experiments were conducted at the treatment facility in the Thermalkurhaus in Badhofgastein on two therapists (male: age 29 years, 191 cm, 100 kg; female: age 59 years, 163 cm, 63 kg; the data presented are from the therapist). The treatment applied in the experiment was the same as usually used for patients, i.e. bathing in the Rn-bath ("Best'sche Wanne", volume: 600 Liter at 37 -39 °C) for 20 minutes, followed by a resting period of at least 35 min. During the bath the water surface was covered with an aluminium foil with a hole for the head of the patient to keep it above the water surface. The aluminium foil prevented the Rn-gas from the water to emanate into the room atmosphere as it was intended to measure the Rn flow from the water into the body. The exhaled air of the test persons was sampled in 2-minute intervals in radon gas tight aluminium bags from the beginning of the bath to the end of the resting phase. During the resting phase the α-activity was measured on the skin for a period of 45 minutes.

For the determination of Rn in the exhaled air Lucas cells were used (Pylon AB-45 and Pylon lucas cells). For the detection of the α-activity on the skin a surface barrier detector (600 mm^2) protected with a grid, in order to establish a definite distance to the skin, was applied. The surface barrier detectors were mounted in a special housing and kept in close contact to the skin with self adjusting bands. The Rn concentration in the water samples collected in the bath tubes was determined with an ionisation chamber.

2. Results

Rn in the exhaled air

The Rn in the exhaled air is controlled by the cutano-pulmonary transfer, defined as the activity incorporated and exhaled by the patient (Grunewald & Grunewald, 1995) as the Rn activity concentration in the inhaled air is negligible. The Rn activity concentration in the exhaled air reaches its maximum a few minutes after entering the bath (Fig. 1) and remains constant during the rest of the time in the bath, followed by a fast decrease during the resting phase. The Rn transfer-rate can be described with a diffusion term, controlled by the concentration gradient, and a convective term which is controlled by the blood stream (Grunewald & Grunewald, 1995). Applying an average minute respiratory volume of 7 Liter/min at a ^{222}Rn activity concentration of 415 kBq/m^3 in the water, the overall Rn transfer was 380 Bq (Fig.2) of which 130 Bq were exhaled during the resting phase. The data are in good agreement with values reported in the literature where the Rn transfer was 1200 Bq with an activity concentration of 2000 Bq/L in water (Grunewald & Grunewald, 1995).

Rn decay products (Rnd) on the skin

It was not possible to distinguish between the different α-emitters deposited as the α-peaks were distorted by the absorption in the air layer between the detector and the skin and, presumably, by a thin water-layer on the skin and the surface roughness of the skin itself. For the calculation the gross alpha-counts were used to determine the initial values of the Rnd on the skin after leaving the bath. As no detailed information is available on the migration of the Rnd into the skin and its distribution, for a first calculation it was assumed that all radionuclides are deposited on the skin-surface and are not attenuated by the skin. This assumption clearly underestimates the total dose delivered to the skin. The

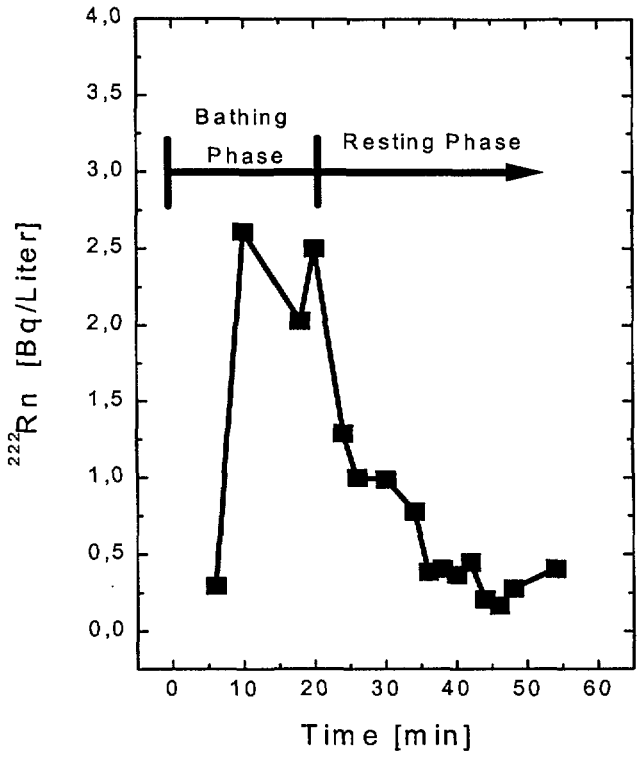

Fig.1. ^{222}Rn in the exhaled air of person treated in underwater thermal Rn bath (Best'sche Wanne)

