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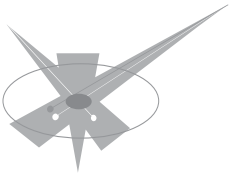

Original Paper

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Evaluation of spinal cord risk during HDR brachytherapy in patients with nasopharyngeal cancer

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

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Summary

Aim Use of Rotterdam applicators was analysed for the purpose of ascertaining the average dose to the spinal cord at the point of greatest load.

Materials/Methods 20 procedures carried out on patients treated in the brachytherapy department were evaluated. Rotterdam nosopharynx applicators were positioned and localised according to the "box technique". The radiographs were used to reconstruct the applicator in PLATO NPS version 14.1.3 treatment planning system. The position of spinal cord points were inserted according to the radiographs. The highest-loaded points were chosen to analyze.

Results Points were localized (along the cord) to within an average accuracy of 0.52mm. A comparison of doses in the cord at these points was carried out and the average dose using geometrical optimization (on distance) was 19.7% of the reference dose while without optimisation the average was 18.7% of the reference dose.

Conclusions From the study undertaken, it appears that the calculated doses in the spinal cord, at the points of greatest load, are as described in the published data. The Rotterdam applicator may be used equally for radical treatment and for locally increasing the dose (boost) because of an acceptable spinal cord dose.

Key words **brachytherapy • spinal cord • Rotterdam applicator**

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Background

Radiotherapy of nasopharyngeal cancer is complicated by the nearness of critical organs. One of the main critical organs in this area is the spinal cord. Brachytherapy is a safe method for delivering high doses to the target. The miniaturised sources used in HDR brachytherapy reconstruction based on CT images, ability to optimize the dose distributions, ensures that the method may be an alternative for the treatment of patients treated with external beam therapy. Attempts to estimate dose in the spinal cords of patients treated with brachytherapy in the nasopharynx are valid.

Aim

Use of Rotterdam applicators was analysed for the purpose of ascertaining the average dose to the spinal cord at the point of greatest load.

Materials and Methods

The use of Rotterdam applicator was analysed for the patients treated between July 2000, and April 2003. A microSelectron HDR (Nucletron) machine with an Ir 192 source was used. Treatments were carried out on 16 patients: 6 women and 10 men. Among these patients a total of 20 procedures were performed: one patient underwent applicator insertion three times, two patients underwent two such implantations and the remaining thirteen patients only once. Altogether 129 therapeutic fractions were delivered. The total dose used in these patients ranged from 6Gy to 51Gy in dose fraction of 3Gy daily: three patients received 51Gy, two received 30Gy, two 15Gy, three 6Gy, and the remainder received 42Gy, 24Gy, 21Gy,18Gy, 12Gy and 9Gy. Procedures were carried out by a laryngologist who fixed silicon applicators in contact with nasopharynx. The Rotterdam applicator set consisted of a contact applicator, 2 catheters into which the iridium source was loaded, and silicon spray to ease fitting of the catheters into the applicator (Figure 1).

The silicon contact applicator remained in nasopharynx from 2 to 5 days, depending on clinical indications and on the tolerance of the patient. X-ray imaging was repeated during the course of treatment, in the case of several selected patients. Implants were stable meaning that daily repositioning of applicators was unnecessary.

Geometrical reconstruction of applicator position was carried out using the "box" technique

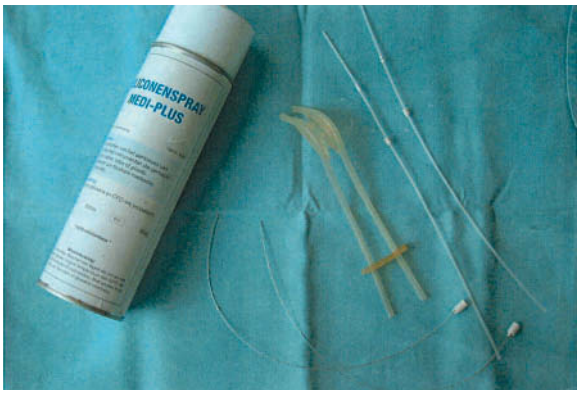

Figure 1. Prepared kit for the insertion of a Rotterdam applicator.

on the basis of two orthogonal X-ray images, with localisation markers (Figure 2). Positioning of applicator was also carried out on the basis of CT images.

Dose distribution was calculated with a PLATO BPS (version 14.1.3) treatment planning system.

Positioning of catheters at several points along the spinal cord was reconstructed. On the basis of CT images, the areas irradiated and active length were defined. The reference dose was the average dose at reference points positioned within 10mm of the source axis for each of the catheters [1]. Two treatment plans were analysed for each application: a plan in which a geometric distance optimisation algorithm had been used and a plan without optimisation in which the dwell time in all dwell positions was the same. The optimisation algorithm changed the dwell time at each position, evening out the dose value at the reference points in order to attain the planned reference dose.

Results

On the basis of X-ray images, points on along the spinal cord were located with an average accuracy of 0.52mm (ranging from 0.1 to 1.5mm). The active length ranged from 20 to 70mm the average value was 45.8mm.

Average spinal cord dose values were compared for the two types of treatment plan. For optimised plans, the average load on the cord amounted to 19.7% (±6.3%) of the reference dose. For treatment plans without optimisation the average load amounted to 18.7% (±6.1%).

