Radiation Synovectomy With Dysprosium-165 ferric-hydroxide - Monitoring Of Biodistribution And Biokinetics With A Shadow Shield Whole-body Counter

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ABSTRACT

Radiation synovectomy is suggested to be an alternative to surgical treatment. The aim of this study was to evaluate the application of the whole-body counter in the General Hospital Vienna for the study of the biodistribution and biokinetics of 165-dysprosium-ferric-hydroxide (^{165}Dy-DFH).

During this study it was possible to measure 42 patients, who were treated with ^{165}Dy-DFH. The applied activity ranged from 520 MBq to 12955 MBq. The emission of gamma-radiation with an energy of 95 keV was used to monitor the kinetic distribution of ^{165}Dy by performing activity profiles with the whole-body counter 2, 4 and 6 hours after injection. The doses to non-target organs were calculated using the software MIRDOSE II.

In 32 patients no leakage could be monitored. In 3 patients a concentration of leakage was detected in the urinary bladder, in 2 patients a leakage was detected in the liver and in 6 patients a small leakage was detected in the inguinal lymphatic nodes of the treated legs. The doses to the bladder were 15 mGy, 64 mGy and 50 mGy respectively, those to the liver were 198 mGy and 68 mGy. The doses to the lymphatic nodes of four patients were 0.54 Gy, 0.89 Gy, 1.0 Gy and 2.41 Gy respectively. In one patient it was possible to detect a leakage in two lymphatic nodes with doses about 2.1 Gy and 1.4 Gy and in one patient a leakge in four lymphatic nodes was found with doses about 1.8 Gy, 1.4 Gy, 1.5 Gy and 1.1 Gy.

The measurments with the whole-body counter represent a reliable method for the lokalisation of ^{165}Dy-DFH in the course of some hours after application. By the aid of the activity profiles of the four detectors of the whole-body counter it is possible to localize an incorporated or injected radionuclide with an accuracy of $\pm$ 1 cm in the three coordinates.

This method guarantees a very detaild information about the activity distribution. The results of this study show, that the leakage of ^{165}Dy-DFH out of the treated joint is neglectable.

Using a whole-body counter activity leakage could be detected with much higher sensitivity than by using a gamma camera. Biodistribution of ^{165}Dy-DFH could be determined, leakage could be localised and related to organs. In consequence, identification of risk groups and appropriate counter-measurments could reduce any unnecessary radiation exposure.

INTRODUCTION

Treatment of chronic rheumatoid synovitis is directed to control the inflammatory process causing pain and disability. Radiation synovectomy is suggested to be an alternative to surgical treatment /1/,/2/. Safety is one of the most important aspects when this method is applied. The physical properties suggest minimal exposure to non- target organs by the reduction of leakage of the radionuclide Dy-165 /3/,/4/,/5/. The aim of this study was to evaluate the applikation of the whole-body counter in the General Hospital Vienna for the study of the biodistribution and biokinetics of ^{165}Dy-DFH /6/.

MATERIALS AND METHODS

During this study (1995-1998) it was possible to measure 42 patients, who were treated with ^{165}Dy-DFH. The use of Dy-165 has some considerable advantages: The half-life of Dy-165 (only 2.3 houres) is important to reduce the whole-body dose due to the relative high activity of approximately 11000 MBq (### 300 mCi) applied. The maximum soft tissue penetration of its ###-particles is 5.7 mm, which is the range necessary to penetrate the inflammed synovia. The emission of ###-radiation acounts to two thirds of the 6 % of the whole disintegration is with an energy of 95 keV. This radiation is used to monitor the kinetic distribution of ^{165}Dy-DFH after injection with the whole-body counter.

The clinical whole-body counter

The clinical whole-body counter is placed in a room of the Department of Nuclear Medicine, which is specially built for the use of this instrument. The walls to the adjacent rooms are shielded with 6 mm lead to reduce the environmental background radiation. All coulers, lacquers and floor coverings used have very low radioactive concentration to reduce the background in the room (Figure 1).The tunnel construction consists of the transport construction and the shielding. The transport construction carries the guide rails of the movable patient-bed, the shielding of the measurement area and the holding device of the detectors and collimators. The lead shielding is divided in a measurement tunnel with 10 cm lead shielding and a shadow shield with 5 cm lead shielding. The patient-bed is made of acrylglass which guarantees a negligible absorption of the gamma radiation in the bed. Two slit collimators of 10 cm thickness can be brought in front of the detectors. The slit width can be varied continuously from 0 mm to 300 mm with an accuracy of ### 0.3 mm.

