Multifunctional Medical Foam (MF) to Enhance Wound Management In Situ

Lynn Pezzanite, DVM, PhD*; Nicholas A. Alfonso, MD; Amelia Stoner, MS; Steven Dow, DVM PhD; Kirk McGilvray, PhD*; *Jacqueline Linn, BS; Olivia Pyke, BS*

Purpose: Effective management of open injuries is critical for improving outcomes and reducing morbidity in austere resource-limited environments. Open wounds are susceptible to infection, delayed healing, and significant blood loss. These complications exacerbate injury severity, increase the risk of systemic complications, and result in greater levels of medical care. To address these challenges, we developed a medical foam (MF) that enables providers to efficiently deliver the antibiotic vancomycin and the hemostatic agent tranexamic acid (TXA) topically in situ at the point of injury.

Methods: A biopolymer-based MF was developed with adjustable viscosity and tailored release kinetics, providing a wound-filling composition capable of delivering multifunctional therapeutics into wounds. Our MF was optimized in vitro for quick-release and slow-release formulations. Mechanical properties, temporal breakdown profiles, biocompatibility, and bacterial killing were systematically evaluated. We hypothesized that MF would enhance therapeutic effectiveness by increasing wound coverage and contact time while minimizing systemic side effects through local delivery.

Results: MF biomechanical testing demonstrated wound-filling capabilities that are adaptable to various wound geometries. MF exhibited a 22% increase in yield strain compared to the base biopolymer solution, indicating enhanced protective wound coverage under mechanical stress. Temporal degradation profiles showed a 200%difference in volumetric breakdown and a 185% difference in volumetric stability between quick-release and slow-release formulations, underscoring precise control over therapeutic release kinetics and wound-filling properties. Human fibroblast viability assays confirmed that MF was biocompatible over both acute (4-hour) and chronic (24-, 48-, and 72-hour) exposure periods in a time- and concentration-dependent fashion. MF significantly reduced USA300 methicillin-resistant Staphylococcus aureus colony formation by 3 to 4 log-fold, which increased with prolonged exposure (4 vs 48–72 hours). MF increased whole blood clot robustness by more than 20% compared to direct agent delivery in saline.

Conclusion: Our MF is a versatile platform for delivering active wound care agents in situ, and its tailorable properties make it ideal for treating a spectrum of open wounds. These early findings demonstrate that MF offers a possible transformative solution, combining biocompatibility, adaptability, and therapeutic precision to enhance wound care in austere combat environments.

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