Characterization of carbohydrate binding and ADP ribosyltransferase activities of chemically detoxified pertussis toxins

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History

- International collaborative study on validation of an in vitro assay system as an alternative to current histamine sensitization test for acellular pertussis vaccines (2010 ~ 2011)
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**Vaccine samples**

Acellular pertussis containing vaccine (ACV) samples were kindly donated by GSK, Belgium, Sanofi Pasteur, Canada and Takeda Pharmaceuticals, Japan. They comprise three different types of ACV products currently in the worldwide market, with three batches of each vaccine type detoxified with glutaraldehyde and/or formaldehyde and they are:

- A purified acellular pertussis vaccine of five components detoxified with glutaraldehyde in combination with Diphtheria, tetanus, inactivated poliomyelitis and Haemophilus influenza type b conjugate vaccine

- A purified acellular pertussis vaccine of three components detoxified with glutaraldehyde and formaldehyde in combination with diphtheria and tetanus.

- A co-purified acellular pertussis vaccine detoxified with formaldehyde in combination with diphtheria and tetanus.
Retrospective analysis of the results of acellular pertussis vaccine toxicity tests performed in Korea

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Specific toxicity test is a major quality control test for acellular pertussis (AP) vaccines performed by manufacturers and regulatory authorities. The mouse body weight gain test (MWGT), the leukocytosis-promoting test (LPT) and the histamine sensitization test (HST) have been conducted to check the specific toxicity of all batches of AP vaccines used in Korea through the national quality control program, which requires a lot of animals, labor and time. In this study, test results obtained in the past 9 years from a total of 258 lots of AP vaccines were examined retrospectively to evaluate the three test methods. A pairwise comparison of the test results indicated a good correlation between LPT and HST, whereas MWGT showed no correlation with either LPT or HST. Moreover, the reversion to toxicity was higher than the residual toxicity in the majority of lots tested by HST, which indicated that the histamine-sensitizing toxicity, although rated within a safe range, increased during the vaccine storage. Thus, the vaccine safety test results accumulated in the past might be useful for the improvement of test protocols.

Figure 2. Comparison of the HST results for residual toxicity and those for reversion to toxicity (n=258).
(A) HST results for residual toxicity. (B) HST results for reversion to toxicity. (C) Overlaps of the two results.
Outline of Study Design

- The aims of the study
  - is to characterize the *in vitro* biochemical assays according to detoxifying agents.
  - is to further evaluate the reversion to toxicity between the aP vaccines using the *in vitro* biochemical assays

- Materials
  - detoxified PTx (PTx is purified from strain Tohama I) according to formaldehyde (at final concentration 0.26%), glutaraldehyde (at final concentration 0.05%), mixture of glutaraldehyde (0.05%) and formaldehyde (0.26%)

- Methods
  - Carbohydrate binding assay
  - Enzymatic HPLC assay
  - Silver staining and western blotting
Cross-linking patterns of the chemically detoxified PTx
Carbohydrate binding activities according to detoxifying agents and storage conditions

Graphs showing absorbance levels of PTx at different concentrations for Native PTx, Formaldehyde, Glutaraldehyde, and Glutaraldehyde + Formaldehyde.
ADP-ribosyltransferase activities according to detoxifying agent and storage condition.
Relationship between the carbohydrate binding and ADP-ribosyltransferase activities according to detoxifying agents.
Summary

1. Formaldehyde treatment effectively detoxified the pertussis toxin, but its toxicity could be reverted during storage at 37°C.

2. Glutaraldehyde treatment did not inactivate ADP-ribosyltransferase activity, but it completely and irreversibly inactivated the carbohydrate binding activity of pertussis toxin.

3. Glutaraldehyde and formaldehyde treatment inactivated two *in vitro* biochemical activities and showed reversion to toxicity, although a much lesser extent than formaldehyde treated samples.

4. The reversion to toxicity was shown in just two weeks.

5. The *in vitro* biochemical assays may be approached as a vaccine specific manner rather than common methods used for all types of aP vaccines.
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Thank you for your attention!