OCCUPATIONAL EXPOSURE IN PROSTATE PERMANENT IMPLANTS WITH I-125 SEEDS

José Fdez. García[1], Victor Luna[1], Jose M.G. Sancho[1], Jaime Martínez[1], Pedro S. Galiano[1], Isabel Jiménez[2], Pedro Prada[2], German Juan[2], Javier Vivanco[1]

[1]Unidad de Radiofísica. Hospital Central de Asturias. Julian Clavería s/n. 33006 Oviedo. SPAIN. [2]Servicio de Oncología Radioterápica. Hospital Central de Asturias. Julian Clavería s/n. 33006 Oviedo. SPAIN.

1. INTRODUCTION:

Prostate brachytherapy is one of the techniques increasing faster in the environment of the radiotherapy and will probably go on increasing in the future. There are two forms in their use; by means of remote afterloading high dose rate (HDR) with Ir-192 radiactive sources or by means of permanent implant by manual/automatic afterloading of low dose rate (LDR) with seeds of I-125 or Pd-103.

Iodine-125 has a half life of 59.4 days and it decays by electron capture with emission of characteristic photons and electrons. The electrons are absorbed by the titanium wall of the I-125 seed. The principal photon emissions are 27.4 and 31.4 keV X-rays and a 35.5 keV gamma ray. Besides 22.1 and 25.2 keV fluorescent X-rays are also emitted resulting from interactions of the iodine-125 photons with the silver rod. The resulting average photon energy is approximately 27.4 keV

In our Department we use the OncoSeed I-125 RAPID (Rigid Absorbable Permanent Implant Device) Strand seed model 6711 of Nycomed Amersham, in form of welded titanium capsules containing a silver rod onto which I-125 has been absorbed (figure 1).

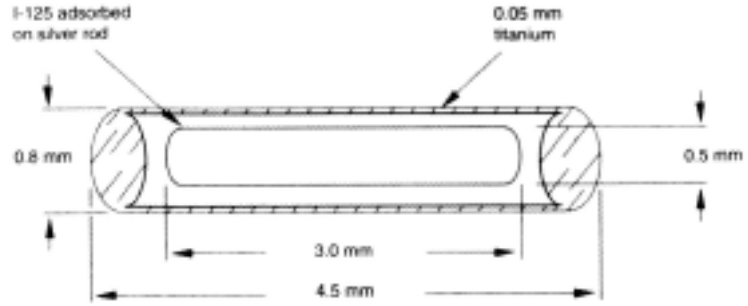

Figure 1. I-125 seed model 6711

The seeds of the same apparent activity are spaced at fixed distances of 1 cm centre to centre within a braided, polyglactin absorbable suture. The suture containing seeds is stiffened and then housed on a plastic spacing jig inside a stainless steel shielding tube (figure 2). This tube attenuates >99% of the I-125 photons.

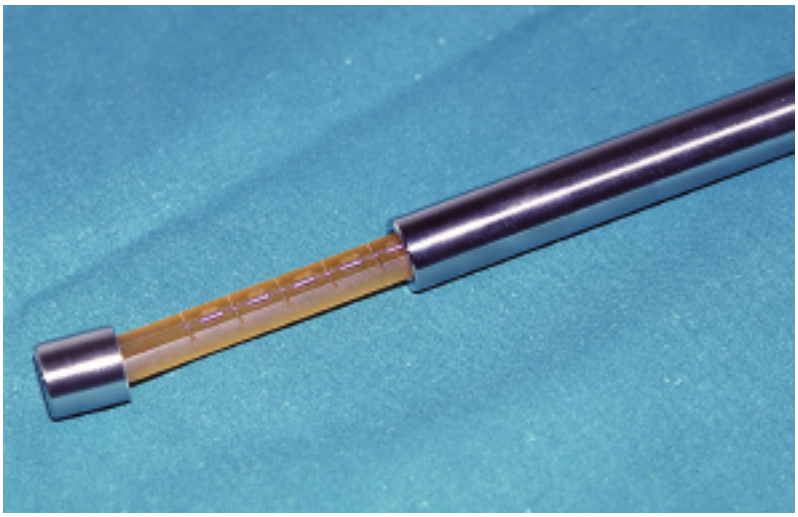

Figure 2.

Thus, the transport of the isotope inside the cylinder involves no problem as regards the protection of the staff. The assembly is sterile when shipped (figure 3).

Figure 3.

The seeds are available in a range of apparent activities between 0.191 to 0.729 mCi (0.243 to 0.926 μGym^2/h). However, with the technique of implantation we use the activity per seed was between 0.31-0.55 mCi.

To measure the levels of radiation we used a portable detector based on an ionizing chamber model 2100 Smart ION from Mini-Instruments Ltd., calibrated and in mode "Dose Rate". All the staff exposed to radiation had also TLD badge dosimeters read monthly and besides the nurse in charge of cutting the seeds has also a TLD wrist dosimeter.

