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Analysis of central vaginal cuff HDR brachytherapy using various cylinder sizes-literature review

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SUMMARY

Background: The technique of brachytherapy in the radiation treatment is superior modality of achieving the radiotherapy goals like maximum dose to the target area and very minimal dose to the other normal organs. But some of the difficulties in the brachytherapy procedures many of radiation therapy centers are forgot their patient's excellent outcomes of brachytherapy techniques and some of the centers are restricted to minimal application like intracavitory, surface mould. On another side, reducing interest in brachytherapy treatment was financial issues of the institution like source cost and maintenance. Due to that there is no major research happening in that field of brachytherapy. So since 1995 brachytherapy dose calculation algorithm of TG-43 was using worldwide which is not accounting the applicator attenuation and patient heterogeneity in the treatment. The many authors are studying the applicator attenuation and applicator effect of different application using brachytherapy treatment will lead to better treatment outcomes of the patients. Aim: The main aim of this study is to review the articles around analysing the different CVS applicators and different method of dose prescriptions to get better outcome in the brachytherapy treatment. Materials: There are four scientific articles reviewed, which was analysed the various diameter of central vaginal application and various treatment length and different methods of dose prescription. Conclusion: To achieve the reduction of normal organ doses and reduction of hot spot near the vaginal surfaces, it's better to prescribe the doses on vaginal surfaces or cylindrical surface when especially using smaller diameter cylinders.

Key words: applicators, brachytherapy, CVS, HDR, TG-43

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INTRODUCTION

Brachytherapy is a most popular modality method in radiotherapy due to its superior dose coverage to target volume and vary minimal radiation spillages to other normal organ while compared to IMRT and IMPT shown in Figure 1. In the history of radiation therapy was actually begins with brachytherapy. In the past earlier years the radioactive materials are used to treat the cancer cells. But recent years brachytherapy treatment are consequently less or restricted to such region like cervical cancers due to difficult procedures of brachytherapy application in all site of the bodies. In brachytherapy treatment the applicators are placed inside or near to the tumour or organs to ensure the safe movement of radioactive material inside the body [1-3]. In further the different shape of the applicator is used depending upon the requirement of the dose distribution and tumour shapes.

The cylindrical tube types of applicator are used in intravaginal cancer patients and different diameter of the cylinder selected by anatomy of the patients. After application of central vagial cylinders in patient body the dose calculation made with Treatment Planning System (TPS). In worldwide the dose calculation algorithm for brachytherapy treatment AAPM Task Group-43 is using in the practice and it's well known that the calculation method of algorithm is bare source in homogeneous water medium shown in figure 2A [4-5].

It's neglecting the applicator attenuation and patient heterogeneit figure 2B when calculation of dwell times of the source. So the research authors are studying those dosimetrical differences in brachytherapy treatment, when using different high atomic number metal applicators. These dosimetrical differences measured with Ion chamber, TLD, OSLD and Radio chromic films etc. The experimental measured data is compared with Monte Carlo simulation methods which is high accurate calculating algorithm in future.

Thus the purpose of this article is to review the different prescription method practicing to the central vaginal brachytherapy treatment and to identify the better suitable prescription method to reduce the normal tissue doses and improve the treatment efficiency.

MATERIALS AND METHOD

The studies are focused on comparison of different diameter central vaginal applicators used in brachytherapy treatment.

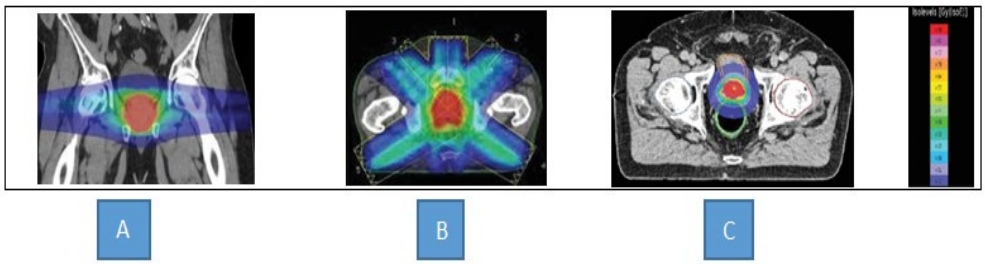

Fig. 1. Dose distribution comparison of different modality of radiation treatment; (A): Proton beam therapy; (B): Intensity modulated hdr brachytherapy (C) Photon radiation therapy