The localisation of ^{165}Dy-DFH is measured with four NaI-detectors of 6" diameter and 4" thickness. The detectors are arranged in pairs above and below the bed. The scanning motion of the bed, the data acquisition separately for each detector, the storage of the data and the output of the results are controled by a computer.

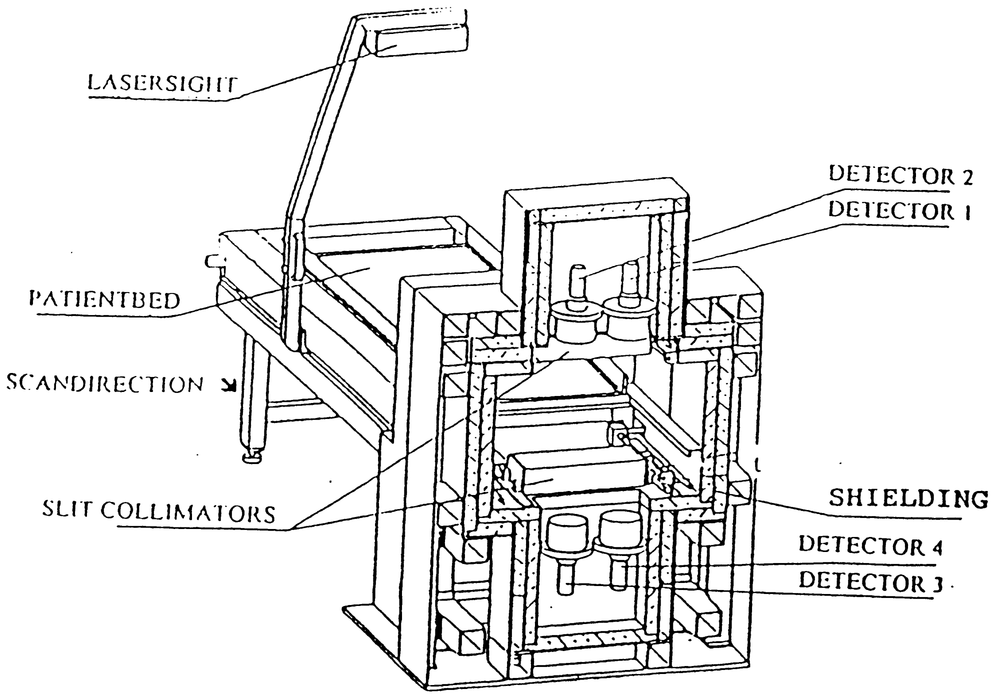

Figure 1.Inside arrangement of the whole-body counter

RESULTS

Measurements with the whole-body counter result in activity profiles displayed as a plot of counts (impulses/channel###1cm) against position along the scan-length (= longitudinal axis of the body), showing a peak as a activity deposit is traversed. Figures 2-6 show such activity profiles.

The results of the measurements of 42 patients can be summarized as followes:

With the aid of the whole-body counter it was possible to monitor the distribution of activity. The applied activity ranged from 520 MBq to 12955 MBq. The activity profiles of 27 patients showed a uniform distribution of the nuclide in the whole knee joint. The measurement of 1 patient showed a concentration in the area of the hollow of the knee and in the case of 4 patients with small or no effusion the ^{165}Dy-DFH became concentrated in the area under the knee-cap. The activity profiles of 40 patients showed a considerable increase of the counts on both sides of the peak, as can be seen in figures 3-6. This increase is not the result of a leakage of the injected activity outside the knee joint, but can be explained as an effect of scattered rays of the highly energetic peaks in the ###-energyspectrum of Dysprosium-165. This effect arised only at activities above 6000 MBq. In 32 patients no leakage could be monitored (i.e. Figures 2 and 3). In 10 patients it was possible to determine some leakage outside the knee joint. In 3 cases occured a concentration of this activity in the urinary bladder (i.e. Figures 4 and 5). Using the software MIRDOSE II (Oak Ridge Iac.) we determined the dose to the bladder, which amounted to about 15 mGy, 64 mGy and 50 mGy, respectively. A more detailed interpretation of the activity profiles of 4 patients revealed a small leakage of the injected activity out of the joint whereby a concentration was seen in the inguinal lymphatic nodes of the same leg (i.e. Figures 5 and 6). The doses calculated to the lymph nodes were 0.54 Gy, 0.89 Gy 1.0 Gy and 2.41 Gy, respectively. In one patient it was possible to detect a leakage in two lymphatic nodes with doses about 2.1 Gy and 1.4 Gy and in one patient a leakge in four lymphatic nodes was found with doses about 1.8 Gy, 1.4 Gy, 1.5 Gy and 1.1 Gy.

