A glimpse into the future: Integrating artificial intelligence for precision HER2-positive breast cancer management

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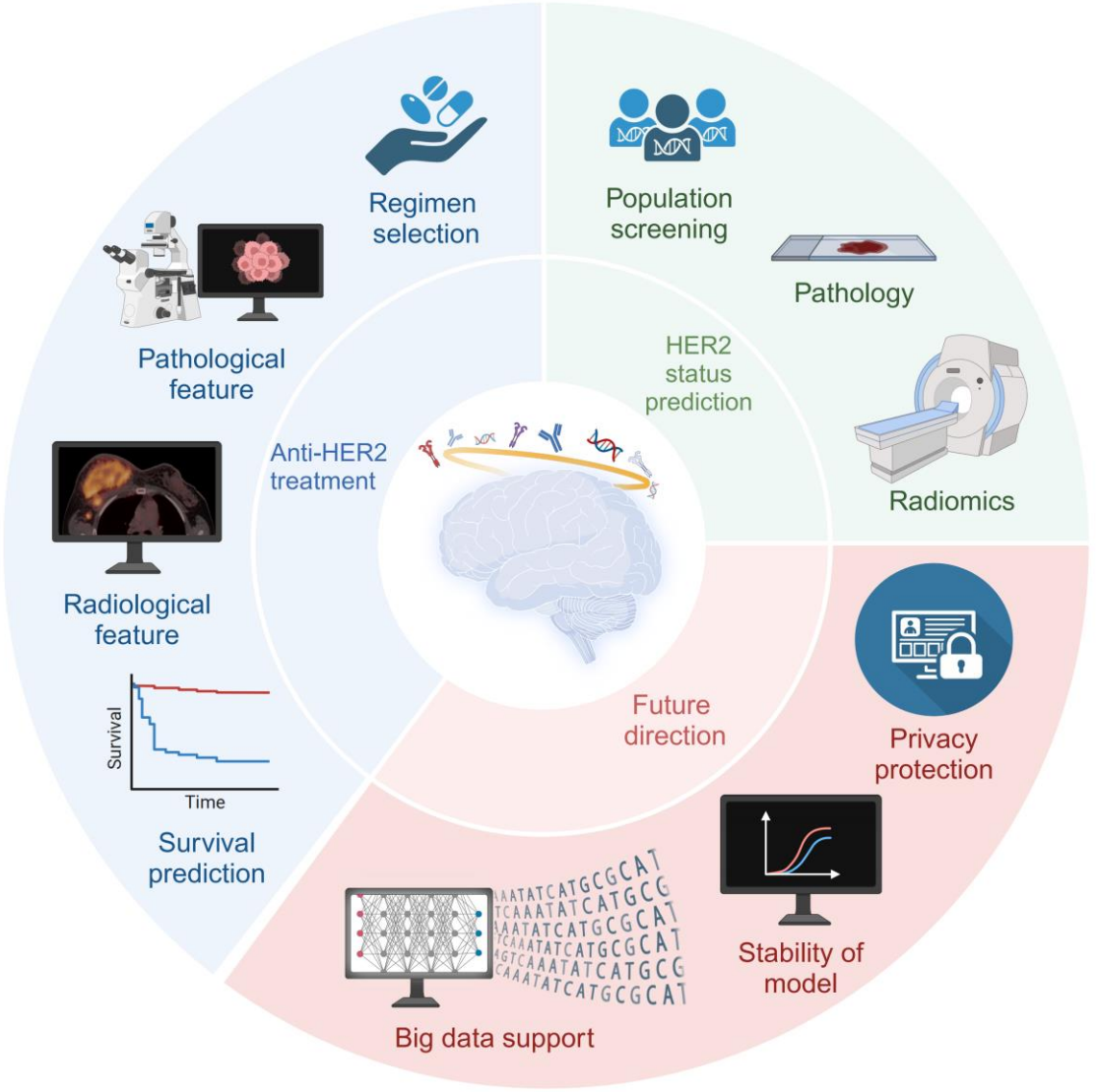
Abstract

