Some physical aspects of characteristics of radioisotopes used in permanent brachytherapy implants

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Purpose: Permanent placement of radioactive sources is a useful method of the brachytherapy in the treatment of prostate cancer and various head and neck cancers. Different radioactive isotopes are used in these treatments alone or simultaneously (mixed implant). There is very little experience with mixed implant. The aim of this study is to investigate the physical background of the use of I-125, Pd-103 and Au-198 in permanent mixed implants and the single use these isotopes.

Material and methods: If all sources contain the same isotope, the dose delivered to any point during an infinite period from the time of implantation (Dinf) is proportional to the product of the initial dose rate and the half-life of the used isotope, assuming no changes in the implant geometry. In present work the half-lives of the studied isotopes are estimated as weighted average of values from publications in which uncertainty of the experimentally determined half-life values are available. Applying practically used half-life values the periods necessary to reach the 50, 90 and 99% of Dinf (T50%, T90% and T99%) are calculated in cases of 10 different initial dose rate ratio combinations of the studied isotopes.

Results: The half-life of I-125, Pd-103 and Au-198 59.37 (±0.12) d, 17.20 (±0.64) d and 2.691 (±0.024) d are obtained. The T50%, T90% and T99% values are given in the table. Initial dose rate ratio of different isotopes period to reach given percent of Dinf in days.

Table 1.

I-125	Pd-103	Au-198	T50%	T90%	T99%
1	0	0	59.4	197.32	394.65
0	1	0	17	56.47	112.95
0	0	1	2.7	8.97	17.94
1/2	1/2	0	29.95	139.39	335.25
1/2	0	1/2	8.95	137.92	335.25
0	1/2	1/2	5.97	39.48	95.95
1/2	1/4	1/4	20.85	138.68	335.25
1/4	1/2	1/4	14.11	90.13	275.9
1/4	1/4	1/2	7.04	85.38	275.87
1/3	1/3	1/3	12.62	106.91	300.51

Conclusions: The differences of the practically used and estimated half-life values are less than the calculated uncertainties of the estimated values. Use of mixed implant causes spatial and temporal inhomogeneities in the dose distribution, and the dominancy of the isotope having the longest half-life increases with the time passed after the implantation. Mixed implants can be useful if different doses should be prescribed for the various part of the target, which can be advantageous in case of head and neck cancers or tumours with very inhomogeneous radiosensitivity, but further physical, technical and radiobiological research is necessary to concise the potential clinical usefulness.