Monitoring of activity profiles of more complex anatomical or pathological structures was also possible using the clinical whole-body counter. One patient suffered for an approximately 12 cm long effusion in the recessus suprapatellaris. The ^{165}Dy-DFH was homogenously distributed into both the joint and the recessus. The analyses of the activity profiles clearly showed an increase in the counts in the direction of the thigh, corresponding with the fact that ^{165}Dy-DFH was distributed in the joint **and** in the recessus.

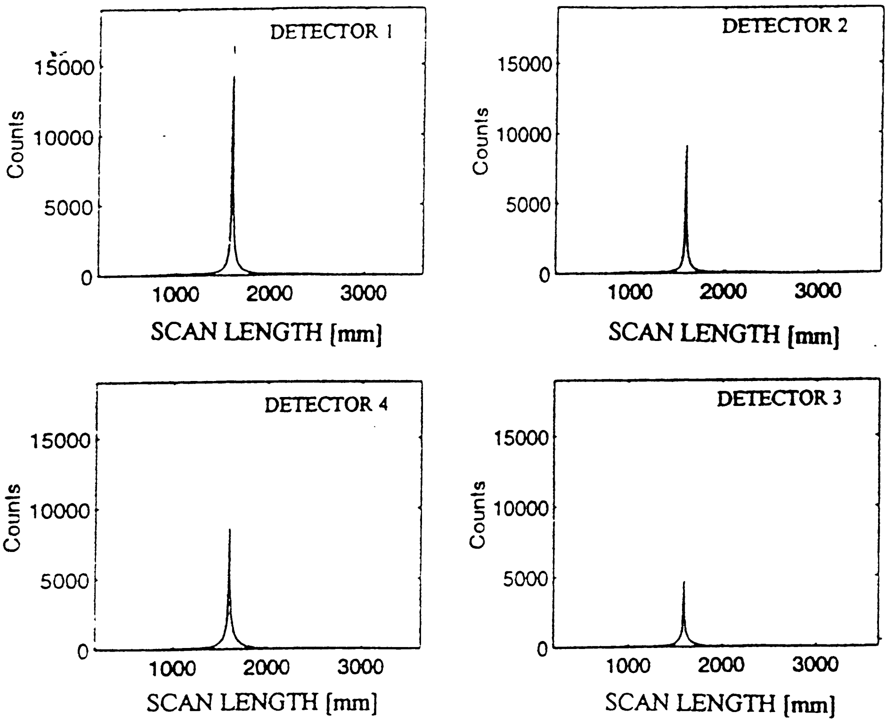

Figure 2: Profiles of a patient where no leakage is detectable (applied activity 3352 MBq)

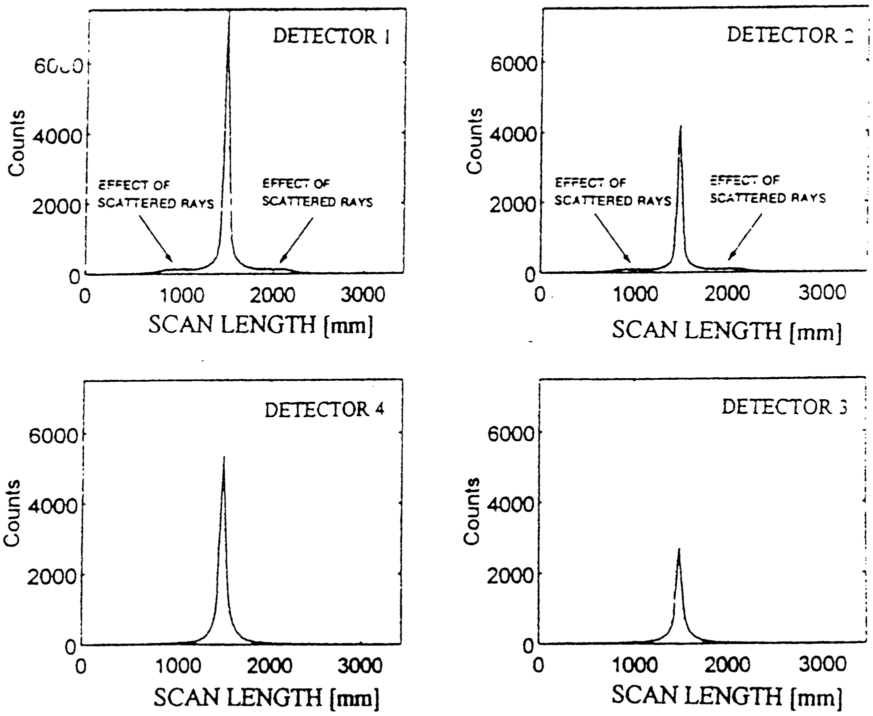

Figure 3: Profiles of a patient where no leakage is detectable, but due to the high activity applied (8932 MBq) the effect of scattered rays can be seen.