From the results obtained it may be calculated that, assuming a fractional dose of 3Gy at the

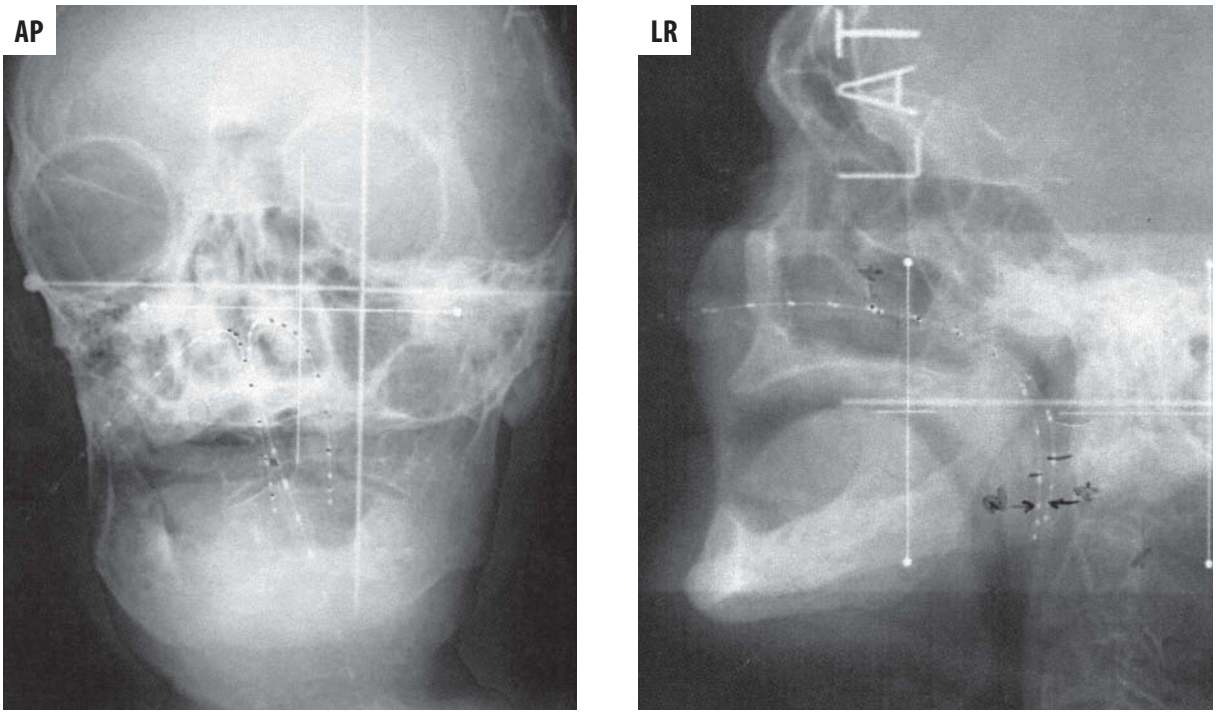

Figure 2. AP and LR X-ray image with localisation markers.

reference points, the average fractional dose in the spinal cord amounted to 0.59Gy (for optimised plans). On the basis of the linear-quadratic model, the EQD_2 dose was calculated using the formula:

$$EQD_2 = D\frac{d + \alpha/\beta}{2 + \alpha/\beta}$$

where D is the total dose and d is a fraction dose.

In the case of the patient who received a therapeutic dose of 51Gy (17 fractions at 3Gy daily), the balanced dose EQD_2 in the spinal cord amounted to 7.2Gy (the value was calculated for: α/β=3Gy [2].

Discussion

Our experience of HDR brachytherapy using Rotterdam applicator shows that it is a treatment well tolerated by patients. Insertion of the applicator to the nasopharyngeal cavity was not a complicated procedure. Once the applicator was fixed into the therapeutic position it was stable, ensuring that the source could follow the same course repeatedly through a series of days of treatment. The treatment plan (and dose distribution plans) was accepted before the first treatment fraction and realized during the course of following days of therapy.

From an analysis of treatment plans it appears that the dose delivered, to the points of the cord closest to the positions of the source, amounted to an average of 19.2% of the prescribed dose. Dose gradients within the area of the spinal cord are very steep and therefore parts of the cord receive markedly lower doses. Because the fraction dose in the cord was low, the equivalent EQD_2 dose was lower than the physical dose. This showed that doses received by the cord during treatments using the described method are safe. The results obtained are in agreement with those of Levendag and co-workers, who found that load on the spinal cord was around 20% of the therapeutic dose [1]. For every patient, individual activity length were defined. No correlation was discovered, however, between the active length and dose values in the cord. A small standard deviation in the values of analysed parameters suggests that the load to the spinal cord during the described therapy was comparable in each case.

Our analysis of spinal cord doses showed a small difference between optimised and non-optimized treatment plans. The differences, according to student's t test for paired data, were not statistically significant. For the majority of patients, dose distribution without optimization may be used. The optimization algorithm increases dwell time at peripheral treatment position, increasing the "contact" dose at the surfaces of the mucousal

membranes, which may be a cause of complications.

Conclusions

We conclude that myelopathy risks during HDR brachytherapy of the nasopharynx, using Rotterdam applicator, is acceptable. Dose absorption in small volumes of the cord amounts to an average of 19.2% of the reference dose. The position of the applicator is fixed for the remainder of subsequent fractions, ensuring reproducibility of dose distribution. Treatment is well tolerated by patients. The described method of treatment may be used both as a radical treatment in the case of recurrence and for localized dosage increase (boost) in the radical radiotherapy of primary malignant tumours of the nasopharynx [3].

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