Pertussis: An Emerging Infection

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Abstract

Pertussis is a highly contagious disease that is re-emerging worldwide despite realistic vaccination coverage. Evidenced-based research concludes contributing factors to the re-emergence of pertussis: increased awareness, improved diagnostics, decreased vaccination coverage, suboptimal vaccines, waning vaccine-induced immunity, and pathogen adaptation. The Centers for Disease Control and Prevention newly recommended guidelines for Tdap administration may assist in disease prevention.

Keywords: pertussis, re-emergence, Tdap
Pertussis: An Emerging Infection

During the 20th century, infectious diseases remain among the leading causes of death throughout the world despite progression of medical advances. One of the reasons that infectious diseases are a primary cause of mortality is due to the re-emergence of old infectious diseases. “Re-emerging diseases are known diseases that have reappeared after a significant decline in incidence” (NIAID, 2010). New strains of old infectious diseases are re-emerging by means of genetic variations, recombinations, and adaptations. Our bodies have not been formerly exposed to these diseases, and therefore, these new pathogenic strains are not recognized by our immune systems. The National Institute of Allergy and Infectious Diseases states (2010), “decreased compliance with vaccination policy has also led to re-emergence of diseases such as measles and pertussis, which were previously under control” (NIAID, 2010).

Pertussis is one such disease that is re-emerging throughout the world. Pertussis, also known as whooping cough, is a respiratory disease that is caused by the bacterium Bordetella pertussis (B. pertussis) and is spread by contact with respiratory secretions or airborne droplets. Pertussis was a major contributor of infant mortality, prior to the inception of childhood immunizations in the 1950s. “Widespread vaccination of children reduced the incidence of illness and deaths caused by pertussis” (CDC, 2009). Morbidity and mortality rates have decreased since the introduction of whole-cell pertussis vaccine during the 1940’s through 1960’s in many countries. However, despite the induction of whole-cell pertussis vaccine, pertussis remains a leading cause of vaccine-preventable deaths throughout the world. The re-emergence of pertussis has been detected in industrialized countries even with high vaccination coverage (CDC, 2010).
Evidence Related to Emerging Pertussis

Transmission & Isolation

“The reemergence of pertussis has been attributed to various factors, including increased awareness, improved diagnostics, decreased vaccination coverage, suboptimal vaccines, waning vaccine-induced immunity, and pathogen adaptation” (CDC, 2009). *Bordetella pertussis* is often transmitted by older unvaccinated family members, friends, and relatives. Scientific evidence supports the observation that pathogenic adaptation has occurred with *B. pertussis*. It has been shown that “antigenic divergence has occurred between vaccine strains and clinical isolates with respect to surface proteins, which confer protective immunity” (CDC, 2009). In a scientific study involving mice, *Bordetella pertussis* strain variations have shown to affect vaccine efficacy. Due to the adaptation of virulent factors of *B. pertussis*, studies have been conducted on the development of *B. pertussis* by examining the polymorphism in the promoter of pertussis toxin (Ptx). The emergence of virulent strains and increased manufacturing of pertussis toxin (Ptx) has impacted the resurgence of pertussis, as seen in the Netherlands (CDC, 2009).

Clinical Presentation

Pertussis is an acute respiratory infectious disease caused by the bacterium *Bordetella pertussis*. It is also known as Whooping Cough or the cough of 100 days. Pertussis is a highly contagious respiratory disease that is characterized by violent coughing, often making it difficult to breathe. After a coughing attack, a “whooping” sound is often heard with someone with pertussis as they take a deep breath. Pertussis frequently distresses infants and young children and can be fatal (CDC, 2012).
Despite the introduction of whole-cell pertussis vaccine, pertussis remains a leading cause of death in children. “Pertussis has become the most prevalent vaccine-preventable disease in industrialized countries”. In the 1990s a resurgence of pertussis was observed in several countries with highly vaccinated populations” (CDC, 2009). In 1995 through 1996, the incidence of pertussis was 6.6% per year for persons age 3–79 in both the United States and the Netherlands. Interestingly enough, the reemergence of pertussis infections is noted to be increasing in older populations who have declining vaccine-induced immunity (CDC, 2009).

