Available online at www.sciencedirect.com

SCIENCE DIRECT®

Advanced Drug Delivery Reviews 58 (2006) 68–89

Advanced DRUG DELIVERY Reviews

www.elsevier.com/locate/addr

Needle-free vaccine delivery☆

Erin L. Giudice *, James D. Campbell

Center for Vaccine Development, University of Maryland School of Medicine, 685 W. Baltimore Street, Room 480, Baltimore, MD 21201, USA

Received 28 March 2005; accepted 20 December 2005
Available online 24 March 2006

Abstract

The search for methods of vaccine delivery not requiring a needle and syringe has been accelerated by recent concerns regarding pandemic disease, bioterrorism, and disease eradication campaigns. Needle-free vaccine delivery could aid in these mass vaccinations by increasing ease and speed of delivery, and by offering improved safety and compliance, decreasing costs, and reducing pain associated with vaccinations. In this article, we summarize the rationale for delivery of needle-free vaccines and discuss several methods currently in use and under development, focusing on needle-free injection devices, transcutaneous immunization, and mucosal immunization. Jet injectors are needle-free devices that deliver liquid vaccine through a nozzle orifice and penetrate the skin with a high-speed narrow stream. They generate improved or equivalent immune responses compared with needle and syringe. Powder injection, a form of jet injection using vaccines in powder form, may obviate the need for the "cold chain." Transcutaneous immunization involves applying vaccine antigen and adjuvant to the skin, using a patch or "microneedles," and can induce both systemic and mucosal immunity. Mucosal immunization has thus far been focused on oral, nasal, and aerosol vaccines. Promising newer technologies in oral vaccination include using attenuated bacteria as vectors and transgenic plant "edible" vaccines. Improved knowledge regarding the immune system and its responses to vaccination continues to inform vaccine technologies for needle-free vaccine delivery.

Keywords: Needle-free vaccine; Jet injectors; Transcutaneous immunization; Mucosal immunization; Oral vaccine; Nasal vaccine; Aerosol vaccine

Contents

☆ This review is part of the *Advanced Drug Delivery Reviews* theme issue on "Challenges in Pediatric Drug Delivery: the Case of Vaccines", Vol. 58/1, 2006.

* Corresponding author. Tel.: +1 410 706 5328; fax: +1 410 706 6205.
E-mail address: egiudice@peds.umaryland.edu (E.L. Giudice).

0169-409X/$ - see front matter © 2006 Elsevier B.V. All rights reserved.
doi:10.1016/j.addr.2005.12.003

1. Introduction

With few exceptions, vaccinations are delivered by injection to the intramuscular, subcutaneous, or intradermal space. This practice has led patients, parents, and practitioners to refer to vaccine administration as "getting one's shots." Although vaccination delivered by injection has led to tremendous advances in the control of many infectious diseases, this technique is not without risks or discomfort, leading to the search for alternate means of vaccine delivery. Increasing concern over bioterrorism has also led to new needle-free vaccine delivery research [1]. In this article, we summarize the rationale behind the development of needle-free vaccines and discuss a number of the methods of needle-free vaccine administration currently in use or under development. Needle-free vaccination includes all methods for delivering vaccines that do not require a needle and syringe for administration. Our review focuses on three of these techniques: needle-free injection devices, transcutaneous immunization, and mucosal immunization.

2. Rationale for the pursuit of needle-free vaccine administration methods

Needle-free vaccine delivery is desirable for many reasons. In fact, most descriptions of an ideal or perfect vaccine include a needle-free method of administration [2]. Needle-free vaccine administration has the potential to lead to the following significant advances in immunization delivery: improved safety for the vaccinator, vaccinee, and community; better compliance with immunization schedules; decreased or eliminated injection site pain; easier and speedier vaccine delivery; and reduced cost. For these reasons, needle-free vaccine delivery is supported by many prominent public health organizations involved in the delivery of vaccines, including the World Health Organization,