Vaccine 31 (2013) 2647–2652

Contents lists available at SciVerse ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine

Randomized trial using ultrasound to assess intramuscular vaccination at a 60° or 90° needle angle

Helen Siobhan Marshall[a,*], Michelle Frances Clarke[a], Susan Evans[a], Lino Piotto[b], Roger J. Gent[b]

[a] Vaccinology and Immunology Research Trials Unit, Women's and Children's Hospital (72 King William Road, North Adelaide) and University of Adelaide, South Australia, Australia
[b] Radiology Department, Women's and Children's Hospital, Women's and Children's Health Network, 72 King William Road, North Adelaide, 5006 South Australia, Australia

ARTICLE INFO

Article history:
Received 17 January 2013
Received in revised form 5 March 2013
Accepted 20 March 2013
Available online 6 April 2013

Keywords:
Vaccine
Ultrasound
Intramuscular
Vaccine administration
Obesity

ABSTRACT

Objective: Globally, recommendations differ on the ideal angle of needle insertion to ensure vaccinate deposition in muscle for optimal safety and immunogenicity. This study aimed to compare the level of vaccinate deposition during vaccination, using two different needle angles (60° and 90°), in young children, adolescents and adults.
Methods: In this randomized cross-over study, two doses of a licensed hepatitis vaccine, were administered to study participants, at a 60° or 90° angle using a fixed template. Ultrasonography was performed with a Philips iu22 ultrasound system. Real time clips and hard copies of images were recorded showing the injection and level of deposition of the vaccinate. Reactogenicity at the site of administration was assessed by participants/parents.
Results: Nineteen participants were enrolled including children, adolescents and adults. Of the total 38 injections performed, 29 (76%) were confirmed by ultrasound as intramuscular (IM), 3 (8%) as not IM, and 6 (16%) unknown. For vaccinations visualised and administered at 60°, 87% (13/15) were intramuscular vs 94.1% (16/17) for those administered at 90°. A body mass index (BMI) ≤ 25 was associated with a higher likelihood of IM injection compared to BMI > 25 ($p = 0.038$). There were no differences in reactogenicity for either 60° or 90° angle of administration.
Conclusion: For the majority of vaccinees, a 60–90° angle of vaccine administration is appropriate for IM deposition of vaccinate. The likelihood of intramuscular deposition is reduced for individuals with a BMI > 25. The increasing rates of obesity globally highlight the importance of tailoring vaccination procedures accordingly.

1. Introduction

Immunisation is considered to be the most significant public health measure implemented globally [1]. Several studies have demonstrated that for most vaccines, local adverse events are minimised and immunogenicity is optimised by ensuring that the vaccine is deposited into the muscle rather than the subcutaneous layer [2–7]. Whilst it has widely been agreed that for many vaccines, an essential process for optimal vaccination is to ensure deposition of vaccinate into the muscle, there is currently no defined methodology for measuring deposition of vaccinate during vaccine administration.

Ultrasound has previously been used to determine the thickness of the subcutaneous and muscle layers of the arm and thigh in an effort to determine appropriate needle length for injection into muscle and to assess extensive swelling reactions following DTPa vaccination to support vaccine administration recommendations [2,5,8–10], however these do not take into consideration differences in angles of administration or effects of actual administration such as pressure on the tissues or bunching or stretching of the skin prior to injection.

Recommendations for administration of vaccine for optimal immune response, safety and reduced reactogenicity have commonly been based on expert opinion leading to inconsistencies in recommendations as to how vaccines should best be administered [7]. In particular, there have been changes in recommendation for the angle of needle insertion in each successive edition of the Australian Immunisation Handbook (AIH) based on expert opinion, with minimal scientific evidence to support the decisions or recommendations [10–13]. In Australia, recommendations for

* Corresponding author at: Vaccinology and Immunology Research Trials Unit, Discipline of Paediatrics, Women's and Children's Hospital, 2nd floor Clarence-Rieger Building, 72 King William Road, North Adelaide, 5006 SA, Australia. Tel.: +61 8 81618115/407414303; fax: +61 8 81617031.
E-mail addresses: Helen.marshall@adelaide.edu.au (H.S. Marshall), michelle.clarke@adelaide.edu.au (M.F. Clarke), sue-evans@adelaide.edu.au (S. Evans), lino.piotto@health.sa.gov.au (L. Piotto), roger.gent@health.sa.gov.au (R.J. Gent).

0264-410X/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.vaccine.2013.03.037

angle of needle insertion have ranged from 45° to 90° over the past decade, with the current recommendation being to administer intramuscular (IM) vaccines using a 25 mm needle at a 90° angle for infants, children and adults or a 38 mm needle at a 90° angle for very large or obese patients [14–17]. The AIH further comments that providing an angle >70° is used, the needle should reach the muscle, however it should be noted that this statement is based on a trigonometric evaluation which identified that a 72° angle of administration or more allows for a needle depth which is at least 95% of that reached using a 90°administration [12]. The UK green book which documents national immunisation procedures recommends a 90 degree angle for IM administration of vaccines, but suggests that in adults, a longer length (e.g. 38 mm) may be required and that individual assessments should be made [18].