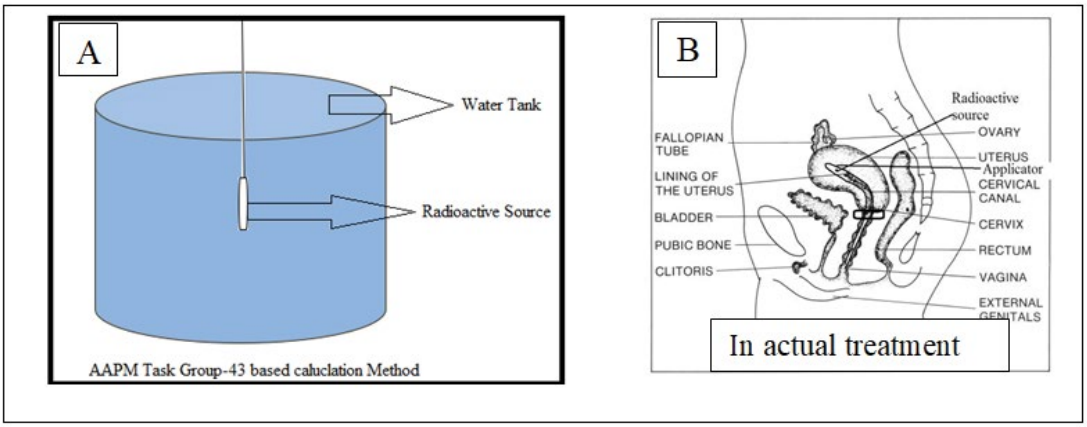

Fig. 2. (A) Schematic representation of TG-43 based dose calculation method (B) Actual treatment scenario shown patient geometry with applicator

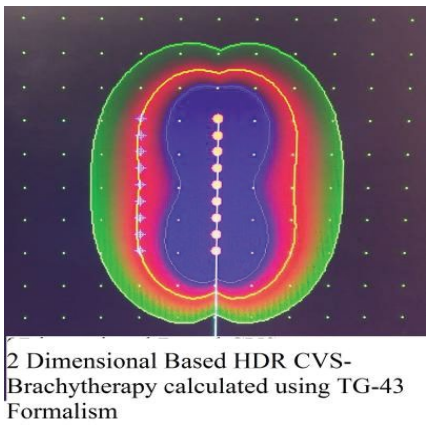

Fig. 3. Prescription points (Blue Cross) are placed 2.0 cm away from the center of the source when planning done with 3.0 cm diameter of the CVS applicator

No restriction was applied in the length of the treatment and prescribed dose to the target.

Guidelines of central vaginal brachytherapy

The American Brachytherapy Society (ABS) recommended for HDR CVS brachy for endometrium cancer patients [6]. Their recommendation for dose prescription should be at vaginal surface or 0.5 cm from the vaginal surfaces. So that intracavitory central vaginal applicator dose prescription points are commonly placed with surface of the applicator or 0.5 cm from the surface of the applicators shown in figure 3. This depth gives the adequate dose coverage to the lymphatic channels which is located within 5 mm from the vaginal surfaces. The surface or 5 mm prescription method will give the greater dose coverage to the tumor and less normal tissue toxicity.

Prescription points

In the treatment of intracavitory uterine cervix patient dose prescription point is Manchester method was following in the clinical practice. The ICRT prescription point was 2 cm superior from the flange of the intrauterine and 2 cm lateral from the central canal was placed [7-8]. So the applicator influence in the prescribed point is very minimal and attenuation and scatter from the applicator also very minimal in the ICRT treatment [9]. In contrast the central vaginal prescription points are near or on above to the applicator materials, which is made by stainless steel tube plus concentric polysulfide cylinders various diameters between 2.0 cm to 4.0 cm. The applicator influence of the applicators more in the central vaginal cylinder while compared with other intracavitory fletcher applicators.

