Psittacosis/ Avian Chlamydiosis

Ornithosis, Parrot Fever

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Importance

Avian chlamydiosis, which is also called psittacosis in some hosts, is a bacterial disease of birds caused by members of the genus *Chlamydia*. *Chlamydia psittaci* has been the primary organism identified in clinical cases, to date, but at least two additional species, *C. avium* and *C. gallinacea*, have now been recognized. *C. psittaci* is known to infect more than 400 avian species. Important hosts among domesticated birds include psittacines, poultry and pigeons, but outbreaks have also been documented in many other species, such as ratites, peacocks and game birds. Some individual birds carry *C. psittaci* asymptomatically. Others become mildly to severely ill, either immediately or after they have been stressed. Significant economic losses are possible in commercial turkey flocks even when mortality is not high. Outbreaks have been reported occasionally in wild birds, and some of these outbreaks have been linked to zoonotic transmission.

C. psittaci can affect mammals, including humans, that have been exposed to birds or contaminated environments. Some infections in people are subclinical; others result in mild to severe illnesses, which can be life-threatening. Clinical cases in pregnant women may be especially severe, and can result in the death of the fetus. Recent studies suggest that infections with *C. psittaci* may be underdiagnosed in some populations, such as poultry workers. There are also reports suggesting that it may occasionally cause reproductive losses, ocular disease or respiratory illnesses in ruminants, horses and pets.

C. avium and *C. gallinacea* are still poorly understood. *C. avium* has been found in asymptomatic pigeons, which seem to be its major host, and in sick pigeons and psittacines. *C. gallinacea* was first identified in poultry flocks that had been linked to chlamydiosis in people, and it is suspected to be a human pathogen. Its virulence for birds is still unclear, although it has not been linked to any illnesses to date.

Etiology

Avian chlamydiosis can result from infection by *Chlamydia psittaci* or the recently recognized species *C. avium* and *C. gallinacea*. There may also be other avian-associated *Chlamydia*, particularly in wild birds. For example, the candidate chlamydial species *C. ibidis* was detected in healthy, free-living African sacred ibises (*Threskiornis aethiopicus*) in western France, and potentially novel chlamydiae have been found in some raptors and seabirds. Avian chlamydiosis is generally called psittacosis (or ornithosis) in humans. This helps distinguish it from chlamydiosis caused by *C. trachomatis,* an organism that circulates among people.

Members of the genus *Chlamydia* are coccoid, obligate intracellular bacteria in the family Chlamydiaceae and order Chlamydiales. They are considered to be Gram negative, due to their relationships with other Gram negative bacteria, but they are difficult to stain with the Gram stain. Chlamydiae have a unique life cycle, alternating between two different forms called the elementary body and the reticulate body (see "Transmission and Life Cycle" for details). *C. psittaci* was the only chlamydial species known to be maintained in birds until the last few years, and nearly all cases of avian chlamydiosis have been attributed to this organism. At least 16 genotypes of *C. psittaci,* based on the bacterial ompA gene, have been recognized in birds or mammals. Genotypes A through F and EB seem to be most common, but other genotypes (I, J, 1V, 6N, MatI16, R54, YP84 and CPX0308) are also found in birds. Genotype WC was isolated from one outbreak in cattle, and M56 from an outbreak in muskrats. Some *C. psittaci* genotypes tend to be associated with certain avian hosts, but this is not absolute, and infections in other species are increasingly recognized. Humans can be infected with any genotype, but some (e.g., genotype A) seem to be associated with a higher incidence of serious illnesses than others. OmpA genotyping can misidentify some isolates, and multi-locus sequence typing (MLST), which is based on a panel of genes, is also used for epidemiological studies.

Chlamydia/Chlamydophila psittaci nomenclature

The genus *Chlamydia* has undergone a number of name changes over the years. At one time, all of the chlamydial organisms in birds, humans and other animals were

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called either *Chlamydia psittaci* or *Chlamydia trachomatis*. Most "*C. psittaci*" associated with mammals were later renamed, becoming *C. pecorum*, *C. abortus*, *C. felis*, *C. caviae* and *C. pneumoniae*. In 1999, members of the genus *Chlamydia* were also split into the two genera *Chlamydia* and *Chlamydophila*. All avian strains of *Chlamydia psittaci* and two mammalian isolates (WC and M56) became *Chlamydophila psittaci*. However, *Chlamydophila* and *Chlamydia* were recently reunited, and *Chlamydophila psittaci* is once again called *Chlamydia psittaci*.