**Diagnosis**

Current laboratory methodology to confirm a pertussis infection and assist clinicians in a confirmed diagnosis include: specimen collection of a culture, polymerase chain reaction (PCR), and serology testing of IgA/IgM antibodies. The use of PCR testing should be used when atypical pertussis is suspected. “The use of PCR has made the rapid diagnosis of pertussis possible and is more sensitive than culture” (Sintchenko, 2008, p.143). The PCR sensitivity rate for testing for pertussis is 94% and its specificity is 97%. Specimen collection obtained by a nasopharyngeal swab or aspirate are the only specimens for culture with a sensitivity rate of 15% and specificity rate of 100%. “The greatest specificity for the serological diagnosis of *B. pertussis* infection is achieved by the measurement of IgG and IgA antibodies against pertussis toxin” (Sintchenko, 2008, p.143). After multiple vaccine trails, it was confirmed that serology testing may be less sensitive and reliable for routine testing.

“Recent evidence for Europe and Australia indicates that we may face the emergence of successful clones on *Bordetella* harbouring new variants of pertussis toxin” (Sintchenko, 2008, p.144). During the past ten years, decreased vaccine efficacy for pertussis was discovered when
multiple forms of *B.pertussis* genes were determined in the form of pertussis toxin and pertactin; an immunogenic *B. pertussis* virulent factor.

Identification of virulent factors of *B. pertussis* is costly and time-consuming. Sintchenko (2008) states, “Researchers at the Centre for Infectious Diseases and Microbiology have been developing new culture-independent methods for molecular subtyping of *B. pertussis* directly from clinical specimens” (p.144-145). This research will permit future observance of possible epidemiological changes and monitor the efficacy of immune response.

**Therapy**

Immunization is the best protection against pertussis. The American Academy of Pediatrics and the U.S. Centers of Disease Control and Prevention have released new guidelines for the use of the Tdap (tetanus-diptheria-pertussis) vaccine (USA Today, 2011). Dr. Len Horovitz, a pulmonologist at Lenox Hill Hospital in New York City states, “Changes in recommendations for pertussis vaccination have come about as a consequence of the re-emergence of whooping cough.” “Vaccination is critical in the pediatric age group because of the higher rate of lung damages, morbidity and mortality of the preventable disease” (USA Today, 2011).

The Centers of Disease Control and Prevention (CDC) recommended administration of a one-time dose of Tdap to all adults. The Tdap immunization is specifically recommended for pregnant women more than 20 weeks gestation, adults that have contact with infants younger than 12 months, health-care providers, and adolescents at 11 to 12 years of age. It is also recommended that a single dose of Tdap be given to children 7 to 10 years of age who were under-immunized or who have an incomplete vaccination history. (CDC-MMWR, 2012).
For clinical treatment and postexposure prophylaxis of \textit{B. pertussis}, the CDC recommends the macrolide antibiotic, erythromycin. It is given four times a day for 14 days. Due to the fact that erythromycin has uncomfortable gastrointestinal side effects, poor compliance to the treatment regimen with erythromycin does occur. In this scenario, two other macrolide antibiotics are the recommendation for treatment of pertussis; azithromycin and clarithromycin (CDC, 2005).

**Analysis of Evidence**

“Evidence-Based Medicine (EBM) is an approach to health care that promotes the collection, interpretation, and integration or valid, important and applicable patient-reported clinician-observed and research-derived evidence. The best available evidence, moderated by patient circumstances and preferences, is applied to improve the quality of clinical judgments” (The Cochrane Library, 2010, para1). Evidence-Based Medicine is the reassurance for quality improvement in patient care and treatment. EBM cannot occur without the analysis of evidence. This may include: an adequate sample size, sampling procedures, data collection and analysis, analysis of findings, and implications or recommendations for quality improvement (Laura Ford, 2011).

The analysis of the evidence suggests that \textit{B. pertussis} is a re-emerging infectious disease throughout the world. The articles chosen for this analysis were all current, but for the exception of one. This was a longitudinal study by Van Loo, Van Der Hyde, Nagelkerke, Verhoef, & Mooi, examining the time of 1949-1996 in highly vaccinated populations. There was an adequate sample size in the studies that were reviewed.

