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Redesign of process map to increase efficiency: Reducing procedure time in cervical cancer brachytherapy

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ABSTRACT

PURPOSE: To increase intraprocedural efficiency in the use of clinical resources and to decrease planning time for cervical cancer brachytherapy treatments through redesign of the procedure's process map.

METHODS AND MATERIALS: A multidisciplinary team identified all tasks and associated resources involved in cervical cancer brachytherapy in our institution and arranged them in a process map. A redesign of the treatment planning component of the process map was conducted with the goal of minimizing planning time. Planning time was measured on 20 consecutive insertions, of which 10 were performed with standard procedures and 10 with the redesigned process map, and results were compared. Statistical significance ($p < 0.05$) was measured with a two-tailed t test.

RESULTS: Twelve tasks involved in cervical cancer brachytherapy treatments were identified. The process map showed that in standard procedures, the treatment planning tasks were performed sequentially. The process map was redesigned to specify that contouring and some planning tasks are performed concomitantly. Some quality assurance tasks were reorganized to minimize adverse effects of a possible error on procedure time. Test dry runs followed by live implementation confirmed the applicability of the new process map to clinical conditions. A 29% reduction in planning time ($p < 0.01$) was observed with the introduction of the redesigned process map.

CONCLUSIONS: A process map for cervical cancer brachytherapy was generated. The treatment planning component of the process map was redesigned, resulting in a 29% decrease in planning time and a streamlining of the quality assurance process. © 2015 American Brachytherapy Society. Published by Elsevier Inc. All rights reserved.

Keywords: Brachytherapy; Efficiency; Process maps; Workflow

Introduction

Intracavitary brachytherapy after external beam radiotherapy is the standard of care for dose escalation of locally advanced cervical cancer patients (1, 2). The treatment usually involves multiple insertions of an applicator composed of an intrauterine component (a tandem) and a vaginal component (ring or ovoids) (1−6). Historically, treatment planning was performed using a standard plan with a pear-shaped distribution and dose specified at Point A. Imaging was limited to two-dimensional plain X-ray films. Since the 1990s, three-dimensional (3D) imaging with CT and MRI has become more common (7−10), allowing image-guided insertion and planning. Insertion-specific plan optimization has become feasible with the introduction of high-dose-rate brachytherapy. The increased use of imaging for the insertion and customized planning has been linked to improved outcomes and low toxicity (11, 12). Nevertheless, the added complexity involved in 3D planning with dose optimization, an attempt to summate external beam dose, and quality assurance (QA) of high-dose-rate plans and treatments may result in an increase in planning time and plan verification time (13). These increased times result in increased demands on clinic resources, which may deter some centers from fully

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adopting image-based brachytherapy. Moreover, several QA practices have been developed and are required by the Nuclear Regulatory Commission to ensure the safe administration of brachytherapy treatments. Depending on the specific implementation of the QA practices in intracavitary brachytherapy, the timing of detection and correction of possible errors may result in significant delays in the administration of treatment after applicator insertion.

Multiple guidelines are available to establish a safe and effective cervical cancer brachytherapy practice (1, 2, 14, 15). Recently, particular attention has been dedicated to failure mode and effect analysis (FMEA) (16, 17), which can be used to improve safety for brachytherapy procedures (18, 19). One of the strengths of FMEA is its focus on potential pathways of failure. FMEA is performed through the delineation of a process map (20−22), which is a description of the various components of a process and their relations with each other. FMEA is generally performed by a multidisciplinary team (23). In industry and the public sector, process map analysis has been used to improve the utilization of resources (24, 25). Although multiple publications have reported process maps in radiotherapy (16, 22, 26), and also in particular in cervical cancer brachytherapy (13), the analysis and redesign of the process map to increase efficiency is an approach that has not yet been used in radiotherapy applications. In this work, we describe the standard process map for cervical cancer brachytherapy and provide results showing how this map was redesigned to reduce treatment planning time. We also sought to implement in the process map an efficient and safe QA practice, which, without loss of quality, would reduce the delay in patient treatment because of possible errors.

Methods and materials

The generation of the process map performed in this study, modifications required and analysis were conducted by a medical physicist in consultation with a multidisciplinary team composed of an attending radiation oncologist (authorized user) specializing in gynecologic brachytherapy; a nurse routinely participating in gynecologic brachytherapy procedures; an operating room technical assistant responsible for maintenance and preparation of the equipment; and a radiation therapist responsible for patient setup, ultrasound imaging and treatment delivery.

Identification of process components (tasks)

The process under investigation is CT-guided brachytherapy for cervical cancer in our department. Standard fractionation for cervical cancer patients in our institution is 25 fractions of 1.8 Gy of external beam radiation to the whole pelvis, followed by five fractions of 5.5 Gy as a boost to the remaining clinical target volume (CTV) with brachytherapy. Procedures are performed in a dedicated brachytherapy suite equipped with a CT scanner and ultrasound imaging available, if needed. Tandem-and-ring, tandem-cylinder, tandem-interstitial, or tandem-and-ovoid applicators are used for outpatient treatments (Nucletron, an Elekta company, Stockholm, Sweden), with the option of inserting interstitial needles through the ring and ovoids when necessary. The overall process is defined as all tasks occurring between the patient's check-in at the Department of Radiation Oncology on the day of the procedure to the exit of the patient from the brachytherapy suite after treatment. Tasks associated with examinations and patient imaging occurring before the day of the procedure are not considered in this analysis.

Process map and redesign

A process map of the intracavitary insertion workflow was generated by analyzing the dependencies between the tasks and organizing the information in a visual map (standard process map). After completion of the process map, a redesign of the treatment planning subprocess (defined as all tasks between end of implantation and treatment) was conducted, with the goal of minimizing anesthesia time and redistributing QA tasks to reduce the effect of potential errors on procedure time, without loss of quality. The redesigned process map was put into clinical practice after validation through simulations.

Measure of effect of process map redesign

The effect of process map redesign on planning time was measured in an institutional review board−approved retrospective analysis by calculating the time between acquisition of the planning CT and completion of the planning process (using the time stamp associated with the planning physicist signature, which occurs at the end of planning, after final physician review, but before independent check). Twenty consecutive insertions were considered in this study with institutional review board approval: 10 consecutive insertions performed before the implementation of the redesigned process map, and 10 consecutive insertions performed after the implementation of the optimized process map. Statistical significance ($p < 0.05$) of the difference in planning time before and after process map redesign was measured with a two-tailed Student's t test.

The planning time analysis was performed retrospectively, and at the time of the procedures, the personnel were not aware that such a study would be conducted. Four physicists, two attending physicians, and two radiation therapists were involved in the planning, QA, and treatment of the 20 insertions considered in this study.

Results

Identification of process components (tasks)

Twelve tasks were identified. The personnel and resources needed for each task and the prerequisite(s) needed for each task are listed in Table 1.