EFFECTIVENESS OF „MOBILE" AND STATIONARY X-RAY UNITS AND COMPUTED TOMOGRAPHY IN BRACHYTHERAPY TREATMENT PLANNING.

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SUMMARY

CT, mobile and stationary x-ray cameras were used with the aim of comparing the source localization effectiveness in brachytherapy planning. Properties of orthogonal X-ray pictures were discussed and their impact on dose planning in brachytherapy was evaluated.

Differences between doses calculated for applicator positions localized by stationary and "mobile" X-ray units ranged between 6% and 11% in the rectum and 10% in the bladder, respectively.

INTRODUCTION

Precise localization of applicators is essential in brachytherapy because the treatment with the use of ionizing radiation affects both the tumour and the surrounding tissues [Górny and Malicki, 1992; ICRU 38, 1985; Murali et. al., 1990]. During brachytherapy of gynaecological diseases the target area lies in close vicinity of critical organs, sensitive to radiation, in which overdosage may cause severe complications. Usually, the position of the applicators is defined on the basis of two composite orthogonal X-ray pictures. The known position of sources, relative to anatomical organs, makes it possible to calculate doses to the target and critical organs (bladder and rectum).

The aim of this paper was to evaluate dose discrepancies in target and critical organs resulting from applicators' movement during preparation and treatment processes.

METHODS

Twenty patients with inoperable endometrial cancers, treated with radiation, have been adopted for the dose accuracy comparison. In all cases, teletherapy with 9 MV or 15 MV photons followed brachytherapy with Cs-137 gamma radiation (Selectron LDR).

Doses were determined in the target defined by points A, and in the critical organs: rectum (R_1, R_2) and bladder (P) [ICRU 38, 1985]. Doses to point A varied between 25 Gy and 30 Gy in each of the two sessions. Total doses to point A after the whole treatment (tele and brachy) ranged from 90 Gy to 100 Gy.

Doses were calculated on the basis of source positions determined on X-ray pictures. For the above group of patients we obtained three sets of orthogonal X-ray pictures using three types of X-ray units: a stationary „TUR", a mobile „Mobilax 201" and Siemens CT „Somatom HiQ". Dose planning was performed on the Brachytherapy Nucletron Planning System and on the Target 2 plus (GE Medical Systems).

RESULTS

Placements of detectors localized by stationary, „mobile" RTG units and CT are presented in photographs 1-3. Pictures were made for anterior-posterior and lateral projections, separately.

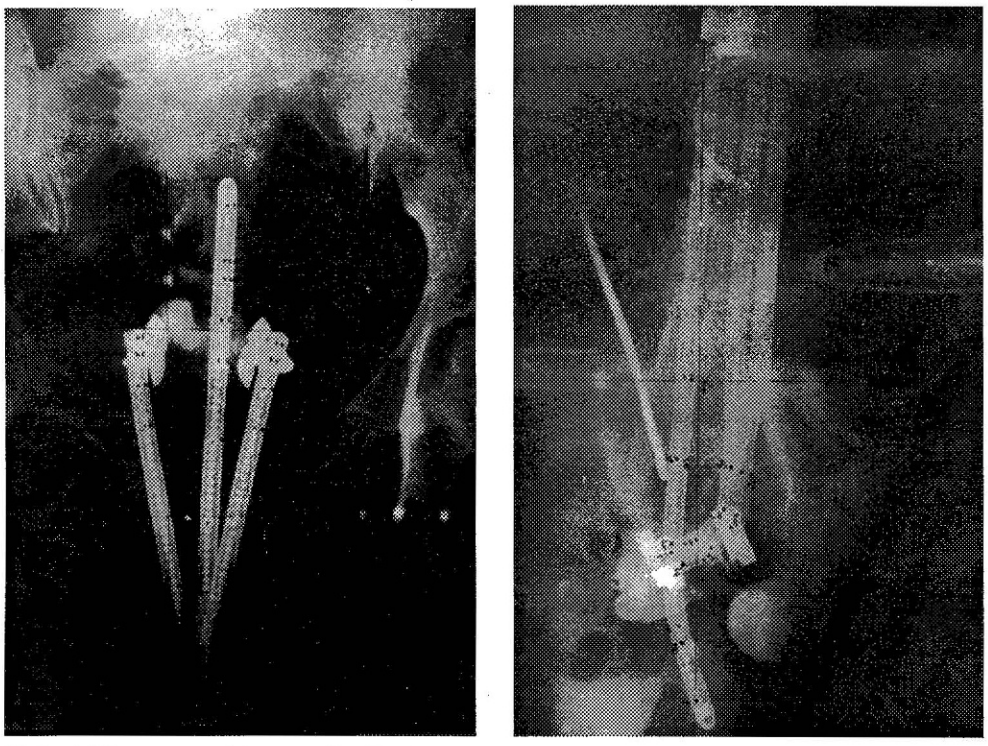


Photo 1. Placements of detectors localized by stationary RTG unit: AP (left); lateral (right).

