Martin J D'Souza, J Clin Exp Dermatol Res 2016, 7:4 (Suppl)
http://dx.doi.org/10.4172/2155-9554.C1.034

8th Clinical Dermatology Congress

August 24-25, 2016 Sao Paulo, Brazil

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Microneedle based transdermal vaccines for infectious diseases and cancer: Are we there yet?

Our Vaccine Nanotechnology Laboratory at Mercer University has been working on the design and delivery of microparticulate vaccines for both infectious diseases and cancer. In this presentation, we discuss the triumphs and tribulations of this rather innovative, in-expensive and painless method of vaccine delivery. Our patented technology is rather broad based and can be used to administer multiple vaccines in a single set of micro-needles. On the infectious disease vaccine front, we have been working on the vaccines for several infectious diseases such as influenza, HPV, RSV, meningitis, gonorrhea and measles vaccines designed for delivery via microneedles. In this presentation, we will discuss the results of some of these vaccine prototypes. The vaccine antigen was formulated in bio-degradable and bio-compatible matrices to prepare microparticles. These vaccine microparticles were administered using micro-needles via the transdermal route. Serum samples were obtained at regular intervals in-order to determine the antigen specific antibody responses (such as IgG). Animals were challenged with live virus/bacteria to determine the level of protective immunity developed after vaccination. Further, we examined the expression of co-stimulatory molecules that impact antigen presentation in human macrophages pulsed with the antigen. We also evaluated antigen presentation (CD80) and death signal (CD 95) in an *in vitro* setup where antigen-presenting cells (APCs) primed by the antigen were used to stimulates plenocytes that had never been exposed to the antigen. The up-regulation of other co-stimulatory molecules such as CD-40, CD-80 and CD-86 were also determined. In conclusion, the novel vaccine particles are robustly taken up by macrophages and up-regulate co-stimulatory molecules that enhance antigen presentation which is a pre-requisite for inducing adaptive immunity. The other innovative microneedle particulate vaccines under study are therapeutic cancer vaccines such as breast, melanoma, ovarian and prostate cancer vaccines. The microneedle formulations resulted in reduced tumor growth. We also report on the effect of adjuvants such as Alum, MF-59 and MPL on enhancing the potency of these vaccine proto-types. Microparticulate vaccine was prepared by entrapping tumor-associated antigens (TAAs), in a polymer matrix of albumin and EUDRAGIT polymers using a Buchi mini spray dryer. Animals were exposed to tumor cell and once the tumor was palpable, these animals received the vaccine microparticles as prime and boosters via transdermal route through microneedles. The tumor growth was routinely monitored. Mechanistic studies such as natural killer cell activity, CD8+ and CD4+ T-Lymphocyte activity after vaccination were also carried out in order to study the mechanism by which the vaccine works to modulate immune response. Flow cytometric analyses for CD8 and CD4 T-cell assays, NK-cell activity were carried out to assess vaccine efficacy. Based upon the vaccine response data, the tumor retardation was found to be significant after transdermal administration. Vaccination may prove to be an efficient treatment for cancer patients in the future.

Biography

Martin J D'Souza has obtained his PhD degree from the University of Pittsburgh, PA, USA. He is working as a Professor and Director of Graduate Programs in the College of Pharmacy at Mercer University in Atlanta, Georgia. He also serves as the Director of the Clinical Laboratory and Co-Director of the Center for Drug Delivery Research. He has published over 90 manuscripts and has been the recipient of several research grants from the National Institutes of Health (NIH), the American Diabetes Association, the Georgia Cancer Coalition and the Georgia Research Alliance. He serves on several Editorial Boards and is a journal Reviewer for over 10 scientific journals and has several patents issued in the area of Nanotechnology.

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