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Cost-Effectiveness of Reduced Waiting Time for Head and Neck Cancer Patients due to a Lean Process Redesign

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ABSTRACT

Background: Compared with new technologies, the redesign of care processes is generally considered less attractive to improve patient outcomes. Nevertheless, it might result in better patient outcomes, without further increasing costs. Because early initiation of treatment is of vital importance for patients with head and neck cancer (HNC), these care processes were redesigned. **Objectives:** This study aimed to assess patient outcomes and cost-effectiveness of this redesign. **Methods:** An economic (Markov) model was constructed to evaluate the biopsy process of suspicious lesion under local instead of general anesthesia, and combining computed tomography and positron emission tomography for diagnostics and radiotherapy planning. Patients treated for HNC were included in the model stratified by disease location (larynx, oropharynx, hypopharynx, and oral cavity) and stage (I–II and III–IV). Probabilistic sensitivity analyses were performed. **Results:** Waiting time before treatment start reduced from 5 to 22 days for the included patient groups, resulting in 0.13 to 0.66 additional quality-adjusted life-years. The new workflow was cost-effective for all the included patient groups, using a ceiling ratio of €80,000 or €20,000. For patients treated for tumors located at the larynx and oral cavity, the new workflow resulted in additional quality-adjusted life-years, and costs decreased compared with the regular workflow. The health care payer benefited €14.1 million and €91.5 million, respectively, when individual net monetary benefits were extrapolated to an organizational level and a national level. **Conclusions:** The redesigned care process reduced the waiting time for the treatment of patients with HNC and proved cost-effective. Because care improved, implementation on a wider scale should be considered.

Keywords: cost-effectiveness analysis, economic evaluation, head and neck, process redesign, waiting time.

Introduction

Optimal treatment for every individual patient has always been the main goal in medicine. However, the increased number of costly new treatment options combined with the aging population result in a dramatic increase in health care costs [1,2]. Because resources are scarce, decisions have to be made on which treatment options should be made available for society and included in health care insurance packages. Cost-effectiveness analyses can support these difficult decisions by providing the relevant information including long-term costs and benefits for patients and the health care sector [3].

A redesign intervention of care processes might optimize quality and efficiency of care, although medical professionals often consider it less attractive than adopting new technologies. Time to treatment or waiting time might be shortened, resulting in better patient outcomes without driving costs to a maximum.

For oncology patients in general, and for patients with head and neck cancer (HNC) in particular, waiting time is significantly associated with patient outcome. Because HNC tumors have a fast doubling time, long waiting times cause tumor progression and negatively affect local tumor control and survival rates [4]. Based on theoretical evidence, delay in radiotherapy (treatment with irradiation) may affect the outcomes of treatment by permitting the proliferation of clonogenic cells, leading to decreased probabilities of local control, which has been confirmed by retrospective observational studies [5]. Chen et al. [4] showed in a systematic review that the risk of local recurrence (relative risk [RR] 1.15 per month waiting time) and mortality (RR 1.16 per month waiting time) increased for patients with HNC with increased waiting time for radiotherapy. Waaijer et al. [6] estimated an average control loss of 16% to 19% due to tumor progression for a mean waiting time of 56 days, potentially resulting in increased mortality [7]. The probability and severity

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of treatment complications might also increase, because larger volumes have to be irradiated, causing a potential decrease in quality of life for patients [8]. Therefore, optimization of care processes to minimize the waiting time is important to improve outcomes for patients with HNC.

The treatment of patients with HNC needs optimal collaboration between several disciplines (head and neck [HN] surgeons, radiation oncologists, medical oncologists, pathologists, radiologists, etc.) to improve medical decision making. Involving all these disciplines could hamper short waiting times. With an aim to optimize waiting times, we redesigned the care process and evaluated its benefits in terms of patient outcome and cost-effectiveness.

Methods

Markov Model Description

A cost-effectiveness analysis was performed for patients with stage I and II and stage III and IV HNC located in the oropharynx, larynx, hypopharynx, and/or oral cavity, for which the workflow was redesigned. Patients were treated at the Maastricht University Medical Centre and at the MAASTRO CLINIC, in the joint Multidisciplinary Head and Neck Board, including HN surgeons as well as radiation oncologists. These particular patient groups were considered because of the expected benefits on patient outcomes from a shortened time to treatment [4] and the possibilities of redesigning the workflow for these patients in particular. Results were stratified for tumor sites and stages because differences in not only improvements in the waiting time, but also the prognoses and quality of life of these patients groups were expected. The Tumor Nodes Metastases stage grouping system of the Union for International Cancer Control, seventh edition, was used for staging [9]. Stage IV can be further subdivided into stage IVa (based on T4 status), IVb (based on N3 status), and IVc (based on M1, distant metastases). In this study, patients only with locoregional disease, that is, stage I, II, III, IVa, and IVb, were included. Patients with stage IVc (metastasized disease) were excluded.