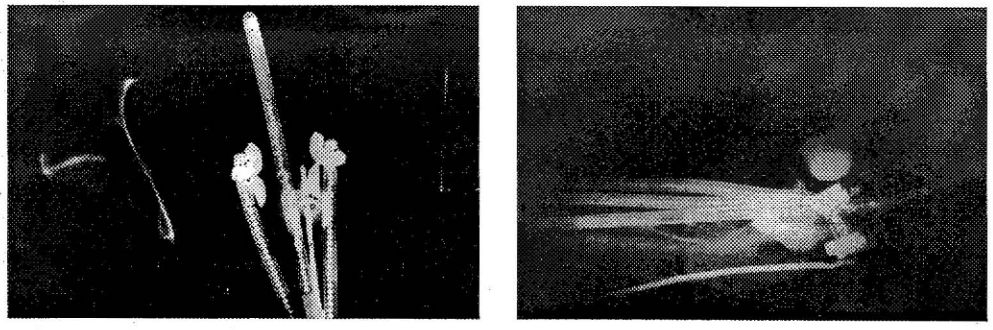


Photo 2. Placements of detectors localized by "mobile" RTG unit: AP (left); lateral (right).

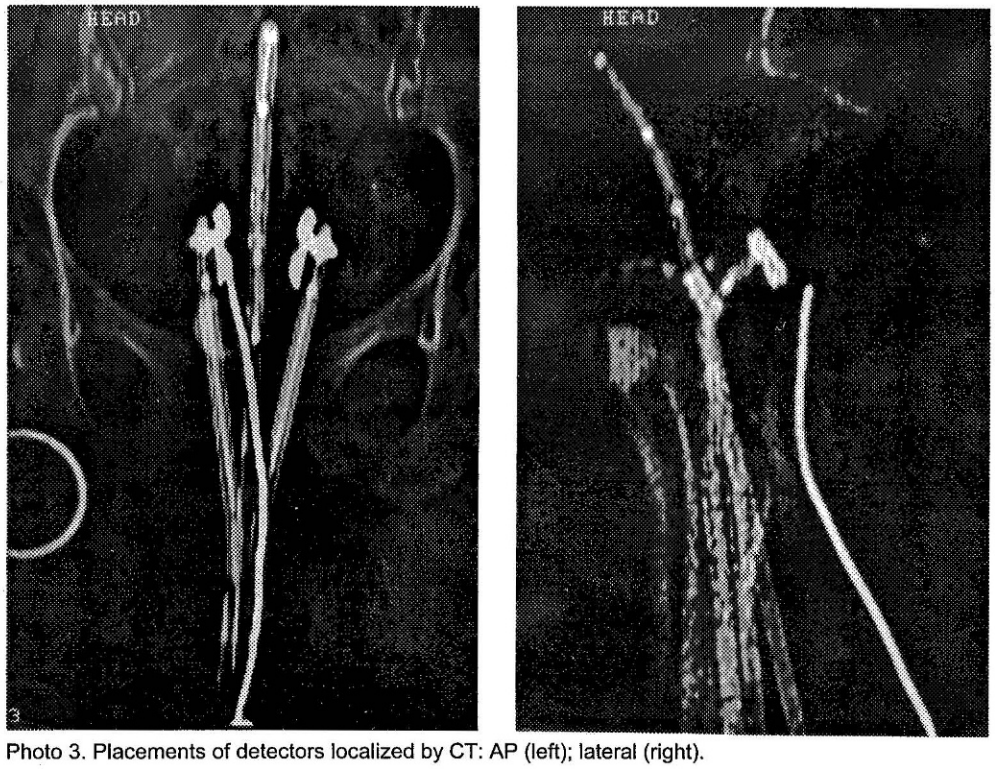


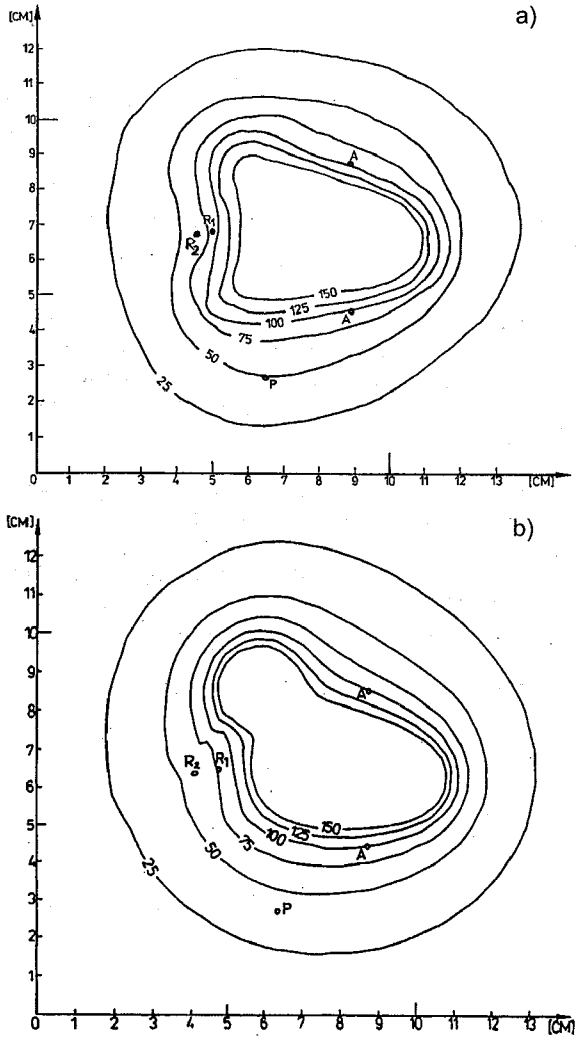
Photo 3. Placements of detectors localized by CT: AP (left); lateral (right).

Figures 1 and 2 represent dose distributions in the pelvis for applicators' positions localized through stationary and "mobile" X-ray units respectively. Mobile X-ray pictures were made at the patient's bed.

In table 1 doses, in percents of the dose at a point A, are determined for the critical organs: rectum (R_1, R_2) and bladder (P) for applicators localized by "mobile" and stationary X-ray units as in photographs 1 and 2.

X-ray unit	Target	Critical organs		
	A[%]	R [%]	R_2 [%]	P [%]
"mobile"	100	77	56	40
stationary	100	88	62	50

Table 1. Doses in percents of the dose absorbed at a point A calculated for surrounding organs sensitive to radiation: R_1, R_2 - rectum; P - bladder; for applicators' positions localized by (a) stationary and (b) mobile X-ray units.



Dose distribution in XY plane: (a) from a stationary unit, (b) from a mobile unit.

DISCUSSION

