HDR brachytherapy using cylinder, tandem-ovoid (T&O) and interstitial implant with prognosis

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Abstract. Purpose: Among the therapeutic modalities available for the treatment of cervical cancer, irradiation is regarded to be the standard treatment for all tumor stages, which includes external beam radiation therapy and HDR brachytherapy or a combination of these two. This modality of cancer, needless to say, is prevalent in Bangladesh as the women are coming forward for its detection. Dramatic advances have been made in brachytherapy for cervical cancer. Radiation treatment planning has evolved from two-dimensional to three-dimensional, incorporating magnetic resonance imaging and/or computed tomography into the treatment paradigm. This allows for better delineation and coverage of the tumor, as well as improved avoidance of surrounding organs. Brachytherapy applications are not restricted to one method only; any method could be combined with another, as well as other radiotherapy techniques. In cervical cancer, intracavitary brachytherapy (ICBT) has been used for practical reasons. Lately though, combination of ICBT and interstitial brachytherapy (ISBT) techniques are being evaluated in deference to feasibility, practicality and reproducibility. Advanced brachytherapy can achieve very high rates of local control with a reduction in morbidity, compared with historic approaches. This study provides an overview of state-of-the-art gynecologic brachytherapy, with a focus on recent advances and their implications for women with cervical cancer.

Materials and Methods: Three patients were selected on different staging. Three different types of applicator (Cylinder, Tandem and Ovoid and Interstitial Implant) were inserted according to the patient’s anatomy and staging. Prescribed dose were different for the implant technique.

Result: Progress from 2D- to 3D-based imaging and treatment planning for cervical cancer brachytherapy has improved local control, reduced toxicity, and improved overall survival for women.

Conclusion: The result of our study indicates that a precise delivery of treatment by applying a appropriate applicator and the choice of treatment planning technique is more important for a better outcome.

Key Words: High Dose Rate (HDR) brachytherapy, cervical cancer, ICBT and interstitial implant.

1. Introduction
Brachytherapy application and treatment procedures are uniquely determined for each procedure aiming at a boost dose to the localized tumor as in EBRT. The choice of brachytherapy implants

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could be Manchester, Fletcher using intracavitary or interstitial one of radioactive source like Co-60 [3].

Human bodies are made up of billions of cells that grow, divide, and then die in a predictable manner. Cancer occurs when something goes wrong with this system, causing uncontrolled cell division and growth. Cancer is not a single disease; it is a group of more than 100 different and distinctive diseases. Brachytherapy, as a procedure, started since Roentgen discovered X-rays in 1895 followed by Becquerel's discovery of natural radioactivity in 1896, when he reported the destructive impact of radioactive isotopes. In brachytherapy (also referred to as curie-therapy) radioactive substance is encapsulated and placed directly or near the tumour. The sources are located into the treatment volume. High-dose-rate (HDR) brachytherapy is a technique using a source of specific high activity (10 Curie Ir-192 or 2 Ci Co-60 source) in delivering a therapeutic dose of radiation, using temporarily placed needles, catheters or other applicators to the respective procedures. HDR brachytherapy was proven to be highly successful treatment for cancers of prostate, cervix, endometrial, breast, skin, bronchus, oesophageal, and head and neck. Soft tissue sarcomas, ocular melanomas and several other types of cancer could also be treated with success. Any tumor that is accessible to needles, catheters or tubes is potentially treatable. Depending on the staging cervical cancer, patients are selected for intracavitary technique before or after surgery. Brachytherapy, is used in management of tumors in one of the two settings: 1) post hysterectomy for most non-bulky stage I, IIA tumors of cervix where radical surgery is performed with the removal of parametrical tissue, a vaginal cuff and pelvic lymphadectomy; 2) for some advanced bulky tumors of uterus, having stages IB, II, III and IV, primary radiotherapy and brachytherapy will be the treatment of choice. Staging IIIB and onwards, patients are selected for interstitial implant [4].

2. Materials and Methods

Physical properties of Co-60 overrides Ir-192 as a brachy source by having $E_\beta$ of 0.313 MeV, $E_\gamma$ of 1.25 MeV, Exposure rate constant of 13.07 R-cm$^2$/h/mCi and air kerma rate constant of 306 $\mu$Gy-m$^2$/h/GBq where these are lower in Ir-192 as 0.24-0.67 MeV, 0.38 MeV, 4.69 R-cm$^2$/h/mCi and 111 $\mu$Gy-m$^2$/h/GBq respectively. High specific activity of 200 Ci/g has made it useful as a high dose rate remote afterloader [10, 11].

For lower energy brachytherapy Sources (I-125 and Pd-103) that release energy by the photoelectric effect, the dose to the bone can be twice the dose to the water.