We reviewed how artificial intelligence (AI) is being used to improve treatment for HER2-positive breast cancer. While this type of cancer has a poor prognosis, anti-HER2 therapy has been successful. The study examines how AI models are analyzing data from biopsies, scans and HER2 protein sites to predict how patients will respond to this therapy. The authors discuss the benefits of AI for personalizing treatment and the challenges that need to be addressed before it can be widely used. Overall, the study suggests that AI has the potential to significantly improve how HER2-positive breast cancer is treated.



Highlight

- We first reviewed the application of AI in assisting HER2 status evaluation and anti-HER2 Therapy.

- Research progress and applications of the current diagnostic and prediction models based on pathology and radiology have been reviewed.

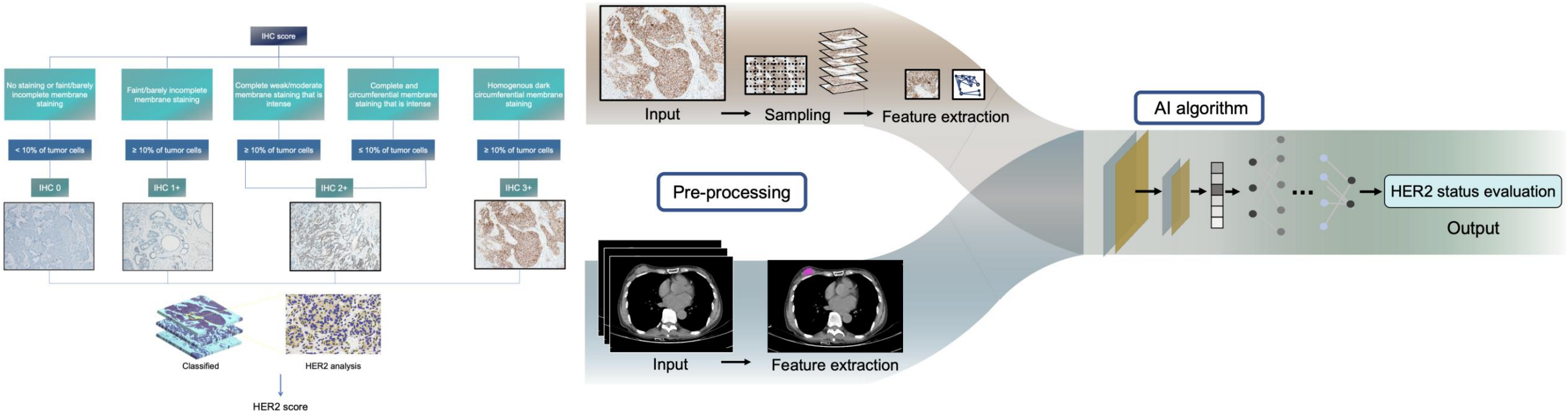
- Then, we also discuss the current dilemmas encountered by artificial intelligence (AI) in the field of anti-HER2 and the future directions that need to be headed.

Introduction

HER2+ BC is a common and aggressive form of breast cancer. The HER2 protein is a key driver of cancer cell growth, making it a target for treatment. There are four main types of anti-HER2 therapies: antibodies, antibody-drug conjugates, tyrosine kinase inhibitors, and combination therapies. While existing treatments like trastuzumab have been successful, some patients become resistant. Researchers are exploring new targeted therapies and combinations to improve treatment outcomes.

