Harnessing the Power of AI in Rheumatology Without Getting Burned

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THIS year's American College of Rheumatology (ACR) Convergence, which took place from Novemeber 14th–19th 2024 in Washington, D.C., saw dozens of fascinating sessions about the latest developments in the field, presented by leading experts from around the world. One such session, 'Harnessing the Power of AI in Rheumatology Without Getting Burned', sought to evaluate the abilities and limitations in the use of AI in rheumatology, analyze ways that the use of AI has the potential to impact rheumatology practice, and discuss the future of rheumatology in the age of AI.

This session, moderated by Genessis Maldonado, Vanderbilt University Medical Center, Nashville, Tennessee, and Bernard Ng, Veteran Affairs, Seattle, Washington, delved into the intersection of AI and rheumatology, and explored the transformative potential that AI holds in the diagnosis, treatment, and management of rheumatic diseases. The various speakers gave the audience a comprehensive overview of various AI practical applications, emphasizing the revolutionary impact on healthcare within the rheumatological domain.

IMPACT OF AI IN RHEUMATOLOGY

After an introduction by the moderators, Bella Mehta, Hospital for Special Surgery, Weill Cornell Medicine, Jersey City, New Jersey, began her presentation on the impact of AI in rheumatology. She provided an insightful exploration of AI's transformative role in healthcare, particularly in enhancing clinical research and practice.

To begin with, Mehta introduced AI concepts by explaining the progression from data handling to advanced AI techniques, including machine learning, deep learning, and large language models (LLM). She emphasized that these technologies perform tasks that mimic human intelligence, such as predictions, decision-making, and data analysis.

> **AI technologies perform tasks that mimic human intelligence**

Highlighting the surge in healthcare data (approximately 40–50 exabytes), she went on to point out how electronic medical records (EMR) and increasing AI-related publications reflect the growing relevance of data in shaping policy and research. Using examples like supervised and unsupervised machine learning, Mehta additionally illustrated AI's ability to classify and analyze data. A key example was a study predicting 90-day mortality post-hip arthroplasty using community-level social determinants of health, revealing that such variables often outweigh race in importance.

The discussion went on to cover the use of deep learning for histopathological analysis of synovial

tissue, demonstrating AI's potential to assess inflammation in diseases like rheumatoid arthritis (RA). The algorithm trained for cell density prediction has clinical implications for distinguishing between conditions such as RA and osteoarthritis (OA).

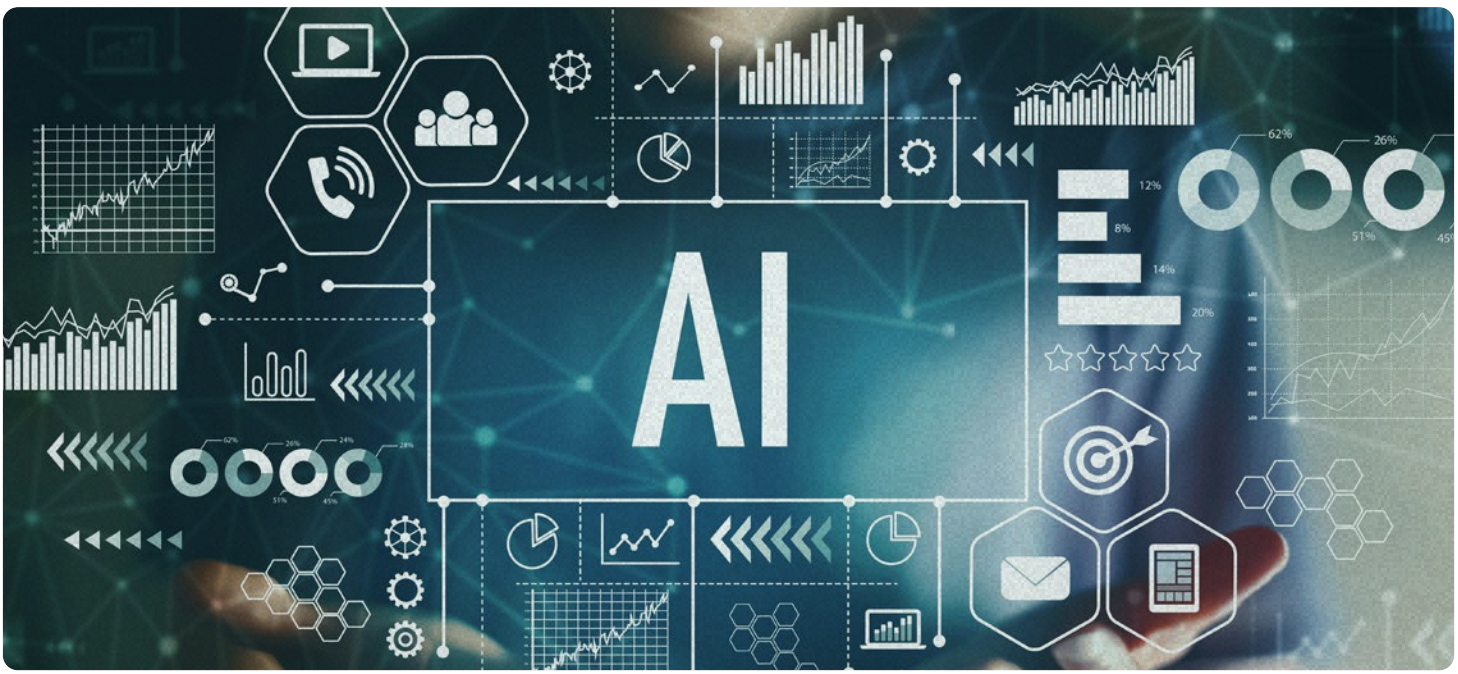
Mehta concluded by spotlighting LLMs' role in natural language processing for patient education and clinical decision support. These models exemplify how AI can bridge gaps in understanding medical conditions and treatments. This presentation underscored AI's transformative potential in rheumatology, from predictive analytics to enhancing diagnostic precision and patient care. She also stressed the importance of collaboration between AI experts and clinicians to maximize the utility of these advancements.