The emergence of virulent strains and increased manufacturing of pertussis toxin (Ptx) has impacted the resurgence of pertussis, as seen in the Netherlands (CDC, 2009). The statistical
analysis in the study of the Netherlands from 1949-1996 was calculated by cross-tabulating frequencies by period and applying the $x^2$ test. The analysis of this data proved that in the Netherlands *B. pertussis* had “undergone major changes since the introduction of wide-scale vaccination in the 1953. One change occurred before 1965 and was reflected in a change in DNA types and a significant decrease in genotypic diversity. The second change occurred after 1980 and involved antigenic shifts in pertactin” (Van Loo, I., Van Der Hyde, H., Nagelkerke, N., Verhoef, J., & Mooi, F., 1999). Also the CDC states (2000), “A mismatch between the vaccine and circulating strains of *Bordetella pertussis* may have contributed to pertussis re-emergence” (CDC, 2000).

Polymerase chain reaction (PCR) is a sensitive and specific method for the diagnosis of *B. pertussis*. Sintchenko states (2008), “The use of PCR has made the rapid diagnosis of pertussis possible and is more sensitive than culture” (p.143). The PCR sensitivity rate for testing for pertussis is 94% and its specificity is 97%. This evidence is also confirmed by a comparison study by Loeffelholz, Thompson, Long, & Gilchrist in 1999. The study contained 319 specimens in which all three tests (PCR, culture, and direct fluorescent-antibody testing (DFA)) were performed. “After resolution of the status of the discrepant specimens, the sensitivity, specificity, positive predictive value, and negative predictive value were 15.2, 100, 100, and 87.5%, respectively, for culture: 93.5, 97.1, 84.3, and 98.9%, respectively, for PCR; and 52.2, 98.2, 82.8, and 92.4% respectively, for DFA” (Loeffelholz, Thompson, Long, & Gilchrist, 1999).

The Centers for Disease Control and Prevention (CDC) states that immunization is the best protection against pertussis (2012). The American Academy of Pediatrics and the U.S. Centers of Disease Control and Prevention have released new guidelines for the use of the Tdap (tetanus-diptheria-pertussis) vaccine (USA Today, 2011). These recommendations were brought
about due to the re-emergence of pertussis; especially in older populations. “Waning vaccine-induced immunity has been suggested as an explanation of the reemergence of the disease in other countries and probably has contributed to the pertussis epidemic in the 1980s and in 1996-97” (CDC, 2000).

**Promotion of Pertussis**

“The reemergence of pertussis has been attributed to various factors, including increased awareness, improved diagnostics, decreased vaccination coverage, suboptimal vaccines, waning vaccine-induced immunity, and pathogen adaptation” (CDC, 2009). These factors, including the transmission of pertussis need to be examined to stop the promotion of pertussis worldwide.

Pertussis is a highly contagious respiratory disease caused by the bacterium, *Bordetella pertussis*. The bacterium attaches itself to the cilia in the upper respiratory system and causes damage and inflammation. It is spread by contact with respiratory secretions or airborne droplets of humans only. The disease is spread by infected persons coughing or sneezing while in close contact with others. The recipient then breathes in the pertussis bacteria. Infants whom acquire pertussis are infected by older siblings, parents, and caregivers that do not even realize that they themselves are infected with pertussis (CDC, 2010).

Immunization is the best protection against pertussis. “Recently, decreased compliance with vaccination policy has also led to re-emergence of diseases such as pertussis, which were previously under control” (NIAID, 2010). It is recommended by the CDC (2012), that all adults, especially those caring for infants, should get a Tdap. Non-compliance with school vaccination policy can promote the prevalence of pertussis within a school system and community. The state of Michigan requires that all students receive a Tdap upon entering the sixth grade. (CDC, 2011)
Conclusion

Pertussis, a highly contagious respiratory disease, is re-emerging worldwide despite the induction of whole-cell pertussis vaccine. The re-emergence of pertussis has been detected in industrialized countries even with high vaccination coverage (CDC, 2010). Evidence-Based Medicine concludes that the re-emergence of *Bordetella pertussis* is due to number of factors: including increased awareness, improved diagnostics, decreased vaccination coverage, suboptimal vaccines, waning vaccine-induced immunity, and pathogen adaptation” (CDC, 2009). The promotion of pertussis is inevitable unless vaccine compliance of all ages takes place and is promoted by medical providers.
References