Species Affected

Chlamydia psittaci

C. psittaci has been reported in more than 450 species of birds belonging to at least 30 orders. Among domesticated and pet birds, this organism is well-known for infecting psittacine birds (parrots and their relatives) and pigeons, but it also occurs in other species including turkeys, ducks, chickens, geese, game birds (e.g., quail, partridges), ratites (rheas, ostriches), pet passerines (canaries and finches) and peacocks. In addition, infections have been found in diverse free-living or captive wild species ranging from waterfowl, seabirds and penguins to passerines and raptors. Clinical cases and outbreaks have been reported in many species of birds, although they seem to be more common in some hosts than others.

C. psittaci has been found occasionally in various mammals including dogs, cats, horses, cattle, goats, sheep, water buffalo (*Bubalus bubalis*), pigs, muskrats, wild ungulates including roe deer (*Capreolus capreolus*), and some zoo species. In some cases, the organism was detected in animals with clinical signs; in others, it was found in asymptomatic animals, or in both healthy and sick members of a species. A polymerase chain reaction (PCR) assay found *C. psittaci* DNA in some healthy reptiles in Japanese zoos. One report described isolating *C. psittaci* from sick African clawed frogs (*Xenopus laevis*), but it was published when "*Chlamydia psittaci*" still included chlamydiae associated with mammals, and the true identity of this organism is uncertain.

There is still some uncertainty in the exact host range of *C. psittaci,* especially among uncommon hosts such as mammals. One issue is that many studies have relied on PCR and/or serology. Serological tests may detect cross-reactive antibodies to other species of *Chlamydia*, and nucleic acids do not necessarily indicate that live organisms are present. The sensitivity of PCR also increases the risk that a positive result could result from environmental contamination. Another issue is that some PCR tests based on the ompA gene might misidentify certain chlamydial species. In particular, recombination can occur between *C. psittaci* and the ruminant-associated species *C. abortus,* and the homology in the ompA gene sequences of these two organisms can be high. Improved PCR assays to distinguish *C. psittaci* and *C. abortus* have recently been published. There seem to be few experiments attempting to reproduce avian chlamydiosis in mammals; however, calves inoculated directly into the bronchi with *C. psittaci* (bypassing some host defenses) became ill. These calves were able to transmit the organism to other calves, although these contacts had few or no clinical signs.

Chlamydia avium and Chlamydia gallinacea

The host range of *C. avium* and *C. gallinacea* is still unclear. *C. avium* has been reported from pigeons, which may be a major reservoir host, and sick pigeons and psittacine birds. *C. gallinacea* has been described in poultry including chickens, turkeys, guinea fowl, ducks and geese, and a captive ultramarine grosbeak (*Cyanocompsa brissonii*). *C. gallinacea* has not been associated with clinical signs in poultry, as of 2017. There are currently no reports of *C. avium* or *C. gallinacea* in animals other than birds.

Zoonotic potential

C. psittaci is zoonotic. Most human infections have been linked to contact with birds or their environments, but suspected zoonotic transmission was also reported after contact with an infected equine placenta. *C. gallinacea* is also likely to infect humans. It was detected in poultry flocks associated with three cases of atypical pneumonia in abattoir workers. These cases had been diagnosed as avian chlamydiosis, but *C. psittaci* was not found in any of the birds. *C. avium* has not been reported, to date, in people.

Geographic Distribution

C. psittaci can be found worldwide. As of 2017, *C. gallinacea* has been described in Europe, China and Australia, and *C. avium* in Europe.