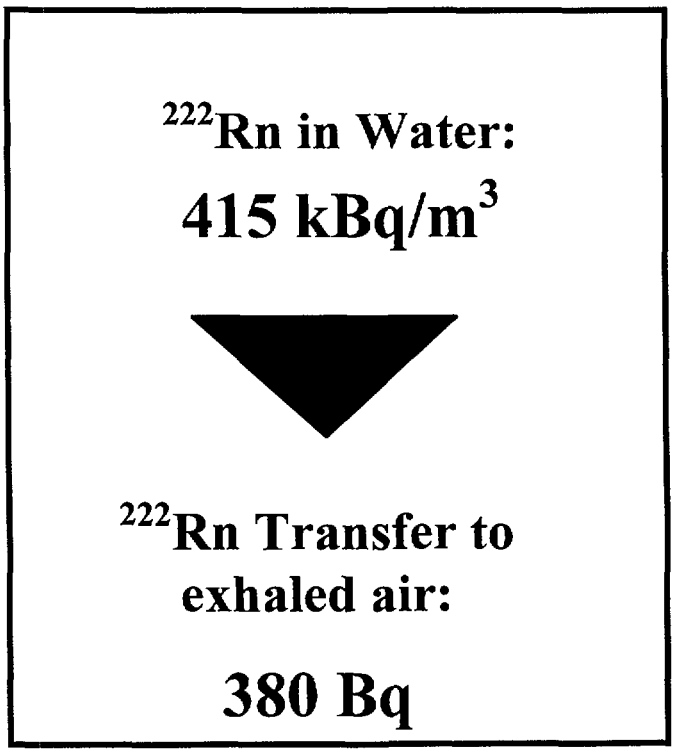

Fig.2. Total ^{222}Rn transfer after 20 min bathing phase and Rn activity concentration in the thermal water

following assumptions were made for the calculation of the Rnd on the skin: (1) saturation for ^{218}Po on the skin (20 min bathing phase, 3.05 min half-life), (2) constant attachment rates during the bathing phase, and (3) a constant activity concentration of ^{218}Po during the bathing phase. Based on these assumptions the attachment rate for ^{218}Po could be calculated. (4) The attachment rates for ^{214}Pb and ^{214}Bi were assumed to be of the same value and (5) no contribution of Rn decay in the skin to Rnd on the skin. Applying these assumptions the calculated Rnd activity concentrations on the skin were: ^{218}Po: 0.30 Bq/cm^2; ^{214}Pb: 0.33 Bq/cm^2, ^{214}Bi: 0.36 Bq/cm^2 with an attachment rate of 0.07 Bq/(cm^2 sec). For an exposed skin surface of the therapist of 20.000 cm^2 the initial activity concentration of the Rnd after the bath is 20.000 Bq/cm^2. For the calculation of the dose an average thickness of 10 μm for the cuticula of the skin and 100 μm thickness for the epidermis were assumed. Based on these simplifications the calculated value for the average dose to the epidermis is 50 μGy.

3. Discussion

For Rn therapy one of the major questions is, by which mechanism the dose is delivered to the patients. Rn is thought to represent more or less the main contribution in inhalation-therapy as well as in water-therapy, but some authors have argued that Rnd on the skin is of much more importance than it has been accepted (Andrejev, 1990). The preliminary results of this study also indicate that the dose to the skin by Rnd (50 μGy) is much larger than the dose originating from Rn, which was calculated to be appr. 0.3 μGy per Rn bath therapy (Hofmann, 1990). Rnd on the skin might even be much higher as calculated because the assumption that all Rnd are deposited at the surface of the skin may result in an underestimation of the activity. The shape of the spectra observed indicate the penetration of the Rnd, but at present it is not possible to perform an exact calculation of the activity concentration without any information on the migration of Rnd into the skin.

4. References

HOFMANN W. (1990): Gibt es "biopositive" Effekte bei der Radontherapie? Z.Phys. Med. Baln. Med. Klim. (Sonderheft 2) 19 (1990) 69-77.

ANDREJEV S.V. B.N. SEMJONOV, D. TAUCHERT (1990): Zum Wirkungsmechanismus von Radonbädern. Z.Phys.Med.Baln.Med.Klim. (Sonderheft 2) 19 (1990) 83-89.

GRUNEWALD M. & GRUNEWALD, W. A. (1995): Radon(Rn)-Transfer während der Balneotherapie in der Bestschen Wanne. Phys. Rehab. Kur. Med 5 (1995) 189-195.