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Laser-based vaccine adjuvant and delivery

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We develop a safe, laser-based adjuvant for cutaneous vaccination, which can be used immediately and unlimitedly at any time, irrespective of skin colors, for existing and new protein-based vaccines. The tentative laser apparatus is FDA approved for home cosmetics. It is as small as a hand-held flashlight and extremely safe and convenient to use. Our investigation showed that illumination of the injection site for 10 ms prior to intradermal (ID) vaccination could enhance immune responses significantly against the vaccine. When imiquimod (ImiQ or ALDARA 5%), an agonist for Toll-like receptor (TLR7) that is also FDA approved for topical application in humans, was topically applied to the site of injection, laser illumination and ImiQ synergistically increased Th1 immune responses.

The laser generates an array of microscopic thermal zones (MTZs) that are each about 100~300 μm in diameter and 300-1,000 μm in depth in the skin. The dead cells in MTZs release "danger signals" that attract and activate a huge number of antigen presenting cells (APCs) around each MTZ. These APCs not only clean the dead cells in the MTZs but also take-up and process antigens ID injected. Because the APCs are concentrated around each MTZ, the resultant inflammation is microscopically restricted and hardly visible in the skin. Moreover, each MTZ is surrounded by healthy growing epidermal cells that migrate and grow quickly toward the MTZ and completely heal the micro-zone in a day or two. As a result, skin reactogenicity was significantly diminished in terms of severity and duration with laser-ImiQ adjuvant as compared to that caused by the vaccine alone. For instance, we found that pre-illumination of the injection site augmented hemagglutination inhibition (HAI) titers against seasonal or 2009-pandemic influenza vaccine by 10~20-folds over intramuscular (IM) immunization, but the resultant skin irritation was milder and resolved faster than flu vaccine alone. While ID immunization blocked viral production in the lung by 2-fold over IM vaccination, ID immunization with laser-ImiQ adjuvant resulted in a blockade of viral production by more than 100-fold.

Conclusion: Many current vaccine adjuvants cause significant skin irritation and are prohibited from skin vaccination. Laser-based adjuvant is able to boost cutaneous vaccination without increasing adverse effects or an involvement of injecting any additives besides antigen itself. It holds great promise to safely boost cutaneous vaccination with a short- and long-term safety profile.

Biography

Mei X. Wu is an Associate Professor in the Department of Dermatology at Harvard Medical School (HMS) and an affiliated faculty of the Harvard-MIT Division of Health Sciences and Technology. She received her Ph.D. from Utah State University in 1992 and was then trained at Massachusetts Institute of Technology and HMS. She has more than 50 publications in peer-reviewed journals and her research has been continuously supported by various competitive funds from National Institutes of Health (NIH), Department of Defense, the American Cancer Society, the Crohn's & Colitis Foundation of America, the American Heart Association, and Bill Gates Foundation.

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