Transmission and Life Cycle

Life cycle

Chlamydiae have a unique life cycle involving two forms, the infectious elementary body, which is smaller and relatively inert, and the non-infectious reticulate body. The reticulate body is found only inside cells. An elementary body taken up by a host cell remains inside a membrane-bound inclusion body in the cell's cytoplasm, where it transforms into the reticulate body. Reticulate bodies divide for a time, then transform back into elementary bodies, which are released when the cell disintegrates or the inclusion body fuses with the cell membrane. The latter process leaves the cell intact. Chlamydiae can sometimes persist for long periods in unknown locations in the body.

Transmission

C. psittaci can be acquired by birds when they inhale infectious dust or airborne particles such as feathers, or ingest infectious material including carcasses. Large quantities of this organism are excreted in feces, and can become aerosolized when the fecal material dries. It is also shed in respiratory and oral secretions. Biting flies, mites and lice may be involved in mechanical transmission. Some birds carry *C. psittaci* asymptomatically, and can shed it intermittently for long periods. Shedding can be precipitated by concurrent infections or stressors such as nutritional deficiencies, handling, overcrowding or egg laying.

Vertical transmission has been reported in diverse avian species, but appears to be infrequent. *C. psittaci* also occurs on the surface of eggs in infected flocks, and eggshell penetration of organisms was demonstrated under experimental conditions. Most infected eggs do not hatch. More often, young birds may be infected in the nest via regurgitated food from the parents, by exposure to environmental contamination, or from ectoparasites. Nestlings that survive can become carriers.

C. psittaci can be transmitted on fomites including contaminated feed or water. The elementary body of this organism may remain viable for longer than a month in the environment if it is protected by organic debris. It is reported to survive in bird feed for up to two months, on glass for 15 days, and in straw for 20 days. While persistence is longer at low temperatures, one study found that *C. psittaci* remained viable for at least 72 hours at temperatures between 4°C and 56°C, in a crude suspension from infected eggs.

Humans are usually infected by direct contact with infected birds, or from the environment when they inhale contaminated dust, feathers and aerosolized secretions or excretions. Dogs have become infected after eating bird carcasses or feces. Person-to-person transmission seems to be uncommon, but a few severely ill patients have transmitted this organism to others. People who became infected included family members, hospital caregivers and a hospital roommate. In at least some cases, the organism was thought to have spread via aerosols generated during paroxysmal coughing. Experimentally infected calves were able to infect other calves in contact.

Disinfection

Some of the disinfectants expected to be effective against *C. psittaci* include quaternary ammonium compounds, aldehydes (e.g., formaldehyde, glutaraldehyde), 70% isopropyl alcohol, sodium hydroxide (including a 1:32 preparation of household bleach) and chlorophenols. This organism is reported to be resistant to acid or alkali.

Like most other bacteria, *C. psittaci* is expected to be susceptible to moist heat of 121°C (250°F) for a minimum of 15 minutes, and dry heat of 160-170°C (320-338°F) for one hour or longer. One study found that the related organism *C. trachomatis* was inactivated by heating at 55°C (131°F) for 10 minutes, although this has not been confirmed for *C. psittaci*.

Infections in Animals

Incubation Period

The incubation period for illnesses caused by *C. psittaci* is usually 3 days to several weeks in pet birds and poultry. Carriers can become ill any time; in some cases, this occurs years after they were infected. The incubation periods for other avian chlamydiae are currently unknown.

Clinical Signs

Chlamydia psittaci in birds

Infections with *C. psittaci* can be asymptomatic or result in mild to severe clinical signs in birds. This organism generally causes systemic illness, but localized syndromes (e.g., conjunctivitis) are also reported.

Infected psittacine birds often remain asymptomatic until they are stressed. Clinical cases in these birds can be acute or chronic. The signs are generally nonspecific, and may include anorexia, lethargy, ruffled feathers, serous or mucopurulent oculonasal discharge, hepatomegaly and weight loss. Severely affected birds can become emaciated and dehydrated. Some birds develop respiratory signs ranging from sneezing and increased respiratory sounds to dyspnea. Swollen sinuses, diarrhea and polyuria, with green to yellowish droppings, may also be seen. Neurological signs (torticollis, opisthotonos, tremors, convulsive movements, flaccid paralysis or paresis of the legs) have been described in some species of psittacine birds, especially in subacute to chronic cases. Conjunctivitis can be a component of systemic chlamydiosis, but it can also occur without generalized signs of disease. A syndrome of recurrent kerotoconjunctivitis has been reported in small Australian parakeets, especially members of the genus *Neophema.* Residual disturbances in feathering may be apparent in birds that recover from chlamydiosis.