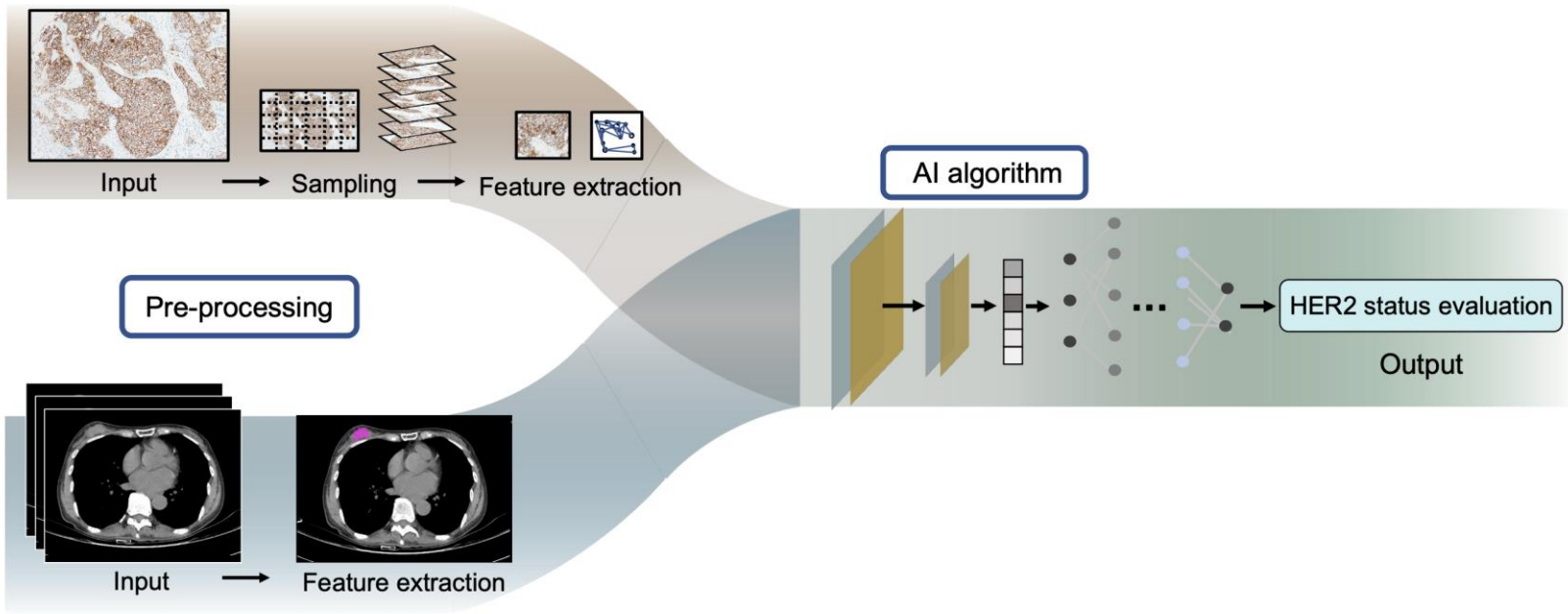
Pathological Examination

Currently, immunohistochemistry (IHC) is the gold standard for HER2 testing, but it can be subjective and time-consuming for pathologists. The process of evaluating HER2 expression is shown in the figure below. AI, specifically deep learning (DL), is being explored to automate HER2 analysis from pathology slides. This technology has shown promise in achieving high accuracy rates. Challenges remain, including the large size of image data, the subjective nature of pathology interpretation, and the cost of training AI models. Overall, AI has the potential to improve HER2 diagnosis but is still under development for routine clinical use.



Radiomics signatures

Traditional biopsies may miss some information due to sample size and tumor variations. Radiomics is a technique that extracts hidden features from medical scans like X-rays and MRIs. Deep learning helps radiomics find even more complex features in these images. AI models are being trained on this data to predict HER2 status with promising results (around 70-88% accuracy).However, larger and more diverse datasets are needed to further improve this technology.



