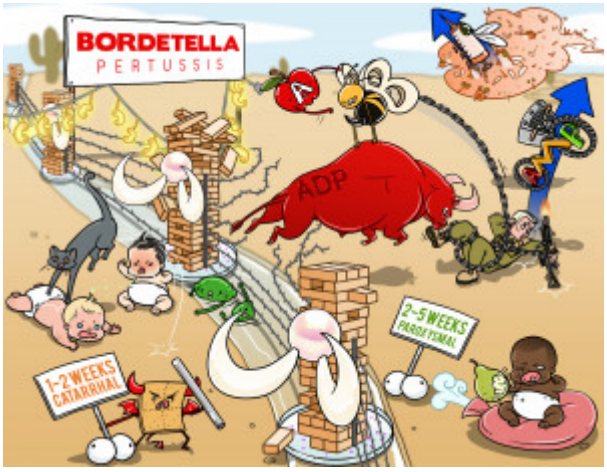
Bordetella pertussis

Bordetella pertussis is a gram-negative coccobacillus that is the causative agent of whooping cough. This organism is typically cultured on specialized medium called Bordet Gengou agar. Bordetella pertussis produces the pertussis toxin, which is an ADP ribosylating AB toxin that is involved in the colonization of the respiratory tract and the establishment of infection. This toxin catalyzes the ADP ribosylation of the Gi subunit, which prevents the G proteins from interacting with G protein coupled receptors on the cell membrane. The Gi subunits remain locked in an inactive or off state and are therefore unable to inhibit adenyl cyclase activity leading to increased concentrations of cAMP. The increase in intracellular cAMP has several systemic effects including lymphocytosis and an increase in insulin leading to hypoglycemia. The first 1-2 weeks of infection is typically called the catarrhal phase. The patient is usually most contagious during this stage of infection and signs and symptoms include nasal congestion, rhinorrhea, sneezing, and a low-grade fever. The catarrhal phase is followed by a paroxysmal phase which occurs during weeks 2-5 of infection. The paroxysmal phase is characterized by paroxysms of intense coughing lasting up to several minutes, occasionally followed by a loud inspiratory whooping sound, characteristic of this infection. Antibiotic use can hasten the eradication of the bacteria and help prevent spread. Erythromycin is one of the preferred agents for patients aged 1 month or older.



PLAY PICMONIC

Pathophysiology

Gram-Negative

Graham-cracker Negative-devil

Bordetella pertussis is a gram-negative organism due to the relatively thin peptidoglycan layer in the cell wall.

Coccobacillus

Cockeyed-rod

A coccobacillus is a type of rod-shaped bacteria that reflects an intermediate shape between a sphere and a rod. These bacteria are short and wide, resembling cocci.

Bordet-Gengou Agar

Border Jenga in Petri-dish

Bordetella experiences optimal growth on a particular type of agar known as Bordet-Gengou agar that utilizes glycerol, potato extract and blood as well as an antibacterial such as penicillin or cephalexin. While Bordet-Gengou remains the classic media for culture of B. Pertussis, microbiologists today frequently use Regan-Lowe media.

ADP Ribosylating AB Toxin

ADP Red-bull with (A) Apple and (B) Bee Toxin

The pertussis bacterial toxin acts via ADP ribosylation of the Gi (G inhibitory) subunit.

Inhibits Gi to cause Increase in cAMP

Inhibiting-chains on Gi-Joe-guy causing Up-arrow cAMP

The pertussis toxin inhibits the Gi (G inhibitory) subunit of the G protein coupling complex which regulates an adenylate cyclase mediated conversion of ATP to cyclic AMP (cAMP). Essentially, this toxin inactivates the off switch of the G protein subunit causing a dramatic increase in cAMP. The increase in cAMP can cause disturbances in cellular signaling mechanisms.

Signs AND Symptoms

Lymphocytosis

Lymphocytes with Lymph-limes

Due to the inhibition of the Gi subunit, there is an increase in the conversion of ATP to cAMP. This increase in cAMP can cause disturbances in cellular signaling mechanisms including preventing phagocytes from correctly responding to an infection. The toxin causes a decrease of the entry of lymphocytes into lymph nodes meaning lymphocytes cannot leave the bloodstream leading to lymphocytosis. Adults can have complete lymphocyte counts over 4000 uL while children may have counts over 8000 uL.

Increase in Insulin

Up-arrow Insect-syringe

Increased intracellular cAMP also leads to an increased release of insulin in the body, causing hypoglycemia.

Catarrhal Phase is Infectious Period

Cat-arrhal Sign and Infectious-baby

The patient is most contagious during the catarrhal stage of infection, often in the first 1-2 weeks of infection. Signs and symptoms of the catarrhal phase include nasal congestion, rhinorrhea, sneezing, low-grade fever, and tearing.

Paroxysmal Phase is Symptomatic Period

Pear-oxysmal Sign

Paroxysms are sudden attacks or outbursts. The paroxysmal phase occurs during weeks 2-5 of infection and is characterized by paroxysms of intense coughing lasting up to several minutes, occasionally followed by a loud inspiratory sound characteristic of pertussis. Patients may make a whooping sound when breathing or may also vomit.

Whooping Cough

Coughing-baby on Whoopee-cushion

Infection with Bordetella pertussis is characterized by paroxysms of intense coughing lasting up to several minutes, occasionally followed by a loud inspiratory sound characteristic of pertussis. Patients may make a whooping sound when breathing or may also vomit. The characteristic whooping inspiratory sound gives the name whooping cough.

Treatment

Macrolides

Macaroni-lights

Antibiotic use can hasten the eradication of the bacteria and help prevent spread. Macrolide antibiotics including erythromycin, azithromycin and clarithromycin are the antimicrobial agents of choice to combat Bordetella pertussis infection. However, which of these becomes the preferred antibiotic depends on the patient’s age, as children less than 1 month of age should not be given erythromycin due to the increased risk of developing hypertrophic pyloric stenosis (HPS).