The clinical signs are generally similar in other species of birds. Conjunctivitis, blepharitis and rhinitis are reported to be common signs in pigeons, and some birds may be transiently ataxic. Turkeys can become mildly to severely ill, with clinical signs that may include conjunctivitis, nonspecific signs of illness, respiratory signs and diarrhea. Mortality is high in some outbreaks among turkeys, but negligible in others. Egg production is decreased. A localized syndrome with inflammation of the nasal glands, and unilateral or bilateral swelling above the eye (but no respiratory signs or mortality) has been reported rarely in turkey flocks. Ducks can develop clinical signs, including trembling or gait abnormalities; however, some infected flocks have few or no signs of disease. Diarrhea and severe respiratory signs were prominent during an outbreak in peacocks, and sudden death (sometimes preceded by weight loss) occurred in some rheas and raptors. Clinical cases are rarely reported in chickens. Some experimentally infected chickens developed respiratory signs, conjunctivitis, diarrhea and anorexia, while others had no obvious clinical signs, but gained weight more slowly than uninfected birds.

Chlamydia psittaci in mammals

Illnesses attributed to *C. psittaci* have been reported occasionally in mammals exposed to birds. Definitive evidence for a causative role is not available in many cases; however, the syndromes generally resemble those caused by other chlamydiae.

C. psittaci has been implicated in a few abortions and/or cases of placentitis in horses and cattle, including one instance where a foal was born alive but weak. There are a few reports suggesting that it might be involved in a cattle syndrome characterized by fever, respiratory signs (e.g., serous nasal discharge, cough, tachypnea) and a sudden drop in milk production. This organism was also isolated from a sheep with pneumonia. Calves inoculated directly into the bronchi with *C. psittaci* developed a febrile illness with moderate to severe respiratory signs (tachypnea, dry cough) at higher doses, and subclinical infections or mild respiratory signs at lower doses. Sentinel calves in contact with these animals remained asymptomatic or had a few mild respiratory signs such as a mild cough or ocular discharge. *C. psittaci* is also suggested to cause kerotoconjunctivitis in ruminants, although it was also found in the eyes of asymptomatic animals. One study reported finding *C. psittaci* DNA in unspecified clinical samples from cattle, goats, cats and a pig.

Several illnesses have been attributed to *C. psittaci* in dogs. A genotype C organism, possibly acquired from a pet bird, was isolated from a group of dogs with recurrent respiratory and reproductive problems, including episodes of severe dyspnea and keratoconjunctivitis. These dogs produced litters that were smaller than normal, with unusually large numbers of dead pups. In another outbreak, the introduction of an infected cockatiel into a household was associated with illnesses in two of three dogs. One dog became acutely ill, with fever, shivering, coughing, retching, dyspnea and a slight oculonasal discharge. Another dog had a mild fever, lethargy, anorexia, congestion of the mucous membranes, and evidence of bacterial endocarditis, which resolved upon antibiotic treatment. A third dog was clinically unaffected but seropositive. *C. psittaci* was also suggested to be involved in a 5-month-old dog with fever, pleural effusion and shifting leg lameness, and a dog with a spasmodic exercise-induced cough and loss of condition. An avian strain of *C. psittaci* was isolated from the 5-month-old dog, while the other case was linked to the ingestion of infected budgerigar carcasses and infectious feces. One case of conjunctivitis in a cat appeared to have been acquired from a macaw recently added to the household, but infection with *C. felis,* which more commonly causes conjunctivitis in cats, was not ruled out.