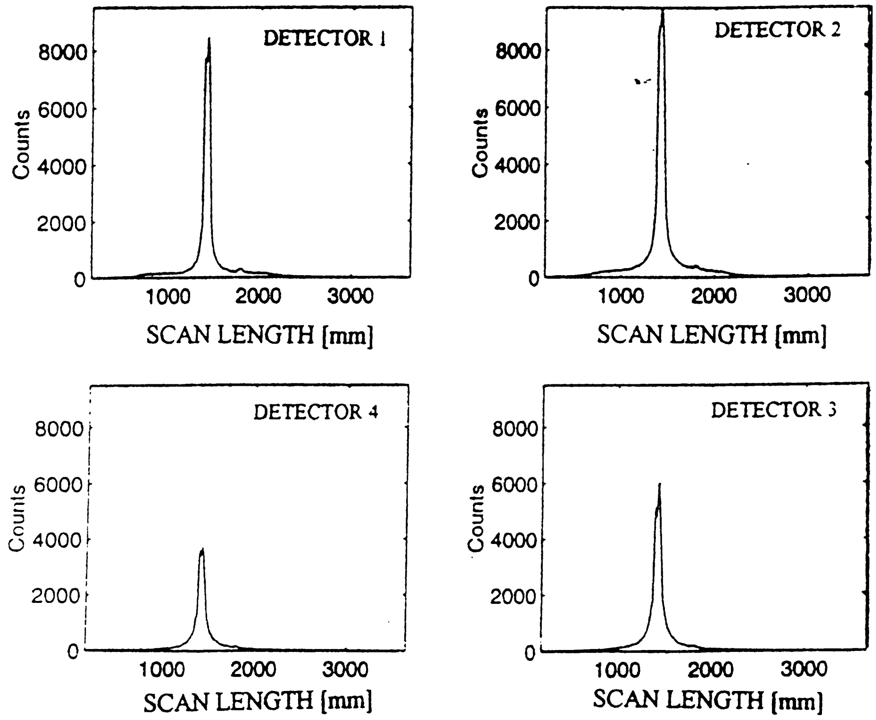

Figure 4: Profiles of a patient where it is possible to determine a leakage in the **urinary bladder** <u>and</u> the effect of the scattered rays of the highly energetic peaks in the γ-energyspectrum of Dysprosium-165, which results in an increase of the counts on both sides of the main peaks.

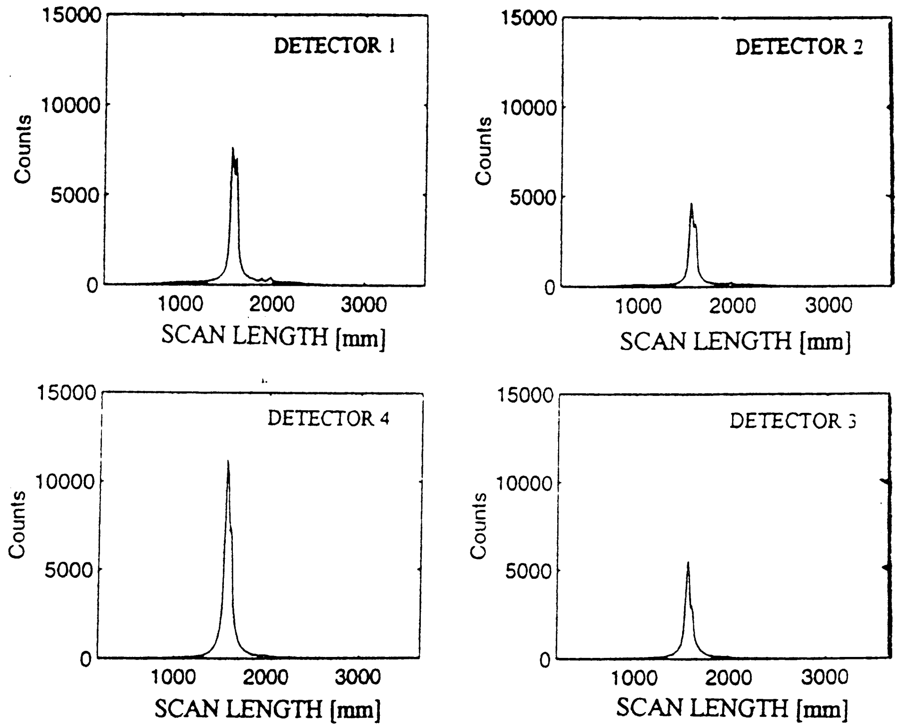

Figure 5: Profiles of a patient where it is possible to determine a leakage in the **urinary bladder** <u>and</u> in the **inguinal lymphatic nodes** of the treated leg (patient 2; left knee). The effect of scattered rays can also be seen.