In all the implants made, and in their previous calibrations, different dose levels were measured in order to quantify the exposure received by different staff.

2. MATERIAL:

In our Department the technique of permanent implants began to be used with seeds of I-125 in June 1999, having performed a total 149 applications up to September 2002.

The implant is performed under spinal anaesthesia in the brachytherapy room available in our Department. The average total duration of the surgery is about 3 hours. Once all the needles are placed by the radiotherapist with the help of the ultrasound scan, the seeds are cut and placed inside them with an average duration of 40 minutes (figure 4 and 5).

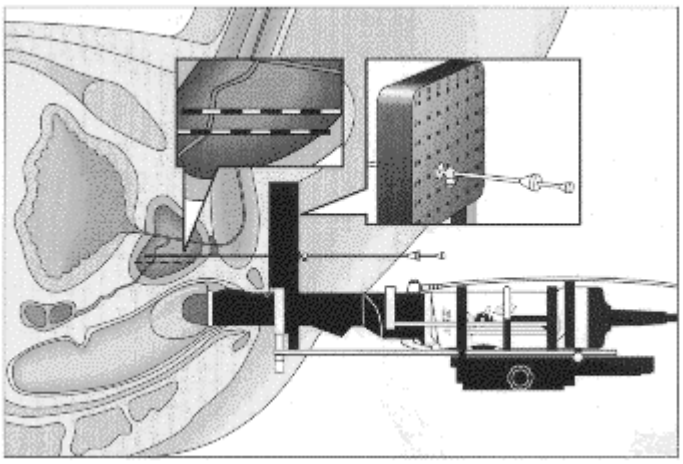

Figure 4. Implantation schematic diagram

Figure 5. Needles implantation with ultrasound scan help

Except unusual cases, during the last phase the anaesthetists as well as the assistants stay outside the brachytherapy room , checking the patient's vital signs by means of video cameras. Therefore the staff exposed to radiation are the physicist who tells how many seeds are needed, the nurse in charge of cutting the seeds and the radiotherapist who places the seeds inside the needles.

Regarding this subject three are the staff exposed at different distances and with a different duration. In the stage of cutting the seeds by the nurse an L-block lead shield with tilted lead-glass window is used and so the hands receive the greatest exposure to radiation (figure 6). During the placing of the seeds the radiotherapist as well as the nurse wear lead aprons to minimize the dose in their bodies.

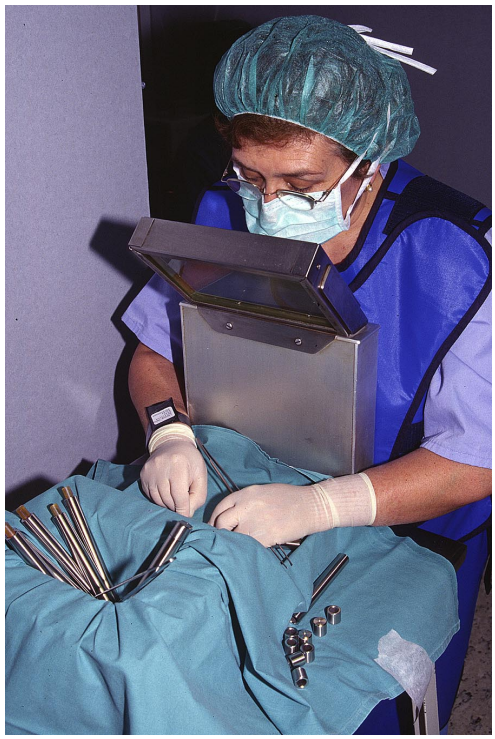

Figure 6. Seeds cutting phase

During the implant the dose rate levels are measured at different distances (skin surface, 0.5 m, 1 m, 2 m y 3 m) in order to estimate the dose that exposed staff and people in general can receive.

The skin surface dose rate is measured in the perineum area once the implant is finished as it is the part of the body subject to the greatest exposure and besides this part of the body is subject to cleaning and dressing by nurses or family members. Our measures gave a mean dose rate of 190.2 μSv/h, ranged between 12-527 μSv/h.

In table 1we can see the average dose rate levels per implant which best exemplify the received dose by different staff involved during the average forty-minute phase which lasts the insertion of the seeds in the prostate using this new technique.

μSv/h	**Distance (m)**			
Staff	**0.5**	**1**	**2**	**3**
Physicians	22.5	6.5	1.9	0.7
Physicist		6.5	1.9	
Nurses	22.5	6.5	1.9	0.7
Assistants				0.7

Table 1. Dose Rate in implantation phase

The highest dose rates of the physicians (0.5 y 1 m) are those of the radiotherapist who places the seeds and the lowest are the ones received by the anaesthetist when he has to go into the brachytherapy room during the placing of the iodine seeds.