C. avium and *C. gallinacea*

C. avium has been isolated from psittacine birds and pigeons with enteritis, respiratory disease, hepatosplenomegaly on postmortem examination, and other signs consistent with avian chlamydiosis. This organism also occurs in the intestinal contents of asymptomatic free-living pigeons. *C. gallinacea* has only been found in asymptomatic birds, to date. There are currently no reports of any mammals infected with these organisms.

Post Mortem Lesions

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The lesions in birds infected with *C. psittaci* are varied, and may include nasal adenitis, congestion of the lungs, fibrinous pneumonia, fibrinous airsacculitis, splenomegaly (often with a mottled or discolored spleen) and hepatic enlargement with multifocal hepatic necrosis. Fibrinous perihepatitis, pericarditis, peritonitis and vascular congestion, as well as enteritis and conjunctivitis, may also be seen. Asymptomatically infected birds often have no gross lesions.

Diagnostic Tests

Methods to diagnose chlamydial infections include the detection of nucleic acids and/ or antigens, serological tests and culture. A combination of techniques including histology may be necessary, especially when only one bird is involved. *C. psittaci* can be found in various secretions and excretions including conjunctival and choanal swabs, feces/ cloacal swabs/ colon contents, and tissues such as the liver, spleen, lung, kidney and pericardium. It is easier to detect this organism in birds that are acutely ill than in asymptomatic carriers, where multiple samples (e.g., repeated fecal sampling) may be necessary. *C. avium* has been found in cloacal samples/ feces from asymptomatic birds, and in tissue samples from sick birds. More than one species of avian *Chlamydia* may be found in a bird.

PCR is increasingly used to detect *C. psittaci* directly in clinical samples. PCR tests to identify *C. avium* and *C. gallinacea* have also been published. DNA microarray hybridization tests can distinguish different species of *Chlamydia*. Chlamydial antigens can be detected by immunostaining methods (immunohistochemistry, immunofluorescence) and antigen capture ELISAs. These tests cannot usually identify the species of *Chlamydia*. At one time, a chlamydial organism found in birds was generally assumed to be *C. psittaci*; however, this assumption can no longer be made. Some antigen detection tests, particularly ELISAs developed for use in human chlamydiosis, may have low sensitivity in birds.

Histology can suggest a tentative diagnosis or be used to support other diagnostic methods. Chlamydiae are small coccoid organisms that can be stained with Giemsa, Gimenez, Ziehl-Neelsen and Macchiavello's stains. They can resemble some other organisms such as *Coxiella burnetii*, the cause of Q fever.

C. psittaci can be isolated in many cell types including buffalo green monkey, McCoy, HeLa, Vero and L-929 cells, or (less commonly) in embryonated eggs. Both culture systems can also be used to recover *C. avium*. The presence of chlamydiae in cell cultures can be confirmed with tests such as immunofluorescence or immunoperoxidase staining, and the chlamydial species can be identified with PCR or other genetic tests. Isolation may be unsuccessful in birds treated with antibiotics during the previous 2-3 weeks. Because biosafety level 3 facilities are required for culture, it is available in only a limited number of laboratories. Various tests (e.g., MLST, PCR-RFLP, DNA microarrays or DNA sequencing) can be used to genotype *C. psittaci* isolates for epidemiological purposes, such as tracing outbreaks.

Serological tests to detect *C. psittaci* in various avian species include complement fixation, ELISAs, latex agglutination, elementary body agglutination (EBA) and microimmunofluorescence. Complement fixation is reported to have a high false positive rate in some species of psittacines. A four–fold rise in titer should be seen in paired samples. Tests to detect IgM, such as the EBA test, are also helpful in identifying recent infections. Asymptomatically infected birds may have low antibody titers.

Treatment

Only a limited number of antibiotics, such as tetracyclines, macrolides (e.g., erythromycin, azithromycin) and fluoroquinolones have good efficacy against chlamydiae. Tetracyclines are used most often in animals. Treatment must generally be prolonged, to eliminate the organism. Doxycycline for 45 days is normally used in psittacine birds, but attempts are being made to find shorter antibiotic protocols.

Sulfonamides can be useful against some species of *Chlamydia*, but they are not effective for *C. psittaci*.