Pictures made with a conventional X-ray unit (both stationary and „mobile") visualized pellets clearly. Except for bones internal organs were barely visible in both lateral and anterior pictures. This lead to an uncertain situation when doses were related to applicators assumed to be in a stable position during irradiation. However, the movement of the patient carried from the treatment bed to an X-ray room, may have resulted in the translation of applicators [Górny and Malicki, 1992; Jayaraman and Lanzl 1983]. Examples of dose distribution changes are given in figure 1, where the prescribed dose based on pictures obtained from a stationary X-ray unit (fig. 1a) differed from that determined from pictures made later with a mobile unit when the patient lay on the treatment bed just prior to the treatment (fig.1b). Doses in the rectum (R_1, R_2), calculated for applicators located by a mobile X-ray unit, were 77% and 56% of the dose absorbed at point A, while the doses calculated for stationary pictures were 88% and 62%, respectively. Doses in the bladder were determined to be 40% for mobile and 50% for stationary cameras relative to 100% of dose absorbed at point A.

Doses in the bladder and rectum should not exceed 70 Gy because of the high risk of acute and late reactions after the treatment, while the total doses at the target near the critical organs, should lie between 90 Gy to 100 Gy [ ].

To prevent from applicators translations during long lasting treatments (over 20 hours) the volume in the vagina around the applicators was tamponed.

