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Now is the Time for Personalized Imaging Protocols in Cancer Diagnosis and Radiotherapy

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Since the discovery of X-ray in 1895, medical imaging procedures, particularly those involving ionizing radiation such as computed tomography (CT) and cone-beam computed tomography (CBCT), have been playing a crucial role in cancer diagnosis and radiotherapy, revolutionizing our ways to detect and fight cancers at every stage of disease [1,2]. Driven largely by advances in technological development as well as a fee-for-service healthcare model, the use of medical imaging modalities in cancer diagnosis and radiotherapy has increased dramatically in the past thirty years [3,4]. For example, it is estimated that more than 81.2 million CT procedures were performed in the United States alone in 2014, which are 7% higher than the procedures performed in 2013 and 27 times increase as compared to 3 million CT scans in 1980 [5]. The same trend of increasing usage of CT, CBCT and other medical imaging procedures, particularly in pediatric diagnosis, adult screening and tumor localization during radiation therapy, has been observed at other countries as well, and the trend is expected to continue for the next few years [6].

In addition to over-usage of imaging procedures, another pressing issue associated with current clinical practices in cancer diagnosis and radiotherapy is non-personalization of medical imaging procedures. That is, a 'one-protocol-fits-all' practice is often applied in the clinic worldwide. Basically, the imaging protocols provided by manufacturers are uniformly applied without considering individual differences of patients being scanned. Consequently, children and small-sized adults may be over-exposed from the default site-specific protocols due to reduced tissue attenuation [7-10]. On the other hand, the same protocol may result in under-exposure with sub-optimal image quality in larger patients, often leading to repetitive and unnecessary imaging procedures [11,12]. As radiation exposure from CT, CBCT and other radiological procedures can be cumulative over a person's lifetime, the increasing exposure to radiation in a large population around the world could become a public health issue in the future [13,14]. In fact, data from a recent retrospective study in UK suggested that a statistically significant correlation exists between radiation exposure and subsequent cancer risks in children who received imaging procedures involving ionizing radiation at their early childhood [15].

As radiation exposure should always operate under the principle of 'as low as reasonably achievable' (ALARA), it is our strong belief that now is the time to incorporate personalized imaging protocols into cancer diagnosis and radiotherapy to address the ever increasing radiation doses from over-used and non-personalized imaging practices. By personalized imaging protocols, we mean that all imaging examinations involving ionizing radiation should be performed with justification and optimized based on lesion site, anatomy, gender, age, imaging history and clinical requirement of each individual patient.

There are three major benefits associated with personalized imaging protocols in cancer diagnosis and radiotherapy: quality of care, patient safety, and cost reduction. First, patients undergoing diagnostic scans will benefit from clinically-justified and customized imaging procedures for improved diagnosis and screening, hence improved quality of care. Second, cancer patients who are more vulnerable to radiation carcinogenesis will be better protected from unnecessary radiation exposure as a result of personalized imaging protocols employed in cancer diagnosis and radiotherapy, contributing to improved patient safety. The avoidance of excessive irradiation of normal tissues could reduce the potential risks for radiation-related secondary cancers, especially for pediatric patients [15]. Third, consistent with a cost-effective and value-based healthcare model, personalized imaging protocols would reduce the need for repeat clinical procedures and provide an opportunity to reduce healthcare costs with long-term economic gains to society [4].

In a foreseeable future, as we are going to embrace a "perfect storm" created by the coming together of a demanding need for all healthcare providers to improve quality of care to their patients, considerably reduced payment for clinical services, and a more challenging environment for external research funding, personalized imaging protocols may provide a viable path to avoid the negative impact of this imminent storm on cancer diagnosis and radiotherapy and lead us to the buildup of a more cost-effective and sustainable healthcare model based on clinical evidence and patient outcome.

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