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Workflow and efficiency in MRI-based high-dose-rate brachytherapy for cervical cancer in a high-volume brachytherapy center

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ABSTRACT

PURPOSE: We report the clinical workflow and time required for MRI-based image-guided brachytherapy (MR-IGBT) of cervical cancer patients in a high-volume brachytherapy center with 10 years of experiences to provide a practical guideline for implementing MR-IGBT into clinical use.

METHODS AND MATERIALS: We recorded the time and workflow of each procedure step within the 40 consecutive ring and tandem applicator fractions of MR-IGBT by our multidisciplinary team. We divided the entire procedure into four sections based on where the procedure was performed: (*1*) applicator insertion under sedation, (*2*) MR imaging, (*3*) planning, and (*4*) treatment delivery. In addition, we compared the current procedure time to the initial procedure time when first implementing MR-IGBT in 2007−2008 via a retrospective review.

RESULTS: Mean total procedure time was 149.3 min (SD 17.9, ranges 112−178). The multidisciplinary team included an anesthesia team, radiologist, radiation oncologist, nurses, radiation therapists, MRI technicians, dosimetrists, and physicists. The mean procedure time and ranges for each section (min) were as follows: (*1*) 56.2 (28.0−103.0), (*2*) 31.0 (19.0−70.0), (*3*) 44.3 (21.0−104.0), and (*4*) 17.8 (9.0−34.0). Under current setting, the combined mean procedure time for MR imaging and planning was 63.2 min. In comparison, the same procedure took 137.7 min in 2007−2008 period, which was significantly longer than the current workflow ($p < 0.001$).

CONCLUSIONS: A skilled and dedicated multidisciplinary team is required for an efficient clinical workflow and delivery of MR-IGBT. Over the years, we have improved efficiency with clinical experience and continuous efforts in staff education.

Keywords: Workflow; Efficiency; MR-IGBT; Cervical cancer; HDR brachytherapy

Introduction

High-dose-rate (HDR) brachytherapy (BT) for cervical cancer has evolved over the last decade with the use of three dimensional (3D) imaging and advances in technology (1, 2). Among various imaging modalities, MRI has been accepted as the ''gold standard'' for visualizing the tumor volume (3−6). Multiple studies, including prospective clinical trials, have demonstrated that the repetitive use of MRI in cervical cancer treatment improves patient outcome (7−14).

A practice pattern survey conducted by The American Brachytherapy Society in 2014 reported that image-guided BT (IGBT) utilization has significantly increased compared to a prior study conducted in 2007 (15). That report found that IGBT planning consisted of CT in 95% of respondents and MRI in 34% of respondents. Of note, 77% of respondents that utilize MRI-based planning did so during their first fraction, whereas only 6% of respondents utilized MRI-based planning for all fractions. These findings may be associated with challenges in workflow logistics including access to an MRI scanner, coordinating multidisciplinary efforts, increased labor demands, and a longer procedure time. Each factor may result in a delay of treatment scheduling and prolongation of treatment time, which has been shown to negatively impact clinical outcome.

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Our department performs approximately 1000 fractions of HDR BT each year. Among them, 200−250 fractions (45−55 patients or 20−25% of total BT volume) are for cervical cancer treatments. We implemented MRI-based BT for cervical cancer patients in the year 2007 following Gynaecological Groupe Européen de Curiethérapie-European Society for Radiotherapy and Oncology working group contouring and planning guidelines (Recommendations I and II by working group) (6, 16). Initially MRI-based planning was performed for the first fraction followed by CT-based planning for the subsequent fractions. In the year 2011, we began performing MRI-based planning for each fraction of HDR BT. Our department now serves as a high-volume BT center with one of the largest and most robust followup databases for MRI-based HDR BT for cervical cancer in North America (14). Herein, we described the clinical workflow and report the time requirement of each step of MRI-based BT, including the change of workflow efficiency over time. Our goal is to provide a detailed guideline for implementing efficient MRI-based BT into widespread clinical practice.