Control

Disease reporting

Veterinarians who encounter or suspect avian chlamydiosis should follow their national and/or local guidelines for disease reporting. This disease is reportable to public health authorities in many nations, due to its potential to affect humans. In the U.S., avian chlamydiosis is also on reportable disease lists for veterinarians in many states.

Prevention

There is no vaccine for avian chlamydiosis, and complete eradication appears impractical due to the large number of potential hosts. However, steps can be taken to reduce the risk of infection. To prevent the introduction of avian chlamydiosis into a facility, new birds should be examined for signs of illness, quarantined for at least 30 days, and tested. Birds that have returned from events such as shows or fairs are also isolated. Wild birds should be excluded, and wild rodents, which might act as mechanical vectors, should be controlled. Regular cleaning and disinfection of the premises and equipment also aids control. The routine use of prophylactic antibiotics has been discouraged because it may favor the development of antibiotic-resistant strains of *C. psittaci* and other bacteria. Certification programs for pet birds may be available in some areas. More detailed recommendations are available from sources such as the National Association of State Public Health Veterinarians (NASPHV) Compendium of Measures to Control *Chlamydophila psittaci* (see Internet Resources).

If a site has become infected with *C. psittaci*, quarantines can help prevent infections from spreading. Birds should be isolated while they are being treated. Measures such as frequent wet-mopping of the floor with disinfectants can reduce the circulation of dust and feathers during this time. Poultry flocks may be depopulated. Infected premises should be thoroughly cleaned and disinfected before restocking poultry flocks or releasing treated birds from quarantine.

People who have become ill after contact with birds should consider avoiding other birds until their illness has been diagnosed. In one case, humans were thought to have infected a flock of bobwhite quail (*Colinus virginianus*) and chukar partridge (*Alectoris chukar*) after being infected by a parrot.

Morbidity and Mortality

Chlamydia psittaci

Morbidity and mortality rates for infections with *C. psittaci* vary with the host species, health of the bird(s), and virulence of the isolate. Concurrent infections, immunosuppression or stressors (e.g., egg laying, food shortages, migration) can precipitate clinical signs or increase the severity of the disease. Age can also be a factor; young birds tend to be more susceptible. In flocks where *C. psittaci* circulates, birds often become infected after they lose their protection from maternal antibodies. Epizootics tend to occur when large numbers of susceptible birds are in close contact.

C. psittaci is found relatively often in psittacine birds and pigeons, but in many cases, it is carried subclinically. In psittacine birds that become ill, the mortality rate can reach 50% or more. Clinical signs tend to be less severe in pigeons, which are usually infected with milder genotypes, and deaths are often caused by secondary infections.

Among poultry, *C. psittaci* has been reported most often in flocks of turkeys and ducks. This organism is fairly common among turkey flocks in some parts of Europe, where it can contribute significantly to respiratory disease syndromes. The mortality rate for untreated infections in this species generally ranges from 5% to 40%, but it can sometimes be higher. Genotype D seems to be associated with particularly severe outbreaks. In endemic regions, however, infections tend to present as a respiratory illness with low or absent mortality.

Symptomatic chlamydiosis seems to be uncommon in chickens, although some isolates can cause illness and death in experimentally infected birds. Significant numbers of subclinically infected chicken flocks were found in some recent European studies. Clinical chlamydiosis has been rarely reported in poultry in the U.S., although cases of chlamydiosis in humans have been traced to processing birds from infected flocks.

Information about chlamydiosis in wild birds is still incomplete. Surveys have reported prevalence rates ranging from 1% to 74% in various wild hosts. Infections seem to be particularly common in waterbirds. In particular, *C. psittaci* infections may be frequent among rescued seabirds (i.e., under birds under stress) in some areas. This has prompted some authors to warn that wildlife rescue operations should take precautions to prevent human illness, especially during disasters such as oil spills where large numbers of birds are admitted. Clinically apparent outbreaks have been seen occasionally in wild birds, including shorebirds, waterfowl and migratory birds. Rare reports of increased environmental transmission to humans might also be associated with wild bird outbreaks.

