

Rectal wall dose estimation in intracavitary brachytherapy: A preliminary comparison of an in-house rectal wire versus ICRU 38 recommendations

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ABSTRACT

Background: In intracavitary brachytherapy for gynecological cancers, various techniques are used to locate the anterior rectal wall nearest to the sources but there is no consensus on the best method to do so. This study aimed to compare a technique used routinely in some centers that employs a wire marker to locate the position of the maximum rectal dose point, versus the method recommended by the ICRU Report 38.

Materials and Methods: In a preliminary prospective study on 34 intracavitary insertions for patients with cervical or endometrial cancer, treated at our center based on the Manchester system, the dose distributions were obtained from a treatment planning system following the input of scanned orthogonal anteroposterior and lateral radiographs. For each case, an in-house marked wire was inserted in the rectal lumen and the doses were calculated on several points along the wire seen on the radiographs, to obtain the maximum dose. For the same insertions, the ICRU method was also applied by considering the rectal wall hot spot as a point 0.5 cm posterior to the posterior vaginal wall (visualized on the radiographs by vaginal packing material containing contrast medium).

Results: Averaged over all insertions, mean rectal wall hot spot dose calculated using the positional information obtained by the wire technique was lower by 28.6% than that given by the ICRU method ($P < 0.001$). **Conclusion:** Our initial results add evidence to the suggestion that the wire technique underestimates the rectal wall hot spot dose significantly compared to the ICRU method.

► Short report

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INTRODUCTION

In intracavitory brachytherapy for gynecological cancers, the points of interest are close to the radioactive sources and, therefore, inverse square law has a very strong influence on creat-

ing a very steep dose falloff as a function of distance from the sources. This steep dose gradient allows prescription and delivery of a high dose to the target cells near the sources. This, however, is normally only true if the critical normal tissues, usually rectal and bladder walls,

are sufficiently distant for a considerable decrease in dose to occur, such that their tolerance dose limits are not exceeded. This is sometimes not the case though, and serious rectal complications have been reported⁽¹⁾.

The highest rectal dose is likely to occur at a point within the anterior rectal wall, which is the part of rectum nearest to the sources. Therefore, one of the main factors that determine whether a gynecological treatment plan is clinically acceptable is if the maximum dose to the anterior rectal wall exceeds its tolerance dose or not.

Different radiotherapy centers use various methods in order to estimate the absorbed dose to the rectal wall⁽²⁾. The traditional method of determining the rectal dose employs a wire marker inserted into the rectum and relies on its visualization in orthogonal pelvic radiographs to show the hottest rectal point⁽³⁾. The International Commission on Radiation Units and Measurements (ICRU), in its Report Number 38, recommended a different method to arrive at a reference point for the dose to the rectum⁽⁴⁾. However, there are controversies regarding the accuracy and suitability the ICRU 38 recommendations on rectal reference point determinations⁽⁵⁾. To investigate this issue further, in this report we present a preliminary study comparing the results obtained from using the two above-mentioned techniques.

MATERIALS AND METHODS

This part of our study involved 34 gynecological applications on patients with cancer of cervix or endometrium who, in addition to intracavitary brachytherapy, received external-beam radiotherapy too. A low-to-medium dose rate brachytherapy unit (Nucletron Selectron, Elekta, The Netherlands) using multiple Cs-137 radioactive pellets was employed.

Fletcher-Suite-Delclos applicators were used for patient insertions. The Manchester system was selected for dose prescription and treatment planning. The prescribed dose was 6 Gy to point A for each application. Point A was defined as 2 cm above the superior edge of the

ovoid colpostat in the tilted coronal plane and 2 cm lateral to the cervical canal⁽⁶⁾. Each patient had between 3 to 6 treatment fractions.

Computerized treatment planning was performed using the Selectron Treatment Planning System (STPS). Apart from the well-known deficiency of such standard analytical algorithms overestimating the dose near the tip of the applicator^(7,8), geometric and dose calculation accuracy of STPS had otherwise been previously established⁽⁹⁾. Treatment planning was carried out for every treatment fraction based on that fraction's anteroposterior (AP) and lateral orthogonal radiographs.

During each insertion, the patient's posterior vaginal cavity was packed with radio-opaque gauze, to both reduce rectal dose and to visualize the posterior vaginal wall for the purposes of the ICRU method. Also, a rectal wire was inserted into the rectum. An in-house rectal wire was used in this study, which consisted of a periodically marked metallic wire placed within a flexible plastic tube.

During treatment planning, two points were determined on each orthogonal radiograph. First, on the lateral radiograph, the ICRU rectal point (R_i) was defined 0.5 cm posterior to the posterior vaginal wall (figure 1), and its left-right position was marked on the AP radiograph, half-way along the vaginal sources between the two ovoids (figure 2). The wire marker reference point (R_w) was marked on the wire marker on the lateral radiograph on the same AP line passing through the ICRU point.