> **AI-generated 'change maps' track disease progression over time, offering insights for clinical trials and treatment effectiveness**

AI-DRIVEN CHANGES IN RHEUMATOLOGY IMAGING

Amanda Nelson, University of North Carolina at Chapel Hill, took to the stage next to discuss the changes currently taking place in the field. The exponential increase in publications on AI and deep learning, particularly in rheumatology, was highlighted during this talk. Much of the research focuses on RA and OA, though applications extend to other diseases. Nelson's work integrates clinical datasets, imaging, biochemical, and other clinical data to improve patient care. A key area of focus is distinguishing OA progressors from non-progressors using AI tools to analyze imaging and clinical features.

AI can enhance decision-making in rheumatology by efficiently processing large datasets, identifying patterns, and aiding in diagnosis. For example, convolutional neural networks have been employed to classify different types of arthritis, such as seropositive and seronegative RA or psoriatic arthritis, using pre-trained models fine-tuned on rheumatology-specific data. These tools can also automatically score features like osteitis or synovitis, saving time and providing consistent results.



Sequential imaging analysis is another promising application, described Nelson, where AI-generated 'change maps' track disease progression over time, offering insights for clinical trials and treatment effectiveness. Beyond imaging, AI has been applied to pathology, where algorithms trained on annotated slides show high accuracy in identifying and classifying features like glomeruli.

Challenges remain, including the need for high-quality, representative datasets, and strategies for managing missing data. Pre-trained models often carry biases, and external validation is essential to ensure generalizability. Nelson stressed collaboration with data scientists and understanding AI tools to apply them appropriately.

AI has the potential to transform rheumatology by streamlining workflows, improving diagnostics, and aiding in clinical research; this much was clear throughout Nelson's talk. However, clinicians must stay informed about AI's capabilities and limitations to ensure its effective implementation. Nelson encouraged further education in AI to enhance its integration into research and practice.

CROSSING THE PRECISION GAP IN RHEUMATOLOGY WITH AI

The final part of this insightful session was delivered by John Isaacs, Newcastle University, UK, and covered the precision gap in this revolutionary technology. Though not a specialist in AI himself, Isaacs was able to provide valuable insights into the role AI plays and will go on to play in the future.

Isaacs highlighted the potential of AI in advancing rheumatology through precision medicine. AI's core function is identifying patterns in data, enabling insights into an individual's exposome, genomics, and epigenetics. He pointed out, agreeing with previous speakers, that this capability has already shown promise in other fields, like oncology, and offers opportunities to transform rheumatology.

This portion of the session outlined elements of robust AI analysis, beginning with data acquisition. High-quality, large, and diverse datasets are crucial, requiring collaboration across institutions and regions. Preprocessing, including cleaning and harmonizing data, addresses issues like

missing values and inconsistencies. Feature selection helps identify variables that distinguish meaningful patterns, and iterative machine learning models refine clustering and classification. However, external validation is vital to ensure models work beyond their original datasets, which is often overlooked.

Challenges in AI applications include overfitting, underfitting, and the limitations of 'black box' models. Explainable AI techniques, such as SHAP (SHapley Additive exPlanations), enhance model transparency, fostering trust and interpretability, which are particularly critical in medical contexts. Ethical considerations, including data privacy and consent, were emphasized, noting that older datasets often lack patient approval for AI-based applications.

Rheumatology lags behind oncology in precision medicine due to differences in the depth of data collection, such as limited tissue biopsies and less robust outcome measures, added Isaacs. Nevertheless, AI does hold promise in treatment response prediction, clustering patient subtypes, and analyzing complex datasets. Success depends on interdisciplinary collaboration among rheumatologists, data scientists, and legal experts, as well as adherence to transparency and reproducibility standards.

Ultimately, Isaacs told the audience that he foresees a future where AI significantly impacts rheumatology, contingent on quality data, robust algorithms, and strong team science.

CONCLUDING REMARKS

Closing with an enlightening question and answer session with the audience, this session at ACR 2024 shed light on the potential of AI in the field of rheumatology. As technology continues to advance, AI will undeniably have a vast impact on the field, shaping the future of rheumatological diagnosis, treatment, and disease management.

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