

Chapter 40

Isocenter Verification in Radiotherapy Clinical Practice Using Virtual Simulation: An Image Registration Approach

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ABSTRACT

This chapter presents an overview of the procedures that are used for the verification of the patient position during radiotherapy. Furthermore, a method for the verification of the radiotherapy isocenter prior to treatment delivery is proposed. The method is based on the alignment of two Computed Tomography (CT) scans: a scan, which is acquired for treatment planning, and an additional verification scan, which is acquired prior to the treatment delivery. The proposed method was applied to CT scans, acquired from 20 patients with abdominal tumors and 20 patients with breast/lung cancer. The results of the proposed method were compared with the ones obtained using conventional methods, indicating that the estimated isocenter displacement can be translated into patient setup error inside the treatment room.

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INTRODUCTION

According to the World Health Organization (WHO), chronic diseases (also known as not noncommunicable diseases) are long duration diseases that are not passed from person to person (World Health Organization, 2014). The main types of chronic diseases are cardiovascular diseases (like heart attacks and stroke), cancers, respiratory diseases (such as chronic obstructed pulmonary disease and asthma) and diabetes. Cancers can be considered the most serious chronic diseases with significant impact on the patients. According to Ferlay et al. (2013), *“there were 14.1 million new cancer cases, 8.2 million cancer deaths and 32.6 million people living with cancer (within 5 years of diagnosis) in 2012 worldwide. 57% (8 million) of new cancer cases, 65% (5.3 million) of the cancer deaths and 48% (15.6 million) of the 5-year prevalent cancer cases occurred in the less developed regions. The overall age standardized cancer incidence rate is almost 25% higher in men than in women, with rates of 205 and 165 per 100,000, respectively. Male incidence rates vary almost five-fold across the different regions of the world, with rates ranging from 79 per 100,000 in Western Africa to 365 per 100,000 in Australia/New Zealand (with high rates of prostate cancer representing a significant driver of the latter). There is less variation in female incidence rates (almost three-fold) with rates ranging from 103 per 100,000 in South-Central Asia to 295 per 100,000 in Northern America. In terms of mortality, there is less regional variability than for incidence, the rates being 15% higher in more developed than in less developed regions in men, and 8% higher in women”*.

One of the most common methods for cancer treatment is radiation therapy, which is a clinical modality dealing with the use of ionizing radiations in the treatment of patients with malignant neoplasias (and occasionally benign diseases) (Halperin, Brady, Perez, & Wazer, 2013).

Radiation therapy (or Radiotherapy) plays a central role in dealing with benign and malignant tumors and is an important way to alleviate the clinical symptoms of the disease when treatment is not feasible. Approximately 60% of all cancer patients in Europe and the United States of America are subjected to radiation therapy (external or internal), which either is the main method of treating cancer or used in combination with chemotherapy or surgical removal of the tumor (Halperin et al., 2013). The term radiotherapy usually refers to external irradiation of the tumor region with the aim of delivering the maximum dose to the tumor with the least possible impact on healthy tissue. This can be achieved by splitting and administering the total radiation dose in successive sessions, in order to destroy cancer cells while leaving the possibility of healthy cells to recover.

The conventional radiotherapy treatment includes the following stages: pretreatment imaging, determination of tumor and critical organs, treatment planning, simulation and treatment plan assessment, patient immobilization, quality control and verification, treatment administration. In particular, during the pretreatment imaging, diagnostic images are collected in order to be used to create the treatment plan. Usually, computed tomography (CT) is carried at treatment position for locating the area to be radiated, while other imaging techniques may be used (such as PET and MRI for patients with lung cancer and prostate respectively). The images from CT and possible other imaging modalities are transferred to the treatment planning system, where areas of interest are defined. The areas of interest include the Gross Tumor Volume (GTV), the Clinical Tumor Volume (CTV) and the Planning Tumor Volume (PTV). The GTV is composed of the primary tumor volume, possible metastatic lymphadenopathy or other metastases (GTV M). The CTV comprises the GTV leaving an additional margin (approximately 1cm)

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