SPOTLIGHT Q/A

Evaluating Drug Eruptions Using AI: Tips From Alina G. Bridges, DO

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Artificial intelligence (AI) is a promising adjunct in dermatopathology, enhancing detection of subtle histologic features in drug eruptions and enabling standardized quantification through whole-slide image analysis. Techniques such as attention-based models and heatmap generation may highlight focal or overlooked findings, but drug eruption–specific validation remains limited. *Cutis* board member Alina G. Bridges, DO, discusses AI's role as an assistive tool, emphasizing explainability, human oversight, documentation, and robust data governance to ensure safe, effective implementation.

How might AI enhance the detection of key histologic features in drug eruptions compared to traditional microscopy?

DR. BRIDGES: AI offers the potential to enhance detection of histologic features in drug eruptions by systematically analyzing entire whole-slide images. Convolutional neural networks and attention-based models can identify subtle or focal findings such as scattered dyskeratotic keratinocytes, focal spongiosis, early interface change, rare eosinophils, or microvascular injury, which may be overlooked during routine microscopy due to sampling limitations. This capability is particularly relevant in drug eruptions, where histologic changes often are heterogeneous and patchy.

AI-generated attention heatmaps can highlight diagnostically relevant regions across the slide, improving consistency and completeness of slide reviews. While AI has demonstrated high sensitivity and specificity in broader dermatopathology tasks, particularly neoplastic conditions, drug eruption–specific validation data are currently lacking. As such, the most realistic application at present is AI functioning as a sensitivity-enhancing adjunct or "second reader," improving consistency and completeness of slide review while preserving expert human interpretation.

Which histologic patterns in drug eruptions are hardest to quantify, and how could AI help standardize their assessment?

DR. BRIDGES: AI-based image analysis can standardize the assessment of histologic patterns through objective reproducible quantification. Deep learning algorithms can segment epidermal and dermal compartments, identify inflammatory cell types, and calculate metrics such as eosinophil density per unit area, percentage of epidermis with vacuolar alteration, or number of affected vessels. Studies in quantitative immunohistochemistry demonstrate high accuracy for tissue segmentation and cell counting, suggesting feasibility for similar applications in inflammatory dermatopathology. While these tools would not replace diagnostic interpretation, they could provide standardized measurements that enhance reproducibility and improve clinicopathologic correlation.

What training challenges must be addressed in AI and drug eruption histology?

DR. BRIDGES: Training AI models for drug eruption histopathology faces several challenges, including the limited availability of high-quality, well-annotated datasets, as most existing AI dermatopathology research focuses on neoplastic conditions. Drug eruptions also exhibit marked histologic heterogeneity, ranging from spongiotic and lichenoid to vasculitic and cytotoxic patterns, often with significant overlap. Accurate labeling, therefore, requires robust clinicopathologic correlation, including medication history, timing, laboratory data, and clinical outcomes—information that is often incomplete or retrospective.

Inaccurate or inconsistent annotations can significantly degrade model performance, and expert disagreement in borderline cases further complicates the

creation of reliable ground truth. Additionally, training data may reflect institutional or demographic biases, risking unequal performance across patient populations. Addressing these challenges will require multicenter collaboration, standardized annotation protocols, inclusion of diverse patient cohorts, and careful attention to bias mitigation. At present, these barriers place drug eruption AI firmly in the investigational rather than clinical domain.

How important is AI explainability in the interpretation of diagnostic suggestions?

DR. BRIDGES: Explainability is essential for trust, particularly in the evaluation of drug eruptions, where diagnostic decisions can have serious clinical consequences. Dermatopathologists must understand which histologic features are driving an AI model's assessment to ensure that conclusions align with morphologic reality and clinicopathologic reasoning. Explainable AI tools (such as attention heatmaps, feature importance rankings, and methods like Shapley Additive Explanations or Local Interpretable Model-Agnostic Explanations) can help clarify which histologic features are driving the AI model's assessment.

Without transparency, AI systems function as "black boxes," limiting their utility in high-stakes settings where diagnostic accountability and clinical communication are paramount. Explainability also supports appropriate skepticism, allowing pathologists to recognize when model outputs may be unreliable due to artifacts, atypical patterns, or out-of-distribution cases. In cases of drug eruptions—where diagnosis relies on combining histology, clinical timing, and medication history—explainability is essential for proper use.

How could AI pattern recognition be integrated into your workflow to enhance diagnostic efficiency and accuracy? What safeguards would be required?

DR. BRIDGES: In the near term, AI pattern recognition can be useful as an assistive tool rather than a diagnostic authority. One potential application is pre-screening whole-slide images to flag cases with features such as prominent interface change, increased keratinocyte necrosis, eosinophil-rich infiltrates, or vascular injury, prompting expedited review in clinically concerning scenarios. During sign-out, AI overlays could aid efficiency by highlighting rare but relevant features and providing quantitative summaries that support standardized reporting.

Safeguards are essential. AI systems must be validated across diverse practice settings, staining protocols, and scanning platforms. Human oversight is mandatory, with the dermatopathologist retaining full diagnostic responsibility. AI involvement should be clearly documented for medicolegal transparency, and performance should be continuously monitored to detect algorithmic drift as new drug eruption patterns emerge. Given current limitations, AI is best viewed as a tool to refine and support expert judgment, not replace it.

What data-sharing or privacy challenges must be addressed to develop robust AI models for diverse drug-eruption histopathology?

DR. BRIDGES: Developing robust AI models for drug eruptions requires large diverse datasets, raising significant privacy and governance challenges. Rigorous de-identification protocols, clear informed consent frameworks, and strong institutional oversight are therefore essential. Multicenter collaborations must employ secure data-use agreements and governance structures that clearly define access, ownership, and downstream use of data.

Ensuring equitable representation is equally critical, as underrepresentation of certain populations may lead to biased performance and disparities in care. Standardized data formats and interoperable systems are needed to facilitate collaboration while preserving security. Transparent governance structures, clear rules regarding data use, and trust-building with patients and institutions will ultimately determine willingness to participate. Addressing these challenges is foundational to advancing AI research in drug eruptions responsibly and ethically.