FACT SHEET

Staphylococcal Enterotoxin B (SEB)

Introduction

Staphylococcal Enterotoxin B (SEB) is an exotoxin produced by the bacterium *Staphylococcus aureus*. These bacteria (Figure 1), which generally measure between 0.8 and 1.2 µm, are non-motile, gram-positive, non spore-forming and can be either aerobic or anaerobic. They are normally present on the skin and in the mucous membranes of both humans and animals, but can also be found in the environment and in (contaminated) food.

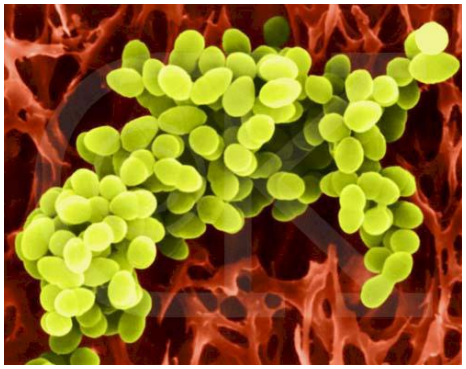

Figure 1:
Grape-like cluster of *Staphylococcal aureus*
Source: http://swampie.wordpress.com/2008/02/17/

Besides SEB, *S. aureus* produces other serotypes (A, C-G), as well as TSST-1, the bacterial toxin responsible for toxic shock syndrome. The acute toxicity of *Staphylococcal aureus* is similar to that of botulinum neurotoxins; even tiny amounts (ca. 25 µg) of SEB can cause acute poisoning. Given that a number of new toxin genes have been profiled in recent years, it is more than likely that there are a great many more serotypes than previously thought.
S. aureus is the most pathogenic of all staphylococci for humans. It causes two types of illness:

The bacterium itself causes purulent, localised surface infections, such as boils, abscesses and infected lacerations. At the same time it can also lead to major systemic infections like blood poisoning, osteomyelitis, pneumonia, internal abscesses and endocarditis). *S. aureus* is also one of the most common causes of hospital-acquired infections. Antibiotic-resistant – or "multiresistant" – strains of staphylococcus can be found in almost all hospitals worldwide.

Illnesses transmitted by the toxin are caused by the ingestion of enterotoxins (food poisoning), chiefly as a result of food contaminated with *S. aureus*. SEB is also toxic by inhalation, though such cases are rarely fatal. The risk of death is highest among newborns and those whose health is already compromised.

Structure and properties of Staphylococcal Enterotoxin B

The superantigen Staphylococcal Enterotoxin B is a protein with a mass of 28.4 kDa. It is considerably more stable in unphysiological conditions than other protein-based toxins such as ricin and botulinum neurotoxins. For example, SEB can survive in boiling water for several minutes, whereas ricin is all but inactivated after some 15 minutes at +80°C.

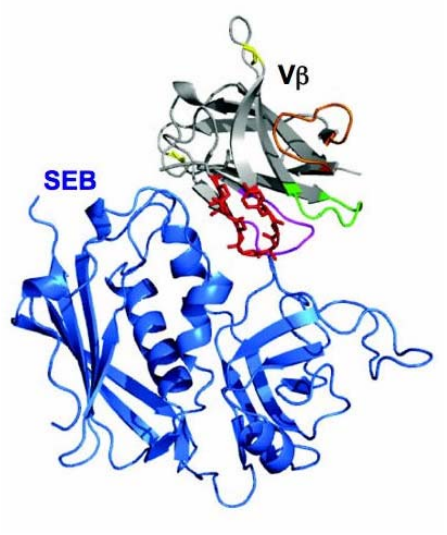

Figure 2:

Structure of Staphylococcal Enterotoxin B with the variable region (grey/multicoloured) of the proteins T-cell receptor.
Source: http://www.sciencedaily.com/releases/2007/05/070521145512.htm

The superantigen SEB deregulates the immune system by stimulating human T-cells, which in turn causes an over-production of cytokines. It would seem that this delays recognition of the bacteria (*Staphylococcus aureus)*, thus enabling the effective proliferation of the toxin. It is the massive over-production of cytokines which is responsible for toxic shock syndrome (TSS). In vitro studies have found that under certain circumstances these toxins can inhibit the humoral immune response, thereby preventing the production of antibodies.

