Artificial intelligence for imaging in immunotherapy

Summary

Chapter 2. Lesion response prediction to immunotherapy.

In this chapter, we aimed to link imaging-derived, *radiomics* features with outcome, lesion-wise. Our findings suggest associations between radiomics features and immunotherapy response. Lesions that are more likely to respond to immunotherapy typically present with more heterogeneous morphological profiles with non-uniform density patterns and compact borders. Moreover, a machine learning model is provided that could be used within the context of lesion response to treatment, patient treatment response, and response pattern characterization.

Chapter 3. Lesion diagnosis to therapy-induced lung disease.

Aim of this chapter was to apply artificial intelligence analytic pipelines on routine medical imaging for the diagnosis of sarcoid-like granulomatous lesions induced by novel cancer immunotherapeutic agents. We found significant performance in the diagnosis of sarcoid-like granulomatous lesions, while simultaneously significantly improving the performance of the original screening network for the diagnosis of pulmonary metastases. Moreover, the network was able to distinguish between sarcoid-like granulomatous lesions and non-specific post-infection granulomas. Diagnostic signatures were also found to possess prognostic relevance.

Chapter 4. Prognostic value of chest-imaging monitoring.

In this chapter, we aimed to investigate the potential prognostic value of AI-mediated monitoring in NSCLC patients receiving PD-1 blockade. We hypothesized the existence of quantitative imaging features describing a set of gross morphological changes happening during treatment that hold prognostic information. Based on image-to-image registration, we develop a deep learning algorithm for the detection of changes between serial imaging of the same patient. Our results demonstrate the existence of such factors (as described by the AI on imaging), that are tumor-related, such as nodal, lung and bone lesions, as well as non-tumor related, such as pleural effusions, atelectasis and non-specific consolidations.

Chapter 5. Whole-body imaging-based prognostic monitoring.

In this chapter, we investigated the prognostic information of AI-derived whole-body imaging monitoring markers in advanced urothelial cancer receiving checkpoint inhibitors. We hypothesised that quantitative AI-derived features describing morphological changes happening during the course of treatment could hold prognostic information. To this end, we designed and implemented a prognostic AI-monitor (PAM), based on the prototype design of Chapter 4, and extended to handle heterogeneous datasets and abdominal imaging. Our findings demonstrate that PAM is complementary to existing monitoring methods, while reaching comparable or superior accuracy. We argue that this could be the result of PAM's ability to analyze the whole body, including non-target cancer lesions and non-cancer lesions.

Chapter 6. Prognostic response patterns in brain imaging.

In this chapter, we present an expansion of the PAM analytic pipeline to brain imaging of BM patients receiving immunotherapy. Our results demonstrate that PAM can be extended to imaging modalities beyond CT, and be used to capture prognostic response patterns that are unique and complementary to a wide range of different brain-specific markers, currently used in the clinics.

Chapter 7. The future of artificial intelligence immunotherapy trials.

Clinical trials serve as a barrier of entry for new interventions and treatments prior to implementation in routine clinical practice. At its essence, the primary role of a clinical trial is to monitor a patient longitudinally using the diagnostic disciplines (radiology, pathology, and laboratory medicine) to assess clinical outcomes. As the diagnostic fields have begun to fully digitalise, large volumes of data are being generated per patient - creating a ripe environment for the implementation of AI. In this chapter, we will explore how AI has been applied in each of these diagnostic disciplines and discuss how this may influence clinical trials in the future.

Chapter 8. Towards integrated healthcare.

Medical imaging is a vital part of the clinical decision making process, especially in an oncological setting. Radiology has experienced a great wave of change and the advent of quantitative imaging has provided a unique opportunity to analyze patient images objectively. Leveraging AI, there is increased potential for synergy between physicians and computer networks – via computer aided diagnosis (CAD), computer aided prediction of response (CARP), and computer aided biological profiling (CABP). The ongoing digitalization of other specialties further opens the door for even greater multidisciplinary integration. In this chapter, we envision the development of an integrated system composed of an aggregation of sub-systems interoperating with the aim of achieving an overarching functionality (in this case better CAD, CARP, and CABP). This will require close multidisciplinary cooperation between the clinicians, biomedical scientists, and (bio)engineers as well as an administrative framework where the departments will operate not in isolation but in successful harmony.