2.1. Patient Selection

In general, all women with locally advanced cervical cancer – International Federation of Gynecology and Obstetrics (FIGO) stage IB2-IVA – should be considered for brachytherapy as part of their definitive treatment management [4]. Selection of patients for treatments with applicators, for this study, was carefully chosen based on criteria such as stage of disease, age, background and general conditions.

2.2. ICBT applicator placement and brachytherapy treatment planning

Brachytherapy for cervical cancer can be performed using an intracavitary, interstitial, or combination approach. Intracavitary brachytherapy involves placing the radioactive source using an applicator, through the vaginal cavity, and can treat the upper vagina, cervix, and uterus. In interstitial brachytherapy, catheters (small tubes) are placed in and around residual disease, using a transperineal/vaginal approach.

The choice of technique depends primarily on disease extent and anatomy. It is imperative to consider which approach should be used, starting at the time of diagnosis.

HDR intravaginal brachytherapy are given to those invasive cervical cancer patients who have high grade histological varieties, positive or closed surgical margins. It is also applied to the
patients having vault recurrence when they are susceptible to vault recurrence i.e. endometrial carcinoma.

Intracavitary brachytherapy remains the most commonly practiced form of brachytherapy for cervical cancer. A wide variety of commercially available applicators exists for intra-cavitary brachytherapy. The T&O consists of a tandem, an intrauterine tube placed through the cervix to the level of the uterine fundus and two ovoids (colpostats) that are placed on either side of the cervix in the lateral vaginal fornices.

Interstitial brachytherapy utilizes a transperineal template, through which several hollow tubes are inserted directly into tissues (Figure 3). A tandem and central vaginal cylinder are incorporated into the template. Commonly used templates include the Syed-Neblett template. Interstitial brachytherapy has been characterized as the treatment of choice when intracavitary applicators are deemed unsuitable. Recognized indications for interstitial brachytherapy include large tumors, lower vaginal involvement, lateral extension of disease (beyond the reach of intracavitary applicators), and ill-fitting intracavitary applicators (which may result from an effaced cervix or narrow vaginal fornices). Patients who have had a supracervical hysterectomy and who develop cancer in the cervical stump should also be considered for interstitial implants. Template-based interstitial methods are (ultimately) the most flexible form of gynecologic brachytherapy, and can be used for the widest variety of clinical scenarios.

Brachytherapy treatment plan was done using Somatom Emotion 16 slice CT scanner and HDR Plus treatment planning system.

2.3. Treatment
For external radiotherapy, Linac was used with box technique and dose given as 50 Gy/25 fractions. Following a rest period of one week for the tissue to recover and to control any associated local infection, but within two weeks for all patients HDR brachytherapy treatment was started delivering dose according to Hospital protocol. The whole treatment was completed within eight weeks [2].

3. Results
Cylinder was chosen (30 mm Diameter) according to patient’s anatomy. The dose in this procedure is usually calculated at 0.5 cm from the cylinder surface where organs at risk (OAR) are very close. A prescription for 5 Gy/2 fractions at 0.5 cm from cylinder surface (i.e. cylinder radius, $r = +0.5$ cm). This is delivered weekly to the upper third of the vagina [1].

| Age | 42 Years |
|-----|----------|
| Diagnosis | Ca-Endometrium |
| Stage | II A |
| Prescribed Dose | 25 Gy/fraction |
| Total Fraction | 2 |
| Total Dose | 100 Gy |
| Cylinder Diameter(mm) | 30mm |
| Bladder Dose | 7.7 Gy |
| Rectum Dose | 6.78 Gy |

Table 1. Patient data [8,9]

Figure 1. Cylinder Treatment Plan [5]
Manchester suit applicators were used with appropriate Ovoid’s: half ovoid (25 mm diameter) with tandem angle 25°. Combination of ovoid size and tandem angle were chosen according to patient’s anatomy. Packing was done to avoid any shift or changes in the geometry of the applicators placement and to prevent the relocation of the rectum and bladder. Dose prescription of 7 Gy per fraction in 3 sessions were done at Point A of Manchester System using standard source loading pattern without immobilization.

The number of needle insertion depends on size and shape of the tumor. In our patients, we used maximum 6 needles through perineal template with one obturator in the center. The treatment was delivered ‘BID’ with a dose of 9 Gy/Fr [6].

4. Conclusions
The ratio of applicator surface dose to dose at some specified distance from the applicator decreases as the applicator diameter increases or, for that matter towards the pelvic wall. The important decision in selecting the applicators (e.g. cylinder, T&O and interstitial) make a significant difference in patient treatments (Figs. 1-3) where prognosis is observed to be excellent.

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