Methods and materials

Treatment procedure in the department

Between November and December of 2017, 46 consecutive MRI-based BT fractions of cervical cancer treatment with ring and tandem applicator (MR-compatible carbon plastic applicator; Nucletron, an Elekta company, Elekta AB, Stockholm, Sweden) were planned with Oncentra treatment planning system v.4.3 and delivered via Nucletron HDR unit (Nucletron, an Elekta company, Elekta AB, Stockholm, Sweden). Treatment was prescribed to 27.5−30 Gy over five fractions to a high-risk clinical target volume (6) for all patients. We categorized our treatment procedure into four sections based on where the procedure was performed: this included applicator insertion under sedation, MR imaging, treatment planning, and treatment delivery/applicator removal. Each section was composed of a series of tasks, and the time associated with each task was recorded. Documentation of the time associated with each task was started when a patient was brought to the procedure room in the department and ended when applicator was removed from the patient after the completion of treatment. Staff personnel needed for each task in the procedure are described as follows. The detailed tasks in each section are also represented in Fig. 1.

Applicator insertion under sedation

1 Patient is brought to the procedure room in the department: therapist.
2 Preparation and sedation: anesthesiology team, nurse, and therapist.
3 Application insertion with ultrasound guidance: radiologist, anesthesiology team, nurse, therapist, and radiation oncologist (and resident).
4 Applicator position verification via CT scan: radiation oncologist, therapist, anesthesiology team, and physicist.

MR imaging

1 Patient transferred to the MRI scanner in radiology department: therapist.
2 MRI scan for planning (1.5 T GE MRI scanner using 3D Cube T2 weighted true axial sequence only): MRI technicians.
3 Patient is transferred back to the radiation oncology department: therapist.

Treatment planning

1 MR images imported to treatment planning system: dosimetrist and physicist.
2 Contouring on MR image: radiation oncologist (and resident) and dosimetrist.
3 Treatment planning with MR image only: physicist.

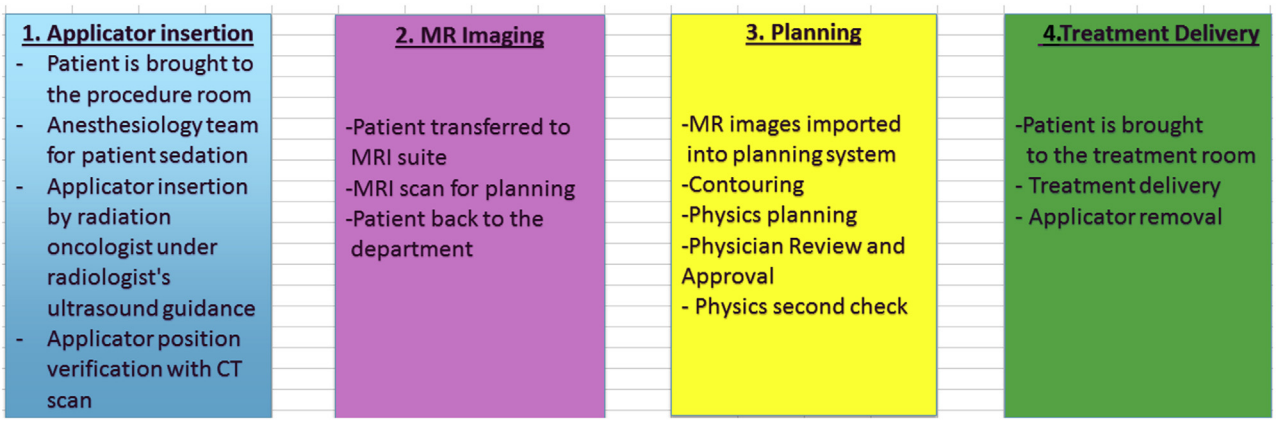

Fig. 1. Workflow and associated task in each procedure.