Rapid on-site analyte-specific peptide intervention and diversion (RAPID): A new approach to snakebite envenomation management

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Dear Editor,

Current antivenom therapy for snakebite envenomation, relying on polyclonal antivenoms, has significant limitations. Clinicians often face diagnostic uncertainty because the offending snake species is unknown, forcing the use of broad-spectrum antivenoms which may lack specificity[1]. Moreover, these antivenoms frequently cause severe adverse reactions, ranging from mild urticaria to life-threatening anaphylaxis[2]. Compounding these clinical issues are logistical failures; antivenom requires an unbroken cold chain for storage and transport, a requirement that is difficult to meet in the remote, resource-poor settings where snakebites most often occur[3]. The significant time delay between the bite and treatment allows irreversible tissue damage to occur.

A severe global shortage of effective antivenom persists due to low profitability, leading to substandard products and eroding clinician and patient confidence[4]. High costs, distribution challenges, and a lack of local production capacity render antivenom prohibitively expensive and inaccessible for the rural populations most at risk. This necessitates a fundamental re-evaluation of current strategies[5].

We propose the rapid on-site analyte-specific peptide intervention and diversion system (RAPID), a comprehensive and integrated technological framework designed as a holistic, end-to-end solution to fundamentally disrupt the challenges of snakebite management[6]. Instead of a fragmented process, RAPID connects four technological pillars that guide a patient from the moment of envenomation to the delivery of a precisely tailored therapeutic, replacing empirical guesswork with a data-driven approach.

Treatment initiation at the point of care with a portable diagnostic unit is proposed[7]. A first responder inputs initial information, including snake species if identifiable, then a blood sample is analyzed by an integrated mass spectrometer. While user input prioritizes the analysis, the final therapeutic recommendation is always based on the actual toxins detected and quantified[8]. If chemical data contradict the user input, or if no user data are available, the chemical data take precedence. Once the venom profile is confirmed, the system directs the team to the nearest equipped medical center and transmits a provisional synthesis order.

Equipped hospitals would in the future house an automated peptide synthesizer capable of producing a custom treatment on demand. Using technologies such as Microwave-Assisted Solid-Phase Peptide Synthesis (MA-SPPS), which can construct peptides rapidly, on-demand synthesis becomes clinically viable. Upon receiving the provisional order, a credentialed doctor logs into the system to review the patient's data and the proposed peptide cocktail. Once the doctor provides authorization, a GMP-grade synthesizer begins production, aiming to have a personalized treatment ready upon the patient's arrival. This process is underpinned by a digital library of synthetic peptide sequences designed to inhibit key venom toxins[9]. These short peptides bind to and neutralize specific venom components, such as the PLA_2 enzymes inhibited by drugs like Varespladib, forming an inactive complex[10].

The RAPID strategy offers a holistic, technology-driven solution that intelligently combines human observation with

advanced chemical analysis to deliver truly personalized medicine. This approach overcomes diagnostic uncertainty, minimizes adverse reactions by using targeted peptides, and eliminates the logistical burden of the cold chain required for conventional antivenoms[11,12]. The successful implementation of the RAPID system will require immediate work, robust clinical trials to validate safety and efficacy, followed by establishing a clear regulatory pathway[13]. In the future, this platform could be adapted to address envenomations from other organisms, such as spiders or scorpions[14,15].

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CONFLICTS OF INTEREST
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