TWO PROCEDURES IN PROTECTION RADIOLOGY FOR BRACHITHERAPY.
Huerga C., Corredoira E., Serrada A., Santa Olaya I., Vidal J., Tellez de Cepeda M.
Radiophysics-Radioprotection. University Hospital “La Paz”. Madrid. Spain

Abstract. Brachytherapy has aspects of Radiation Protection of special interest that are not given in the external radiotherapy. This is the case for the permanent implants with seeds of I-125 and for treatments with ophthalmic plates of Ru/Rh-106. The aim of this work is to show the performances fulfilled from Radioprotección Service of our hospital, establishing the similarities and the differences found in the application of every technology. Material and Methods: Seeds of I-125 Rapid Strand type 6711 given by Amershand Health. Ru-106 eyes Ophthalmic plates supported by Bebig. Dosimetric measurements were performed using TLDs, and chambers of several sizes. Results: Dosimetric measurements reflect that in the seeds load processes the dose in finger is far below of the legal limits applied to the public. In both cases, the sources implantation process does not suppose radiological risk, taking into account that the doses are below the limits applied to the public. The area dosimetry verifies that the remaining personnel (nurses, anaesthetists) can be treated as members of the public. Different recommendations are established in every case.

1. Introduction

The braquitherapy has aspects of Radiation Protection that are not given in the external radiotherapy. From the point of view of the personnel: a) the preparation of the sources, b) the design of circuits adapted for the movement of them inside the hospital, c) is also necessary the agreement of multidisciplinary personnel, which in many cases lacks specific formation in Radiation Protection. From the point of view of the patient, in many of these technologies it is necessary to give Radiation Protection information for the public in general. This is the case of I-125 permanent seed implants and Ru/Rh-106 ophthalmic plates [1].

I-125 is utilized for certain prostate tumors treatment by means of "afterload" and manual permanent implant guided by needles using interstitial braquitherapy techniques. The prescribed dose is 145 Gy maintaining rectum dose below 100 Gy and the dose in the uretra is below 125 %[2]. Approximately 50-100 seeds are used following our model.

The ophthalmic plates of Ru-106 are utilized for retinoblastomas treatment. The implant of the radioactive plate is positioned on the tumour bed by means of ophthalmologic surgical techniques. The prescribed dose is 40Gy in the tumour apex (3-6 mm tall) the sclera is the organ at risk where the plate is fixed, which must not exceed 500Gy[3][4].

In the present work, instructions given by the Radiation Protection Service describing similarities and differences for each technology are established.

2. Material and methods

Characteristic sources
The I-125 decay by means of electronic capture emitting photons of energies 27.4, 31.4 and 35.5 keV. The half-life is 59.4 days. Model 6711 I-125 Rapid Strand seeds are used in our hospital supported by Amersham Health. The I-125 is deposited on a silver rod and encapsulated in a cap of 0.05 mm of titanium. The size of every seed is 4.5 mm of length and 0.8 mm of diameter. Due to the photoelectric interaction with the silver X-ray beams of energies 22.1 and 25.5 keV are emitted. The average energy of all the emissions is of the order of 27.4 keV with an auto-absorption of the source of 37.5 %. The half-value thickness is 0.025 mm of lead. In our hospital the seeds are manually loaded in guiding needles that allow their transference to the PTV in the operating room.

The Ru-106 decay product is Rh-106 with a T_{1/2} = 373d. Particles of clinical interest come from stable species of Pa-106 following Rh-106 decay (beta radiation energies of: 3.54 MeV (79 %), 3.0 MeV (8 %), 2.4 MeV (11 %) and 2.0 MeV (2 %)). The plate’s activity changes between 9 and 26 MBq (0.24 and 0.70 mCi) depending on the model and geometry. We utilized plates supported by BEBIG in
which a thin layer of Ru-106 is encapsulated inside a cover of silver of high purity (99.99%), with a total thickness of 1 mm. The plates are hemispherical with radios between 12-15 mm.

Completely sterilized radioactive sources must be submitted in the operating room for patient implantation. The I-125 seeds should be completely sterile. Ru-106 plates are sterilized in the Hospital according to the procedure recommended by the manufacturer.

**Dosimetry**

We performed finger dosimetric measurements during loading seed procedures. Also, we measured operating room radiation and simulated the experiment in our laboratory by means of a head and full body anthropomorphic phantom. Our measurements were performed by using TLDs and ionization chambers of several sizes.