AI FOR ASSISTING ANTI-HER2 TREATMENT

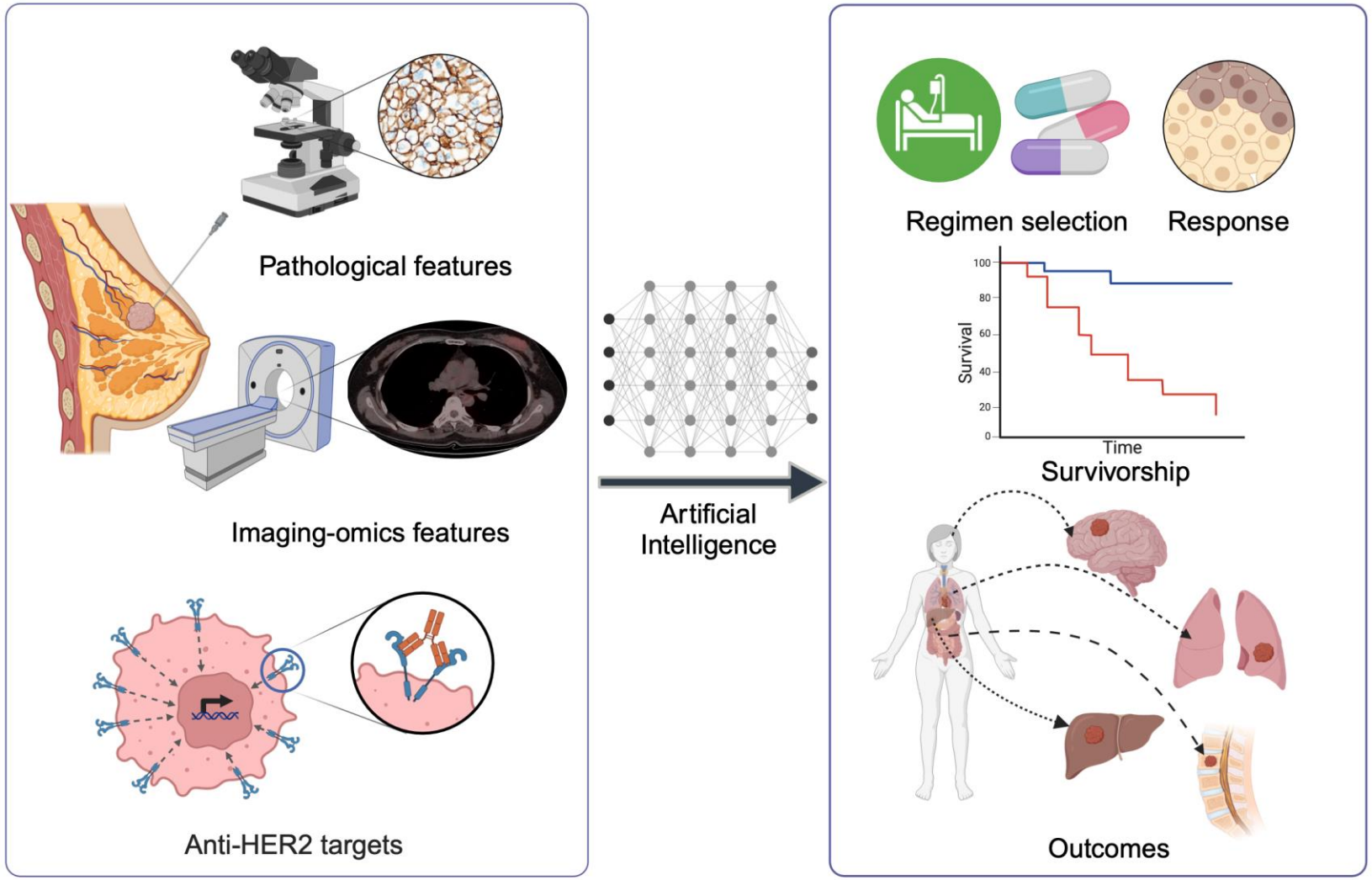
AI predicts anti-HER2 therapy efficacy by pathological features

Traditionally, doctors look at these slides under a microscope to make predictions, but this can be subjective and time-consuming.AI, specifically convolutional neural networks (CNNs), can analyze these slides and identify patterns linked to treatment response.This technology has shown promise in predicting success rates (around 80% accuracy).AI can also find HER2-negative tumors that might still benefit from this therapy, potentially expanding who can receive this treatment.AI models that consider the tumor's immune system cells alongside the cancer cells themselves may provide even better predictions.Overall, AI with HE staining offers a faster, cheaper, and potentially more accurate way to predict how well anti-HER2 therapy will work for HER2-positive breast cancer.