Shidong et al. studied the effect of prescription depth, cylinder size, treatment length etc. In their studies cylinder diameter range used 2 cm to 4 cm and treatment length ranges from 3 cm to 8 cm were analysed. The prescription point is either cylinder surface or 0.5 cm from the cylinder surface. In the dose calculation they used commercial HDR planning system of Plato BPS version 14.2.4.

RESULT

There result was suggested that significant difference in the dose distribution was observed when various prescription methods used in the treatment. The hotspots with 140%-170% of the prescribed dose at the surface occurred at the 2 cm cylinder using

0.5 cm-depth prescription. The uniform doses were observed while dose prescribing at the vaginal surfaces rather than 0.5 cm depth [10].

Stanley Gutintov et al. analysed the single HDR vaginal cuff brachytherapy treatment. They were analysed 15 patient of vaginal carcinoma treated with various diameter of the cylinders ranging from 2.5 cm to 3.5 cm and treatment length of 3.0 cm, 4.0 cm and 5.0 cm. Dose prescription point is kept surface or 0.5 cm depth from the surface of the vaginal wall.

There result showed that the significant dose variation in the treatment when using different diameter of applicators. The Organ at Risk (OAR) dose increases with increasing treatment length when diameter of the cylinder kept invariable. They were strongly suggested that changing the prescription for surface to 0.5 cm from the surface of the vagina has the largest dose to bladder, rectum and other surrounding OARs [11].

Hualin Zhang et al. studied the dosimeteric impact of cylinder size in HDR vaginal cuff brachytherapy for endometrial cancer patients. The group was studied the different diameter cylinders ranging from 2.5 cm to 4.0 cm with treatment length of 3 cm to 5.0 cm and prescription method was used in the surface of the vagina or 0.5 cm from the vaginal surfaces. They were used oncentra version 3.4 brachytherapy planning system and Mean and dose coverage of 90%, 10% (D10), 5% (D5) doses were calculated [12].

They were concluded, HDR vaginal cuff brachytherapy cylinder size has moderate and various impact on the doses. Smaller diameter cylinders have larger surface doses and longer treatment length will provide uniform doses to the treatment volume.

Giridharan et al. studied the influence of central vaginal cylinders in high dose rate Ir-192 brachy treatment with different diameter applicators. There were analysed four different sizes in the range of 2.0, 2.5, 3.0 and 3.5 cm. The oncentra planning system was used for the dose calculation and 0.125 cm ion chamber used to measure the TPS calculated data in the phantom of Radiation Field Analyser (RFA). The ion chamber data was compared with EDQ2 radiographic films.

There results showed that using of small diameter cylinders having more surface doses when compared with larger central vaginal cylinders [13].

DISCUSSION

In the world wide brachytherapy dose calculation TG-43 AAPM formalism was using for treatment. The TG-43 calculation method is only based on the bare source in the center of water simulation. The formalism is effectively neglecting the applicator attenuation and patient heterogeneity. In the clinical practice the treatment is done with help of high atomic number metal applicator to ensure the safe movement of source and other patient safeties.

Many authors studied that the radial dose factor and anisotropic factors are changing with respect to using different kind of applicators [14]. After such distance from the applicator the both function are equal to bare source simulation values. So there is no much difference when dose prescription point is far from the applicators like ICA application method. In contrast the CVS application prescription point on most properly near to the applicator or on the surface of the applicators. Due to this reason the many authors analyzed the doses of CVS application while using different diameter cylinders.

In the end of our analysis proven that the surface prescription gives better target coverage and less toxicity to the other OAR's. This is due to the scatter photons and secondary electrons produced by the applicator materails, passes easily through the applicator having small diameters. When diameter of the applicator increases, scattering contribution reduced in the precription points. When the usage of small cylinder like less than 2.5 cm diameter, better to prescribe the doses on surface to ovoid the hot spot and sufficient sparing of bladder and rectum.

CONCLUSION

From the review of above published scientific articles we have suggested that, the surface prescription method is giving greater possibility of reducing hot spot near the treatment region and better avoidance of OAR form the radiation doses especially using small diameter cylinders.

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