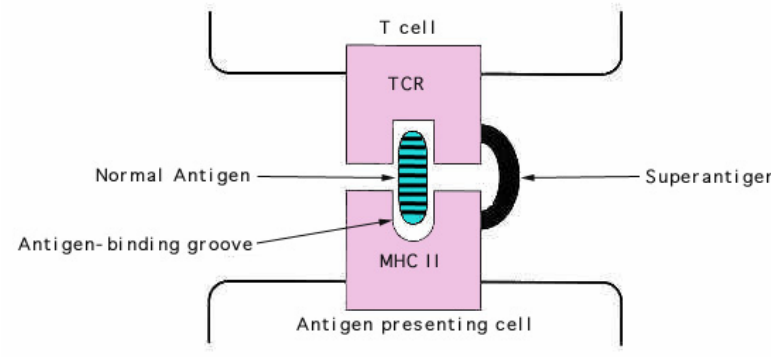

Figure 3:

Superantigens: Mechanism of action. As a bifunctional molecule, superantigens bond simultaneously with the receptor sites of Class II MHC molecules in the cell containing antigens and with the T-cell receptors (TCR) found on the T-cells.

Source: http://bioinfo.bact.wisc.edu/themicrobialworld/staph.html

Toxicity of SEB

Three to 12 hours after inhaling the toxin, the onset of flu-like symptoms occurs, such as high fever, dry tickly cough, muscle pain and headaches, possibly accompanied by diarrhoea and vomiting. The inhalation of high concentrations of the toxin is associated with additional symptoms, including breathing difficulties, nausea, weakness and even pulmonary oedema. Such cases are rarely fatal.
Shortly after ingesting the toxin (2 to 4 hours), hypersalivation and nausea occur, followed by bouts of vomiting, stomach cramps and diarrhoea. As a general rule, ingestion of the toxin does not cause breathing difficulties or fever. However, high doses can lead to septic shock and death.

There is no effective therapy against SEB. Treatment is merely symptomatic.

The oral ED_{50} value (effective dose) of SEB is 0.3 μg/kg[1] and toxicity via inhalation (LD_{50}) is 20 μg/kg[1]. Consequently, it takes the ingestion of around 25 μg SEB to cause serious symptoms in 50% of cases. According to the scientific literature, sensitivity to the toxin can vary considerable from one individual to another.

Detection

The Staphylococcal Enterotoxin B (SEB) protein can be identified quite easily using immunological methods. Highly-sensitive rapid detection systems - or lateral flow assays - are readily available on the market that can identify SEB (limit of detection = < 10 ppb or < 10 ng/ml) in the space of 20 minutes (manufacturer: Tetracore, USA, see Links). These types of assay are designed primarily to handle aqueous solutions and swab samples.

The ELISA kit, which is also readily available on the market (manufacturer: R-Biopharm, Germany see Links), can screen for the presence of a range of Staphylococcal Enterotoxin serotypes in food.

Besides immunological methods such as the ELISA Sandwich (microtiter plate with 96 wells) or multiplex systems (X-Map Luminex Technology, BioPlex 200 by Bio-Rad), traditional laboratory analyses also involve the use of other protocols like mass spectrometry (peptide map). The SPIEZ LABORATORY has established a protocol which is capable of simultaneously identifying SEBs, ricin and botulinum toxins using Bio-Plex 200

SEB as a biological warfare agent

In military circles SEB is better known as an "*incapacitating agent*". Tiny amounts can cause acute poisoning, which completely incapacitates the victim within a short space of time. However, such cases are seldom fatal. The use of this agent can rapidly overwhelm the medical infrastructure if it causes large-scale incapacitation.
It can be used either in aerosol form or could be used to contaminate the food supply.

Literature

- Toxine - Biogene Gifte und potenzielle Kampfstoffe; H. Russmann (2003) 46:989-996; Springer-Verlag Heidelberg.
- Review Staphylococcal Enterotoxins; N. Balaban, International Journal of Food Microbiology 61 (2000) 1–10.
- Staphylokokken-Enterotoxine: Bildung, Eigenschaften und Nachweis; Becker H. et al, Journal für Verbraucherschutz und Lebensmittelsicherheit, Volume 2, Number 2/May 2007, pp. 171-189.
- Public health response to biological and chemical weapons: WHO guidance (2004), Annex 2: Toxins.
- Laboratory exposures to staphylococcal enterotoxin B; Rusnak J.M. et al, Emerg Infect Dis. 2004 Sep;10(9):1544-9.
- Strategies to Protect the Health of Deployed U.S. Forces (Detecting, Characterizing and Documenting Exposures, National Academy Press (2000), Author: Thomas E. McKone, page 60.

Links

http://en.wikipedia.org/wiki/Superantigen
http://en.wikipedia.org/wiki/Staphylococcus_aureus
http://emedicine.medscape.com/article/830715-overview
http://www.who.int/csr/delibepidemics/biochemguide/en/
http://www.tetracore.com/
http://www.r-biopharm.com/

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