During the implantation phase of the seeds a physicist is always present. He is the one responsible for telling the radiotherapist the number of the seeds which have to be used in the different needles. He also helps the radiotherapist with the software of the ultrasound scan machine and finally he is in charge of verifying by means of a portable detector that there are no seeds blocked in the disposable needles which are removed and in the surgical material used. In order to carry out these jobs he usually ranges from 1 to 2 m.

The nurse who gets the highest dose is the one in charge of cutting the seeds (0.5 and 1 m), and the nurse who gets the lowest dose is the one assisting the anaesthetist who rarely goes into the brachytherapy room and when he/she does, he/she is at a distance of above 2 meters

The average monthly reading of the wrist dosimeters from June 1999 until September 2002 is of 0.2 mSv/month. However, not all the dose are due to the use of the seeds, as in our Department iridium wires are also used for

the low dose rate brachytherapy in different parts of the body. Nevertheless, as the use of the HDR and PDR machines is increasing, the number of applications where Iridium was used is much lower than the Iodine seeds.

During the introduction of the seeds the assistants are rarely inside the brachytherapy room, and when they are, it is in order to supply materials at the entrance for the nurse to collect and so the distance of 3 m is rather conservative.

Bearing in mind these conditions, we can see in table 2 the average dose per application (left value) and an annual estimation (right value) with a total of 80 applications. For the staff who are not present all the time of the implantation of the seeds we have assumed a five-minute stay which represents a very conservative superior limit.

μSv (application/annual)	**Distance (m)**			
Staff	**0.5**	**1**	**2**	**3**
Physicians	15/1200	4.3/347	0.2/13	0.06/4.8
Physicist		4.3/347	1.3/104	
Nurses	15/1200	4.3/347	0.2/14	0.06/4.8
Assistants				0.06/4.8

Table 2. Estimation mean dose per application and annually

In every delivery of seeds the activity/kerma nominal given by the manufacturer is checked by means of a well chamber Standard Imaging model HDR 1000 Plus (Figure 6). This process is usually done by a physicist and occasionally by a technician. Ten seeds are used in the jig for the process introducing it in a device in order that only 5 seeds contribute to the reading of the electrometer. Then the plastic jig is turned to measure the other five seeds and get the mean.

While the seeds are inside the well chamber the dose rate in the external walls is the same as the background, so the exposure only takes place during the introduction of the plastic jig in the chamber which normally takes a few seconds and with the help of forceps to minimize the dose.

Figure 6. Seeds calibration with well chamber

In table 3 we can see the dose rates at different distances per application and in table 4 an estimation of the dose received annually.

μSv/h	Distance (m)	
Staff	**0.5**	**1**
Physicist Technician	25	6.1

Table 3. Dose rate with plastic jig in calibration phase

μSv	Distance (m)	
Staff	**0.5**	**1**
Physicist Technician	8	2

Table 4. Annually estimation dose with plastic jig in calibration phase

Sometimes, in order to verify the variation of activity between the seeds, ten seeds are measured one by one to estimate the interval of variation. When we want to do this, the 10 seeds must be cut from the plastic jig and they must be measured individually so that the physicist/technician is exposed to radiation about one minute per seed. In table 5 we can see the dose rates per seed achieved in this case.

μSv/h	Distance (m)	
Staff	**0.5**	**1**
Physicist Technician	3.6	0.6

Table 5. Dose rate with individually seeds in calibration phase

3. CONCLUSIONS:

In view of the measures achieved, we come to the conclusion that prostate brachytherapy with seeds of I-125 is a technique where the levels of radiation received are very low bearing in mind the low activity used per seed and the low energy emitted by the isotope.

In our Department the reading of the TLD badge dosimeters are not significantly higher to the rest of the staff who don't work in the prostate brachytherapy field.

4. BIBLIOGRAHPY:

1. Bret Heintz, Robert Wallace and James Hevezi. Comparison of I-125 sources used for permanent intersticial implants. Medd. Phys. 28 (4), April 2001.
2. Yan Yu, Lowell Anderson, Zuofeng Li, David Mellenberg, Ravinder Nath, MC Schell, Frank Waterman, Andrew Wu and John Blasko. Permanent prostate seed implant brachytherapy: Report of the American Association of Physics in Medicine Task Group No.64. Med. Phys. 26 (10), October 1999.
3. C.A.F.Joslin, A.Flynn and E.J.Hall. Principles and Practice of Brachytherapy. Arnold, London 2001.
4. Stock RG, Stone NN, Lo TC. Intraoperative dosimetric representation of real-time ultrasound-guided prostate implant. Tech in Urol 2000;6:95:98.