According to additional vaccine administration guidance provided in the UK [19] and recommendations in the US [20], a 90° angle is recommended for vaccination for children, adolescents and adults, with specific weight based guidelines outlined for when a longer needle length (38 mm) is recommended. The UK guidance on best practice in vaccine administration and the US redbook, recommend that a 38 mm needle is used with a 90° angle for women who weigh greater than 90 kg and men who weigh more than 118 kg [19,20].

No previous studies have directly examined whether using either a 60° or 90° needle angle affects the likelihood of vaccinate being deposited into muscle.

The aim of this study was to compare vaccine administration at a 60° and 90° angle to assess the level of deposition of vaccinate by ultrasound examination.

2. Material and methods

This was a randomized, cross-over study conducted in children, adolescents and adults comparing vaccine administration at a 60° and 90° angle to visually assess the level of deposition of vaccinate using ultrasound (Fig. 1). The secondary aim was to describe and compare any reactogenicity events associated with vaccine administration at a 60° and 90° angle of insertion. The study was registered on the Australian Clinical Trials Registry: ACTRN:12609000050257 and approved by the Children, Youth and Women's Health Service Human Research Ethics Committee (REC 2093). Informed consent was obtained before any study procedures were performed. This study was conducted in the Department of Paediatrics and the Department of Medical Imaging at the Women's and Children's Hospital in Adelaide, South Australia.

2.1. Study participants

Participants were healthy volunteers enrolled from the community between December 2008 and November 2010. Inclusion criteria included healthy individuals, eligible for either hepatitis A or combined hepatitis A and B vaccine in the following age groups: children (aged 4–11 years of age), adolescents (aged 12–15 years of age) and adults (aged between 16 and 50 years) and able to receive a vaccination in the deltoid region of the arm. Vaccines administered included either two doses of Havrix 1440® or VAQTA Paediatric® (Hepatitis A) or three doses of Twinrix Junior® (Hepatitis A and Hepatitis B) depending on age and vaccine history of participant.

Exclusion criteria included: (1) any contraindication to vaccine administration according to recommendations in the AIH, including history of allergy to any component of the vaccine, (2) previous vaccination with the licensed vaccine offered (3) history of allergy to aquasonic contact gel (used in the ultrasound examination) (4) previous infection with Hepatitis A or Hepatitis B, (5) a bleeding disorder or condition associated with a prolonged bleeding time that would contraindicate IM injection (6) pregnant or breast feeding at time of enrolment in the study and for the duration of the study.

Table 1
Reactogenicity events severity scoring scale.

	Grade 1	Grade 2	Grade 3
Redness	0–20 mm	>20–50 mm	>50 mm
Swelling	0–20 mm	>20–50 mm	>50 mm
Pain	Minor reaction to touch	Discomfort, interferes with normal activity	Prevents normal activity

Following informed consent, participants were randomized to receive vaccine administered at a 60° or 90° angle (Fig. 1). A computer generated randomization list was used to sequentially randomise participants to either a 60° or 90° angle of administration for their first vaccination under ultrasound. Blinding of randomization was not possible for this study due to the nature of the intervention and method of measurement. An experienced immunisation nurse or a research doctor with expertise in immunisation, was instructed to administer the vaccine using a 23 gauge 25 mm needle, inserted to the needle hub, into the deltoid muscle. The injection was given using the administration technique as recommended in the Australian Immunisation Handbook of an injection administered over 5 s to avoid injection pain and muscle trauma [17]. All staff involved were part of the investigative team and were trained in study processes. Templates showing a 90° and 60° angle to the upper arm were held at the injection site during vaccination to ensure an angle approximating 90° (85°–95°) or 60° (55°–65°) was achieved.

Ultrasonography was performed with a Philips iu22 ultrasound system, using a 17 MHz linear-array transducer placed on the deltoid while the vaccine was administered by the study research nurse. This included positioning of the participant with serial views of muscle and subcutaneous tissues before and during vaccine administration. Real time clips and hard copies of images were recorded showing the injection and deposition of the vaccinate with the site of vaccinate deposition confirmed by the ultrasonographer (Fig. 2). Only the ultrasonographer observed the screen during the vaccination procedure. In order to minimise any inter-observer variation only two ultrasonographers were involved as part of the research team and were trained in study processes for this study.

Reactogenicity at the site of administration for vaccines given at either a 60° or 90° angle was assessed by participants or their parents and included measuring and recording pain, redness and/or swelling in mm on a defined scale of 1–3 on a 7 day diary card (Table 1).

In addition, during the study it was determined that assessment of body mass index (BMI) should be included and so height and weight measurements were taken at the next scheduled appointment.

2.2. Statistical analyses

This is a descriptive pilot study with a small sample size in each age group. A sample size estimation was not determined for this pilot study as only a small number of participants was planned to test the feasibility of study processes, particularly in children. Descriptive statistics performed included tabulating counts and proportions for each cohort for whom IM vaccinate deposition was achieved by angle of administration as well as counts and proportions experiencing reactogenicity events. Chi square testing was used to identify any associations between angle of administration and the proportion achieving IM injection.