Using radiomics and deep learning-based imaging biomarkers to predict radiotherapy outcomes and toxicity

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Impact

1. Clinical impact

This thesis examined radiomics and image-based biomarkers in the context of clinical needs. The outcomes studied are the most important for radiation oncologists to consider when making clinical decisions. There are three implications for the clinic. First, different sources of information used in our daily work, such as clinical parameters, tumor metabolic information, and anatomical imaging information can be valuable in the field of artificial intelligence (Chapters 4, 6, and 7). Clinical cognition is the basis of AI research in the medical field. In Chapter 5, I optimized the ROI based on clinical experience and demonstrated that clinical knowledge could guide the optimization of models. Second, the efficacy of parameters based on radiomics, for example, may meet or even exceed the benchmark parameters currently used in the clinical practice. In Chapter 6, I demonstrated that dosiomics predictive power outperforms current benchmark DVH parameters. Third, artificial intelligence tools have the potential to be embedded in daily clinical practice. The application platforms presented in Chapter 7 evidence the potential for future applications of artificial intelligence.

Overall, this thesis contributes to the application of radiomics and artificial intelligence to assist clinical work and update clinical tools.

2. Technological impact

Although I do not propose new algorithms or invent new hardware in this paper, there are several lessons learned from the application of the technology that can help technologists working in the field. First, problems that are considered clinically intractable can be accomplished using the appropriate technology needed for the clinical task. As discussed previously, predictive power beyond the benchmark model can be achieved using simple artificial intelligence models. Again, the approach presented in Chapter 7 adapts commonly used algorithms to specific tasks, dynamically combining CT images and radiation dose images to achieve results that are difficult to accomplish with non-artificial intelligence approaches. Second, trials and studies from a technical perspective should take full account of clinical experience and clinical needs. For example, the image preprocessing methods and the choice of algorithms, should be adapted to the task context. Third, I follow the tenet of open science and made our code, configuration files and data as open as possible. This can be made available to future technologists for reference.

3. Impact on patients

Although the users of the model developed in this thesis are physicians, it is the patients who are ultimately the recipient of the clinical intervention. The methods and models presented in this thesis have practical implications for patients.

First, in terms of practical benefits to patients, the approach proposed in this thesis can help optimize clinical decision making, thereby prolonging patient prognosis (Chapters 4 and 5) and reducing patient suffering (Chapters 6 and 7). They may also be used to inform patients better of their expected outcomes and ultimately in shared decision making, where appropriate.

Second, from a financial burden perspective, as a result of accurate screening of high-risk groups, physicians will be able to target patients for closer follow-up or recommend certain treatments or medications. Considering the whole population, this will reduce the overall economic burden. All of the models developed in this thesis are based on routine examinations without the need to undertake expensive tests such as genetic sequencing. Hardware such as computers are reusable. Therefore, patients do not have to bear additional costs. This is important for society as a whole, but especially important in countries, such as China, in which patients themselves have to pay a significant part of the treatment cost.

4. Societal impact

In this thesis, we demonstrated the potential of image-derived biomarkers for clinical applications. From a societal perspective, effective support for clinical decision making can reduce the financial burden on patients and insurance expenditures, thereby increasing the effectiveness of health insurance utilization.

The application of the clinical prediction models presented in the paper has the potential to provide better treatment protocols for patients, reduce the incidence of side effects, and improve prognosis. As a result, the workload of physicians can be reduced to some extent and more medical resources can be freed up to serve the society.

At the same time, this thesis provides an explanation of the clinical applications of AI, which may improve physicians' acceptance of AI and thus contribute to the future application of AI tools in the real world.