DISCUSSION

The measurements with the whole-body counter represent a reliable method for the lokalisation of ^{165}Dy-DFH in the course of some hours after application. By the aid of the activity profiles of the four detectors it is possible to localize an incorporated or injected radionuclide with an accuracy of ### 1 cm in the three coordinates. The main peak marks the position of the knee joint, the small peak on its right side (Figures 4, 5 and 6) represents the position where a small amount of activity had escaped. The count-rates of the four detectors make it possible to determine the position of this small peak and relate the peak to an anatomical structure. The rather high background activity results from scattered rays (Figures 3-6). With data received from phantom-measurements it was possible to determine the amount of activity applied and the exposure to non-target organs i.e. the urinary bladder and the lymphatic nodes. Using the MIRDOSE II software we determined the energy dose in these organs. The radiation exposure of the patient in the case of a concentration of escaped activity in the urinary bladder can be reduced by advising the patient to use the toilet immediately after detection of the leakage.This method guarantees a very detailed information about the activity distribution. Our results show, that the leakage of ^{165}Dy-DFH out of the joint is neglectable. The radiation exposure due to this treatment is relative low.

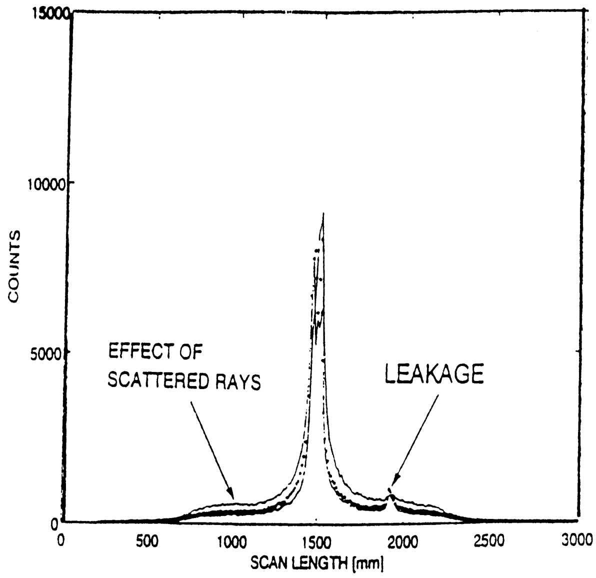

Figure 6: Three measurements 2, 4 and 6 hours after application of Dy-165. The effect of scattered rays can be seen. Further it is possible to determine a leakage in the **inguinal lymphatic nodes** of the treated leg. It can be seen, that the peak of the leakage maintains its level in the course of some hours after application so there must be a "delivery" of Dy-165.

Using the whole-body counter of the Department of Nuclear Medicine in the General Hospital Vienna activity leakage could be detected with much higher sensitivity than by using a gamma camera. Biodistribution of ^{165}Dy-DFH could be determined, leakage could be localised and related to organs.

REFERENCES

/1/ C. L. Barnes, S. Shortkroff, M. Wilson, C. B. Sledge: *Foot & Ankle International*, **15**(6), 306-310, (1994).

/2/ C.B. Sledge, R.W. Atcher, S. Shortkroff, et al: *Clinical Orthopaedics and Related Research*, Jan.Feb. **182**, 37-40, (1984).

/3/ L. S. Johnson, J. C. Yanch: *Arthritis and Rheumatism*, 34(12), 1521-1530, (1991).

/4/ Ch. Pirich, et al.: *Acta Medica Austriaca*,**1/2**, 49-53, (1993).

/5/ J.D. Zuckerman, C.B. Sledge, S. Shortkroff, P. Venkatesan: *Int. J. Radiat. Appl. Instrum. Part B*, **14**(3), 211-218, (1987).

/6/ Ch. Pirich, U. Prüfert, E. Havlik, E. Schwammeis, J. Flores, H. Kvaternik, P.Angelberger, H. Aiginger, A. Wanivenhaus, H. Sinzinger: *European Journal of Nuclear Medicine*, **24**, 398-402, 1997