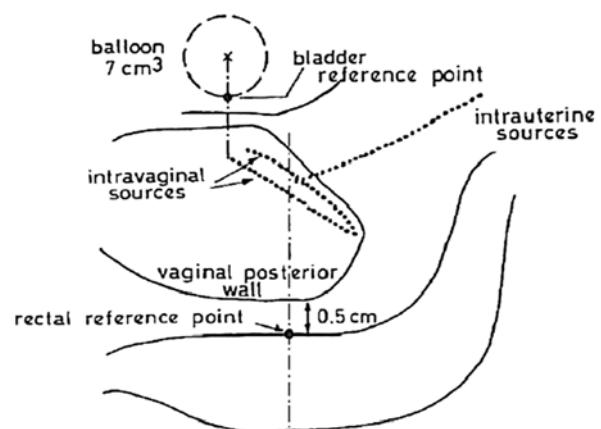


Figure 1. Location of the ICRU rectal reference point viewed laterally⁽⁴⁾.

Each treatment plan was normalized to the average dose received by the left and right point As.

Statistical comparisons between the rectal doses from the two methods were made by using a paired t-test and $p < 0.05$ was considered statistically significant. The SPSS software (version 16) was used to analyze the data.

RESULTS

In the majority of applications (94%), the rectal point dose from the ICRU method was higher than that of the wire marker point. The opposite was observed in only 2 cases.

Table 1 shows the mean doses plus the associated standard deviations and standard errors for the two methods. Mean dose at the ICRU rectal points was $526.6 \text{ cGy} \pm 54.5 \text{ cGy}$ and for wire marker, it was $331.1 \text{ cGy} \pm 27.4 \text{ cGy}$. Mean dose difference between the two points was 195.5 cGy , which was a statistically significant difference ($p < 0.001$). When each

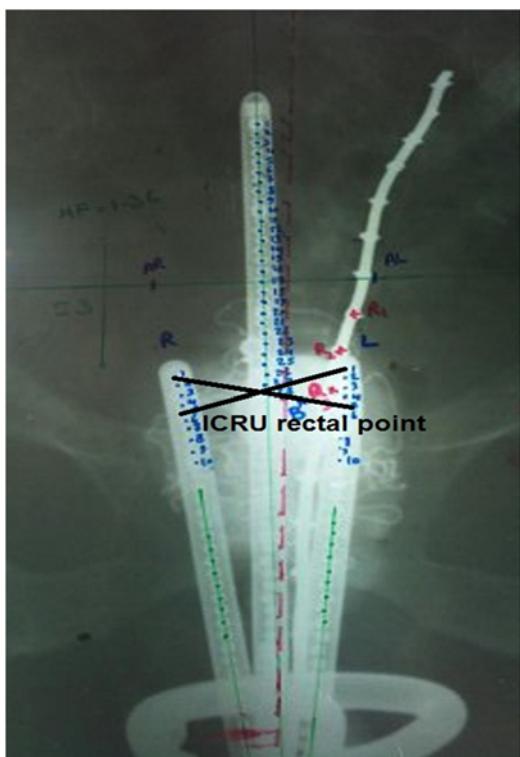


Figure 2. An AP radiograph showing the ICRU rectal reference point as well as the in-house rectal wire used.

two rectal point doses in the same patient insertion were compared, the mean percentage difference between them was 28.6% (range - 31.1% to 74.4%).

Table 1. Mean doses calculated at the ICRU and wire rectal reference points together with the associated uncertainties.

	Mean (cGy)	Std. Deviation (cGy)	Std. Error Mean (cGy)
ICRU	526.6	318.0	54.5
Wire	331.1	159.5	27.4

DISCUSSION

Brachytherapy is well established for delivery of a high radiation dose directly to the tumor while sparing, to some degree, the surrounding normal tissues ⁽¹⁰⁾. However, this has not been achieved universally. Crook et al reported that 348 patients who received brachytherapy for at least part of their treatment of uterine cervix cancer showed complications after therapy, of which 48% occurred in the rectum ⁽¹⁾. Suggesting a reliable method of estimating and recording the maximum rectal wall dose was among the aims of the ICRU Report 38 and the concept of recording the dose in the organ at risk, as recommended by that report, has been implemented to various degrees among centers worldwide. A survey of mostly European countries and the United States showed that 90% of the institutions taking part in the survey recorded the ICRU rectum reference points routinely ⁽⁵⁾. Other practices, such as using a rectal wire are, however, used by some clinics worldwide.

Governed by geometry (and in particular distance from the sources), the dose obtained from a rectal wire differs from that of the ICRU 38 method. In our study, in 32 out of 34 cases, the dose of the ICRU rectal point was higher than that shown by the wire marker. This particular question has not been studied much but, similar to our study, Serkies et al. and Shrivastava et al reported that the rectal dose obtained by the wire method underestimates the actual rectal dose ^(3, 11). These differences probably stem from the fact that the wire marker's small diameter

causes its position in the rectal lumen variable and its indicated dose generally lower than the actual anterior rectal wall maximum dose.

Our preliminary patient study, therefore, adds data to the suggestion that a rectal wire usually underestimates rectal wall dose, thereby rendering this method suboptimal. CT- or MRI-based treatment planning offers a more acceptable way to overcome this problem^(12,13).

Conflict of interest: Declared none.

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