In the studied organizations, the standard diagnostics of the mentioned patient groups included a computed tomogram or magnetic resonance imaging, an X-thorax, and a tumor biopsy under full anesthesia in an operating theater in accordance with the national guidelines for clinical practice [10]. For patients with HNC treated by radiotherapy, a therapeutic computed tomography-positron emission tomography (PET-CT) is performed for treatment planning. In the regular workflow, this PET-CT is performed after diagnosis within the preparation phase of radiotherapy. To reduce waiting times and use equipment and personnel more efficiently, the workflow of the diagnostic and preparation phases of radiotherapy was redesigned. A Markov model was used to analyze costs and benefits of this logistic process redesign. This redesign included two main organizational changes:

1. Performing a diagnostic tumor biopsy and evaluation of the upper aerogastrointestinal tract under local instead of general anesthesia (time to treatment shortened by 17 days).
2. Performing a diagnostic PET-CT in radiation treatment position using an immobilization mask before radiotherapy instead of an additional PET-CT during preparation for radiotherapy (time to treatment shortened by 5 days).

The rationale for the first change was that the examination under general anesthesia required available time in the operation theater and this proved to be a rate-limiting step in the diagnostic process of patients with HNC. To increase the efficiency of the diagnostic process and decrease waiting times for patients, new methods were evaluated to diagnose HNC without losing the quality of investigation. Chip-on tip cameras provide excellent imaging and are technologically advanced as compared with earlier fiber optic tools [11]. Imaging of the lungs has improved drastically, and is increasingly performed under local anesthesia since the development of these chip-on tip cameras. Because of these positive results combined with the possibility of performing a tumor biopsy under local instead of full anesthesia, a pilot was performed for patients with HNC. Preliminary results from this study show that flexible pan endoscopy under local anesthesia is as good as pan endoscopy under general anesthesia, and in some situations superior, for example, assessment of larynx movements. Although the accuracy of this diagnostic tumor biopsy for HNC using local anesthesia is promising, it is still under consideration.

The rationale for the second change was that staging PET-CT is not standard in the diagnostics of patients with HNC. Usually, locoregional staging is performed by CT and/or magnetic resonance imaging of the HN region in accordance with the national guidelines for clinical practice [10]. Screening for distant metastases is usually done by a conventional chest X-ray (for low-risk patients), or a CT-chest for high-risk patients. PET-CT in treatment position of the HN and the upper thoracic area is not performed in every radiotherapy center for radiation treatment planning of HN tumors. An increasing number of radiotherapy centers (including the studied organization), however, consider PET-CT a standard procedure for treatment planning to facilitate the delineation of the gross tumor volume for particular patient groups [12,13]. Because of the etiological factors associated with HNC (i.e., nicotine and alcohol abuse), these patients are also at risk of secondary tumors, for example, lung cancer and/or esophageal cancer. Performing a PET-CT for radiation treatment planning, therefore, increases the detection of second primary tumors and/or metastases that had not been identified in conventional staging. This would lead to additional investigational procedures and delay the start of treatment. By performing a diagnostic PET-CT of the HN area and the chest in radiation treatment position instead of performing a PET-CT after diagnosis, optimal staging, including screening for second primaries, or metastases, is combined with the preparation for state-of-the-art radiation treatment planning. By including a PET-CT in radiation treatment position in the diagnostic process of patients expected to receive radiotherapy treatment, time to treatment can be reduced and a diagnostic CT becomes unnecessary.

The original/regular process flow (regular workflow [RWF]) was compared with three new process flows (new workflow [NWF]): 1) tumor biopsy (to define tumor status) under local anesthesia. Because local anesthesia can be provided outside of operation theater, scheduling is independent of surgery schedules and delays; 2) a diagnostic PET-CT used before radiotherapy; and 3) a combination of 1) and 2) (see Table 1). Because only the logistics of the workflow changed, the actual care/treatment of the included patients did not, and was still in accordance with the national guidelines for clinical practice [10]. Only patients with tumors located in the larynx and in the oral cavity were considered for a biopsy under local anesthesia, because the other tumors cannot be optimally assessed under local anesthesia because palpation forms a big part of this assessment. Most patients with tumors of the oral cavity are treated with surgery as primary treatment. Postoperative radiation therapy is given on the basis of indications derived from the pathology report. Therefore, these patients were not considered for a PET-CT in radiation treatment position.

The current Markov model used in this study included four health states: progression-free survival, local/regional recurrence