Pictures from a „mobile" x-ray camera had the same properties as those from a stationary camera, but they offered two significant benefits. Firstly, a mobile X-ray camera could be attached to the patient's bed in the brachytherapy unit, which made it possible to perform several pictures for several patients in a short time. Secondly, the patient did not need to be moved, which prevented the applicators from being exposed to motion. Such a mobile X-ray camera also permitted quick check of the localization of pellets during treatment [Górny and Malicki, 1992; Jayaraman and Lanzl, 1993; van der Laarse and de Boer, 1990].

CT pictures visualized internal organs and applicators clearly. The process of performing CT pictures was quick and comfortable for patients. The CT radiogram with a known magnification factor remained in the files, unlike the conventional X-ray unit when the magnification had to be found manually. For the on-line connection of CT to the planning system, a transfer both of the tele and brachy images

directly to the planning system was possible. Additionally, the relationship between the computer planes for tele and brachy techniques could be established and this resulted in a smaller error for the total dose plan [Schoeppel et al., 1989]. However, like the stationary X-ray unit, the applicators were exposed to motion when the patient was carried between the treatment and diagnostic rooms, which resulted in dose changes (photograph 3).

CONCLUSION

Differences in dose distributions for pictures made with stationary and mobile X-ray units ranged between 6% and 11% in the rectum and 10% in the bladder, respectively.

A mobile X-ray unit was easy to use and made the source localization easy for patients by preventing applicators from being moved during transport. Thus, the uncertainity in the dose determination was minimized.

REFERENCES

Baltas D. Abstracts of 2nd Central European Brachytherapy Conference, 1991.

Fletcher H. Textbook of Radiotherapy (3 ema ad.) Lea, Febiger., Philadelphia 1980, 720-789.

Górny A, Malicki J. Influence of applicator's moves to dose distribution during Selectron LDR Brachytherapy. Ginekol. Pol. 63, 1992, in polish.

ICRU Report No. 38. Dose and volume specification for reporting intracavitary therapy in gynecology. 1985.

Jayaraman S, Lanzl L H. An overview of errors in line source dosimetry for gamma-ray brachytherapy. Med. Phys. 10, 1983.

Jayaraman S, Lanzl L H. An overview of errors in line source dosimetry for gammamay brachytherapy. Med. Phys. World, 1990, 6, 4.

Jones C H. Med. Phys. World, 1990, 6, 4.

Jones C M. Proceedings of IAEA Symposium Vienna, 1997, 1, 275.

Kierzkowski J, Kosicka G, Malicki J, Kożbiał W, Magdziarz M, Drozdowska M. Localization of the intracavitary „Selectron" applicators by CT pictures. Abstracts of 2nd Biennial Meeting on Physics in Clinical Radiotherapy. Prague 1993, 25.

Kosicka G, Malicki J, Roszak A, Górny A. Łączne obliczenia dawek z brachy- i teleterapii w leczeniu radiacyjnym raka szyjki macicy. Ginek. Pol. 12, 1994, 706-713.

Laarse R van der, Boer de R W. Computerized high dose rate brachytherapy treatment planning". In Martinez A A, Orton C G, Mould R F (eds): Brachytherapy HDR and LDR. Nucletron, Columbia 1990.

Mould R F. Radiotherapy Treatment Planning Medical Physics Handbooks, 7, 1981.

Murali V, Balakrishnan I S, Lakshmanan A V. A comparative study between computed dosimetry and film dosimetry for the Selectron applicator. Phys. Med. Biol. 1990, 5.

Pierguin B, Marinello G. A Practical Manual of Brachytherapy Pierguin B Cervix. Medical Physics Publishing Madison, 1997, 165-196.

Roszak A, Kosicka G, Malicki J, Cikowska-Woźniak E, Kierzkowski J. Łączne rozkłady dawek w miednicy mniejszej w pooperacyjnej radioterapii pacjentek z rakiem błony śluzowej macicy. Ginekol. Pol. 1996, 67, 9, 460-466.

Schoeppel S L, Fraass B A, Hopkins M P, Vigne M L, Lighter A S, Mc Shan Dö, Noffsinger S, Perez-Tamayo C, Roberts J A. A CT-compatible version of the Fletcher System intracavitary Applicator: Clinical application and 3-dimensional treatment planning. Int. J. Radiat. Oncol. Biol. Phys. 17 1989.