AI FOR ASSISTING ANTI-HER2 TREATMENT

AI assists in developing novel anti-HER2 therapeutics & therapy outcome

- AI can help design drugs that target specific variations of HER2 protein isoforms.This is important because some drugs target all isoforms, while better outcomes might be achieved by targeting specific ones.
- AI can also be used to improve existing drugs, like trastuzumab, by predicting how mutations in the cancer cells will affect how well the drug binds to them.Finally, AI can be used to identify patients at high risk of developing brain metastases, a complication of HER2-positive breast cancer.



PROSPECTS FOR THE FUTURE: WHERE ARE WE HEADED?

With successful implementation, AI has the potential to improve the efficiency and quality of care for HER2-positive breast cancer patients.

But there are several challenges including:

- Lack of large, standardized datasets for training and testing AI models.
- Difficulty in sharing medical data due to privacy concerns.
- Limited transparency and reproducibility of AI models due to a lack of shared code.
- Need for better integration of AI with existing medical practices and workflows to gain trust from patients and doctors.
- Rapid advancements in HER2 therapy create a moving target for AI models, requiring continuous updates with new data.
- The article concludes that collaboration between researchers, businesses, and medical professionals is needed to overcome these challenges.

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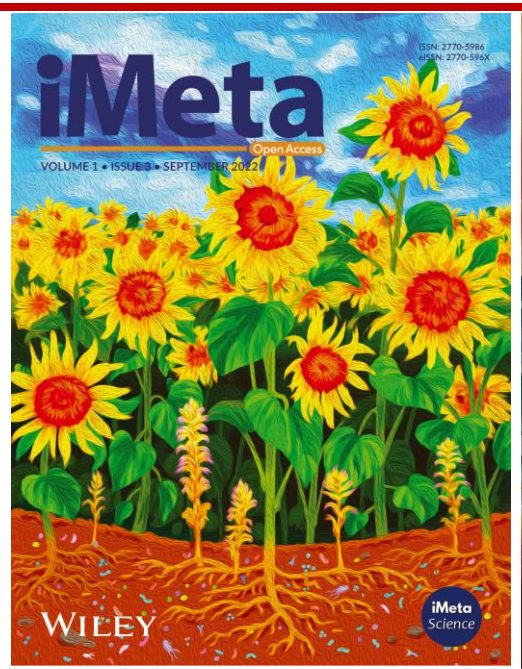

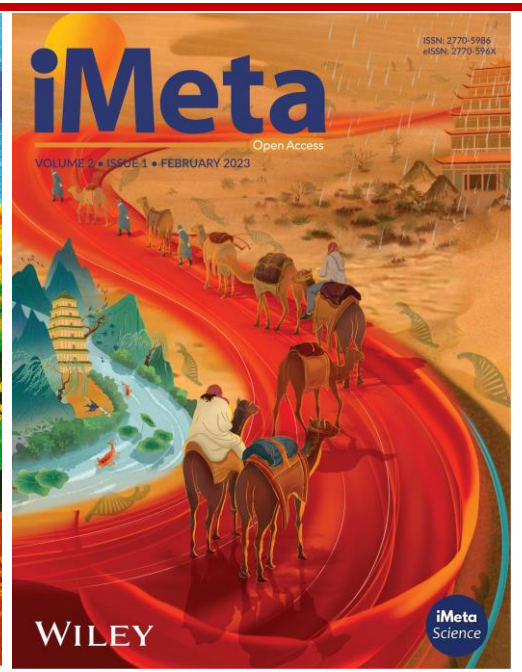

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