In I-125 permanent implants case we measured radiation which escaped from the patient during several months following patient treatment.

For Ru/Rh-106 case, in which maximum energy of 3.54 MeV comes from beta decay, the principal source of radiation out of the patient eye is due to Bremmstrahlung's phenomena. The energy of these photons was evaluated by means of half-value layer and homogeneity coefficient measurements. The activity magnitude used was the Air Kerma Strength in $\mu$Gym$^2$/h = 1U.

TLDs and several ionization chambers have been used. LiF-TLDs were calibrated with a Co-60 gamma ray source, so the I-125 energy response is overestimated in a factor 1.20-1.30 according to different authors [5][6][7][8]. Counts have not been modified in this regard.

### 3. Results

The required time for every procedure phase was considered in order to elaborate the final results. Moreover, completely trained involved personnel was supposed in order to estimate different times in a conservative way.
### Table 1

The performances are reflected in every case and the involved personnel. Last column shows the rate dose estimated in every operation.

In case of I-125 sources a possible incident has been evaluated: the direct manipulation of the seeds with the hands, resulting in a 0.15 mSv/min·U value.

In order to evaluate the radiological risks in other persons we have performed radiation measurements that escape from patient, in every case:

### Ru-106

For Ru-106 plates we have calculated the Bremmstrahlung’s energy magnitude that escapes from the plate. By using HVL and homogeneity coefficient measurements, we have obtained:

#### Table 2

The area dosimetry was carried out by means of simulation in our laboratory by using an anthropomorphic phantom and direct measurement of area radiation rate in our operating room.
Fig. 4. Measurement of radiation in operating room once the plate has been implanted. Position of measurement points.

<table>
<thead>
<tr>
<th>Points</th>
<th>Position</th>
<th>Rate [μSv/h]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Over eye</td>
<td>64</td>
</tr>
<tr>
<td>2</td>
<td>Top skull</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>Ipsilateral</td>
<td>40</td>
</tr>
<tr>
<td>4</td>
<td>Oposite site</td>
<td>13</td>
</tr>
</tbody>
</table>

The measurements in the laboratory have been performed by introducing I-125 seeds in an anthropomorphic phantom by means of TLDs.

Table 3. Radiation that escapes from the patient measurements obtained from in middle-plane prostate simulation.

<table>
<thead>
<tr>
<th>Post.</th>
<th>Ant.</th>
<th>Right Lat.</th>
<th>Left Lat.</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.3 μGy/h·U</td>
<td>7.6 μGy/h·U</td>
<td>0.4 μGy/h·U</td>
<td>0.4 μGy/h·U</td>
</tr>
</tbody>
</table>

Maximum dose rates measured through different points in the operating room after the implant were as follows:

<table>
<thead>
<tr>
<th>Perineum</th>
<th>Testes</th>
<th>Abdomen</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.92 μSv/h·U</td>
<td>0.7 μSv/h·U</td>
<td>0.35 μSv/h·U</td>
</tr>
</tbody>
</table>

Table 4. Radiation that escapes from the patient measurements in the operating room.
Así, para un paciente con una carga de 100 semillas de valor $U=0.45$, se obtiene:

<table>
<thead>
<tr>
<th>Perineum</th>
<th>Testes</th>
<th>Abdomen</th>
</tr>
</thead>
<tbody>
<tr>
<td>86 $\mu$Sv/h</td>
<td>31 $\mu$Sv/h</td>
<td>16 $\mu$Sv/h</td>
</tr>
</tbody>
</table>

The dosimetric measurements reflect that during seed loading processes the dose in finger is far below of the legal limits applied to the public.

In both cases, the sources implantation process does not suppose radiological risk, assuming that the doses are below the limits applied to the public.

The area dosimetry verifies that the remaining personnel (nursing, anaesthetists) can be treated as members of the public.

4. Conclusions
In this work, methods that ensure workers who manage ionizing radiation sources to have minimal risks are provided through a Radiation Protection Service in the medical area. It is accomplished by means of the accomplishment of dosimetric measurements, that allow to establish the correct guidelines of functioning. Also, it is important the formation in Radiation Protection, sufficient to perceive the risk according to the actual situation. This aim is fulfilled by means of suitable programs of formation, informative sheets, and specifically, being accessible for both personnel and patients.

Bibliography: