

PREFACE

Over the years, the International Commission on Radiological Protection (ICRP), referred to below as ‘the Commission’, has issued many reports providing advice on radiological protection and safety in medicine. Its *Publication 73* is a general overview of this area. These reports summarise the general principles of radiation protection and provide advice on the application of those principles to the various uses of ionising radiation in medicine and biomedical research.

Most of these reports are of a general nature, and the Commission wishes to address some specific situations where difficulties have been observed. It is desirable that reports on such problem areas should be written in a style that is accessible to those who may be directly concerned in their daily work, and that every effort is taken to ensure wide circulation of such reports.

A series of such reports was initiated at the Commission’s meeting in Oxford, UK in September 1997. On the recommendation of Committee 3, the Commission has established a number of Task Groups to produce reports on topical issues in medical radiation protection.

Some such reports have already appeared in print as ICRP *Publications 84, 85, 86, 87, 93, and 94*. The present report continues this series of concise and focused documents, and several further advisory reports are being prepared.

The Task Group drafting this report was launched at the Commission’s meeting in Albuquerque, New Mexico, USA in October 2002. Its initial terms of reference were to: (1) provide recommendations as necessary for keeping doses to family and caretakers below applicable levels; (2) provide recommendations on the management of expelled seeds; (3) provide recommendations for subsequent pelvi-abdominal surgery; and (4) provide recommendations as necessary concerning cremation and burial. At the Commission’s meeting in Buenos Aires, Argentina in November 2003, these terms of reference were amended to include a somewhat more general discussion of radiation safety issues in connection with the treatments concerned (primarily prostate cancer treatment).

The membership of the Task Group was as follows:

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The membership of Committee 3 during the period of preparation of this report was:

F.A.Mettler, Jr. (Chairman)	J.-M. Cosset	C. Cousins
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This report aims to serve the purposes described above. In order to be as useful as possible for those purposes, its style differs in a few respects from the usual style of the Commission's publications in the *Annals of the ICRP*.

The report was approved for publication by the Commission in October 2004.

MAIN POINTS

- The use of permanent radioactive implants to treat selected localised prostate cancers is increasing rapidly all over the world.
- No adverse effects to medical staff and/or the patient's family have been reported to date.
- The annual dose from patients to family or household members remains well below 1 mSv in almost all cases.
- Expulsion of sources through urine, semen, or the gastro-intestinal tract is a rare event. Simple recommendations should allow the patient to minimise all radiation risks in case of such an expulsion.
- Cremation can be allowed if 12 months have elapsed since the implantation. If cremation is to be considered before that time, specific measures must be undertaken.
- The patient must be provided with specific recommendations concerning the previous points, subsequent pelvic or abdominal surgery, fathering of children, and possible triggering of some security monitors.

EXECUTIVE SUMMARY

(a) The use of permanent radioactive implants to treat selected localised prostate cancers is increasing rapidly all over the world. In the USA, where 180,000 new cases of prostate cancer are diagnosed each year, between 30,000 and 40,000 implantations for localised prostate neoplasms are performed annually, and the number of such permanent implants is anticipated to soon exceed the number of radical prostatectomies (Michalski et al., 2003; Smathers et al., 1999; Stone and Stock, 2002). In Europe, as in other countries, several thousand cases are already treated annually and this number is increasing rapidly. It seems reasonable to anticipate that these numbers will increase further in the coming years for two reasons, as follows.

- We enter an era when prostate-specific antigen, performed more and more frequently in younger patients, allows the detection of an increasing number of very small lesions, mainly in asymptomatic patients. These small lesions actually represent the best indication for permanent implantation techniques.

The results reported recently by several American groups, with more than 10 years of follow-up, are comparable with results obtained by radical surgery in terms of local control (cure) of prostatic tumours. Moreover, these same reports appear to demonstrate an advantage over radical prostatectomy in terms of urinary continence and potency (Buron et al., 2004; Kollmeier et al., 2003; Kupelian et al., 2004; Langley and Laing, 2004; Potters et al., 2004; Ragde et al., 2000; Stone and Stock, 2002; Sylvester et al., 2004a,b; Woolsey et al., 2003; Zelefsky and Whitmore, 1997; Zelefsky et al., 2000, 2003).

(b) No adverse effects to medical staff and/or the patient's family associated with permanent seed implantation have been reported to date. This shows that the technique, already applied to thousands of patients (see above), is extremely safe. However, it is necessary to address a number of issues raised by both the medical community and patients' families. The following issues have to be considered.

- Dose to people approaching the patient, in order to identify when specific radio-protection steps should be considered.
- Management of expelled sources (although this occurrence is rare).
- Potential problems linked to cremation of the patient's body (a major issue in some countries).
- Other complementary recommendations.

1. Dose to people approaching implanted patients

(c) The available data, derived from direct measurements or from calculations, indicate that the annual dose to the family or household members will remain well below the limit of 1 mSv in almost all cases, and will not even reach the level of 5 mSv set for comforters and carers of such patients by the IAEA (1996). Therefore, systematic dose measurement is not necessary. However, more for peace

of mind than for strict radiation protection reasons, it is recommended that children should not sit in the lap of a patient for more than a few minutes or on multiple occasions, and the patient should avoid close contact with pregnant women for extended periods of time within the first two months of the implant when using ^{125}I (less for ^{103}Pd). This should be explained in the written information given to the patients and their caregivers (Appendix C).

2. Expelled sources

2.1. Loose (or free) seed technique

(d) Due to the (rare) expulsion of seeds, a reasonable precaution is to recommend sieving the urine for 3 days. The very few seeds migrating later on will be flushed away in the toilet, with the water and sewage pipes offering sufficient protection at this photon energy level. Use of a condom is often recommended for sexual intercourse for 2–3 weeks after the implantation, but it seems more appropriate to advise wearing a condom for the first five ejaculates, whatever the delay after the implantation. Early sexual intercourse, e.g. a few days after the implantation, should be avoided. The (very rare) seeds passing through the gastro-intestinal tract will be flushed away, with the water and sewage pipes again providing sufficient protection for the photon energy considered here. If found by the patient (or by a member of the family), the seed(s) must not be touched.

2.2. Stranded (or ribbon) seed technique

(e) Urine should be sieved while the patient is under medical observation just after the implantation. However, some migration/expulsion may occur several weeks after implantation, when the ribbon dissolves spontaneously. At that time, the very few expelled seeds will be flushed away in the toilet (see above).

3. Cremation

(f) While relatively uncommon in a number of countries, cremation is frequent in others (e.g. in China and India) and is the rule in Japan. The cremation of a patient previously implanted with ^{125}I or ^{103}Pd sources raises a number of issues related to:

- the activity remaining in patient's ashes, potentially responsible for irradiation of crematorium staff and members of the family; and
- the airborne dose, potentially responsible for inhalation of radioactive particles by crematorium staff, members of the public, and for the triggering of some environmental monitors.

(g) When ^{125}I seeds have been used, cremation can be allowed without any special precautions if 12 months have elapsed since implantation (3 months for ^{103}Pd). Prior to 12 months, it is recommended to: (1) remove the prostate from the dead body and

store the organ (and seeds) according to national regulations (e.g. Japanese societies, 2003); or (2) to take specific precautions that include:

- the crematorium staff, while handling the remains, should observe precautions to reduce the potential for inadvertent ingestion and inhalation, such as the use of gloves and respiratory protection; and
- the patient's remains should be placed in a sealed metal container for a minimum of 1 year after the date of implantation.

Cremated remains should not be scattered in the environment until a minimum of 10 half-lives has elapsed from the date of implantation (about 20 months for ^{125}I).

4. Subsequent pelvic or abdominal surgery

(h) In exceptional cases (less than a few percent), it may be necessary to perform a very limited and careful transurethral resection after the implantation due to urinary retention. This must be done by an experienced surgeon who is fully aware of the brachytherapy implantation technique. When possible, this resection should not be performed before 6 months. The seeds should be identified, put into a container, and returned to the hospital in charge. In some other cases, abdominal or pelvic surgery (without any connection with prostate cancer) may be necessary after prostate brachytherapy. To avoid any problem, the patient should carry a card explaining that he had an implant and providing the hospital phone number(s) to call for further clarification.

5. Fathering of children

(i) One of the inevitable consequences of prostate brachytherapy with permanently implanted seeds is a drastic reduction in the volume of the ejaculate, most often associated with a change in colour and consistency. These changes, together with the irradiation delivered to the prostate, strongly suggest to the patient that he is definitively infertile. It is true that fathering a child after an implant appears unlikely. However, the dose to the testicles may not reach the threshold for castration, and the modified semen may, in rare cases, allow the survival of viable spermatozoa. Actually, a few cases of fatherhood have been reported after permanent implants, so patients must be aware of this possibility and take all necessary precautions if indicated.

6. Triggering of radiation detection monitors

(j) Certain types of radiation detection monitors, set at a very low alarm level (1.5–2 times the natural background radiation level), can be triggered by a patient who has undergone a permanent implant, essentially during the first months. These monitors can typically be found at the entry/exit of nuclear plants and nuclear research centres, in some waste areas, and in some scrap metal factories. Recently, in order to restrict transport of illicit radioactive material and detect inadvertent (or malevolent) transport of radioactive sources, some airports and border crossings have been equipped with such detectors. In case the patient triggers such a security monitor,

he should be able to show the personal ‘wallet card’ given to him at discharge from hospital (see Appendix D) in order to avoid any problem.

7. Secondary cancers

(k) The risk of radio-induced secondary tumours (mainly bladder and colorectal cancers and sarcomas) appears to be extremely low after external irradiation of prostate cancer. In terms of brachytherapy, very few cases of secondary cancer have been reported to date; this may be due to insufficient follow-up, but one can reasonably hypothesise that this risk is lower than after external irradiation as the amount of normal tissues/organs irradiated by the implant is smaller than that irradiated by external radiotherapy. Therefore, only standard follow-up of patients appears to be necessary.

1. INTRODUCTION

(1) Parallel to the development of external radiotherapy, the use of radioactive sources inserted directly into tumours, or simply placed in contact, was explored early in the 20th Century. This technique was called ‘brachy’ (‘short’ in Greek) therapy’ by the English-speaking world, and ‘Curiethérapie’, in order to honour the discoverers of radium, Pierre and Marie Curie, in France.

(2) In the first decades of the 20th Century, most treatments were performed with temporarily inserted (or in contact) radioactive sources, mainly using radium tubes or needles,¹ but interest in permanently implanted sources dates back to the 1910s. The first radioactive element to be used was radon. This gas, the first daughter product (‘emanation’) of radium, was felt to offer interesting advantages, i.e. small volume per unit of activity (so that it could be enclosed in very small 1-mm seeds) and a very short half-life (the radioactivity becoming insignificant within weeks, so that it could be implanted permanently). Permanent implants were initially performed using radon emanation contained in ‘bare’ glass capillary pipes, about 3 mm in length and 0.3 mm in diameter. Apart from the problems linked to the production and implantation of such tiny glass pipes, another problem was that most of the dose was delivered by short-range beta particles (electrons), with some ‘overdosage’ of the tissues located at contact or close to the sources. To overcome this latter problem, tiny gold-encapsulated seeds were developed, with the gold casing filtering most of the electrons and also the softer x rays, resulting in a much better dose distribution.

(3) A large number of patients, mainly presenting with gynaecological and prostatic cancers, received treatment with permanently implanted so-called ‘radon’ seeds, with favourable results in some cases. Interestingly, radiographs of the pelvis after implantation of radon seeds for prostate cancer, performed in the 1920s, look rather ‘modern’, and not so different from current implantation pictures using ¹²⁵I seeds (see below) (Aronowitz, 2002). However, this technique was progressively abandoned, mainly due to the complexity of managing the radium emanations and also because, at that time, most tumours were diagnosed at such an advanced stage that tumour extension exceeded the possibilities of cure by any type of implantation.

(4) It was only in the 1950s that several groups re-activated techniques of permanently implanted sources, using ¹⁹⁸Au seeds. The short half-life (2.7 days) of these sources allowed permanent implantation. ¹⁹⁸Au seeds were used to treat a wide variety of tumours, including pelvic neoplasms. However, the use of gold seeds was progressively abandoned when ¹²⁵I seeds became available in the 1970s. About the same size (4 mm in length) as ¹⁹⁸Au seeds, ¹²⁵I seeds offered some advantages as the half-life is longer (60.14 days), which was considered to be an advantage for slow-growing tumours such as prostate cancer, and the lower energy of its photons (mean 28 keV compared with 420 keV for ¹⁹⁸Au) provided for better radioprotection.

(5) Since that time, ¹²⁵I became the standard for permanently implanted radioactive material, only challenged, more recently, by ¹⁰³Pd. Again, a large variety of

¹ In particular for prostate cancer (Pasteau and Degrais, 1913).

tumours were implanted with ^{125}I seeds. As examples, a number of patients had their tumour bed implanted after resection of lung carcinomas, and the New York Memorial Sloan Kettering Cancer Center (MSKCC) implemented the implantation of prostate cancer as early as 1970 (Hilaris et al., 1987). ^{125}I seeds have also been proposed for treating brain tumours (Marchese et al., 1984).

(6) Today, although still used to irradiate the tumour bed after resection of lung cancer, and also for some other cancer sites, permanently implanted ^{125}I (and ^{103}Pd) seeds are mainly used to treat prostate cancer. Impressive development of the technique has taken place over the last decade.

(7) In the USA, where 180,000 new cases of prostate cancer are diagnosed each year, between 30,000 and 40,000 implantations for localised prostate neoplasms are performed annually, and the number of such permanent implants is anticipated to soon exceed the number of radical prostatectomies (Kollmeier et al., 2003; Michalski et al., 2003; Stone and Stock, 2002; Smathers et al., 1999).

(8) In parallel, high-dose-rate (HDR) remote afterloaded brachytherapy gained wide acceptance, usually for more advanced prostate cancer cases and often in association with external irradiation. The radiation safety aspects of the use of HDR brachytherapy are presented and discussed in another recommendation from Committee 3.

(9) In Europe, as in other countries, several thousand cases are treated annually and this number is increasing rapidly. It seems reasonable to anticipate that these numbers will continue to increase in the coming years for two reasons.

- We enter an era when prostate-specific antigen, performed more and more frequently in younger patients, allows detection of an increasing number of very small lesions, mainly in asymptomatic patients. These small lesions actually represent the best indication for permanent implantation techniques.
- The results reported recently by several American groups, with more than 10 years of follow-up, are comparable with results obtained by radical surgery in terms of local control (cure) of prostatic tumours. Moreover, these same reports appear to demonstrate an advantage over radical prostatectomy in terms of urinary continence and potency (Buron et al., 2004; Grimm et al., 2001; Kollmeier et al., 2003; Kupelian et al., 2004; Langley and Laing, 2004; Potters et al., 2004; Ragde et al., 2000; Stone and Stock, 2002; Sylvester et al., 2004a,b; Woolsey et al., 2003; Zelefsky and Whitmore, 1997; Zelefsky et al., 2000, 2003).

(10) Nowadays, it can be estimated that more than 90% of patients benefiting from permanently implanted radioactive sources are treated for prostate cancer. This is why the ICRP decided to address the issues of radiation safety specifically related to permanent implantation of radioactive sealed sources for prostate cancer.

(11) No adverse effects to medical staff and/or the patient's family associated with permanent seed implantation have been reported to date. This shows that the technique, already applied to thousands of patients (see above), is very safe. However, it is necessary to address a number of issues raised by both the medical community and patients' families. The following issues have to be considered.

- Dose to people approaching the patient, to identify where specific radioprotection steps should be considered.
- Management of expelled sources (although this occurrence is rare).
- Potential problems linked to cremation of a patient's body (a major issue in some countries).
- Other complementary recommendations.

(12) The radiation safety issues related to brachytherapy staff performing such implantations will be addressed more specifically in a subsequent ICRP publication.

(13) In addition, appendices are devoted to specific points:

- Appendix A – characteristics of the more frequently used permanently implanted radioactive sources;
- Appendix B – dose measurement technique after implantation;
- Appendix C – example of recommendations to be given to patients undergoing prostate cancer brachytherapy with permanently implanted seeds; and
- Appendix D – example of a personal identification card to be given to patients undergoing permanent seed implantation.