Chlamydia avium and Chlamydia gallinacea

There is little information yet about *C. avium* or *C. gallinacea*. In initial reports, *C. avium* appears to be common among asymptomatic pigeons. A German study found this organism in 15% of breeder flocks of domesticated pigeons, and a French study detected it in 8% of urban pigeons. Although *C. avium* has been linked to clinical cases, the role of *C. gallinacea* in avian illnesses remains to be determined.

Infections in Humans

Incubation Period

The incubation period in humans can be as long as one month, but most infections become symptomatic in 5-14 days.

Clinical Signs

C. psittaci can infect people asymptomatically, cause keratoconjunctivitis or result in a systemic illness. Systemic signs can be either acute or insidious in onset, and range from a mild flu-like disease with fever, chills, headache, myalgia, anorexia, malaise, sore throat and/ or photophobia, with or without respiratory signs, to severe atypical pneumonia with dyspnea. Some patients develop a dry cough, which may become mucopurulent. Gastrointestinal signs, arthralgia, joint swelling and nonspecific rash have also been reported. Some uncomplicated cases can resolve without treatment in about a week. In other patients, clinical signs may persist for months before diagnosis. Pregnant women may become severely ill and can also give birth prematurely or abort. Complications of chlamydiosis can include endocarditis, myocarditis, renal disease, hepatitis, anemia, multiorgan failure, and neurological signs such as encephalitis, meningitis and myelitis. Deaths are possible.

Atypical forms of psittacosis have also been reported. One infected person experienced severe abdominal pain, vomiting, constipation, headache and weight loss over six months, with no history of respiratory disease. A recent study from Egypt found *C. psittaci* DNA in some women who presented with various gynecological complaints including mucopurulent vaginal discharge, lower abdominal pain, recurrent abortion and/or infertility. *C. psittaci* has also been proposed to be involved in ocular adnexal MALT (mucosa-associated lymphoid tissue) lymphomas, although this is currently unproven.

Diagnostic Tests

C. psittaci infections in people can be diagnosed by methods similar to those used in birds. Cross-reactivity with chlamydiae circulating in human populations (*Chlamydia pneumoniae* and *Chlamydia trachomatis*) can be an issue in some tests, such as antigen-detection assays. A combination of clinical signs, serology and epidemiological association with birds has been used to diagnose psittacosis in many cases, but the use of PCR is increasing. In humans, *C. psittaci* can be found in sputum, pleural fluid or blood during the acute stage of the disease. Micro-immunofluorescence (MIF) and ELISAs are commonly used serological tests. Treatment with antibiotics can delay or diminish the antibody response. As in animals, culture is not widely available at diagnostic laboratories.

Treatment

Psittacosis is treated with antibiotics effective for *C. psittaci*, combined, if necessary, with supportive care. Surgical intervention may be required in cases of endocarditis. Some infants survived in erythromycin-treated pregnant women infected with zoonotic chlamydiae (*C. psittaci* or *C. abortus*) when the pregnancy was terminated early; however, erythromycin did not seem to be able to cure these cases on its own.

Prevention

Prevention and testing programs in birds help protect humans. Pet birds should be bought from reputable suppliers, and examined by a veterinarian when they are first acquired. Birds and cages should be kept in a well-ventilated area to prevent the accumulation of infectious dust, and cages should be cleaned regularly. Dampening cages and other contaminated areas with cleaning solution or disinfectant reduces aerosolization. Good hygiene, including frequent hand washing, should be employed when handling birds, their feces and their environments. Eating and drinking should be discouraged in these situations. Any bird that has regular contact with the public (e.g., birds in schools and long-term care facilities) should be routinely screened for *C. psittaci*.

Protective clothing and gloves should be worn in situations where exposure to *C. psittaci* could be possible. Respiratory and eye protection may be advisable in some situations. Some high risk activities include removing accumulations of pigeon feces, or working in abattoirs that may receive infected poultry. Regular cleaning, dust control, ventilation and disinfection are likely be helpful in reducing the number of organisms in environments such as abattoirs and hatcheries. Tending bird feeders was linked to one outbreak, and feeders should be cleaned in well-ventilated areas rather than indoors. Wetting droppings before removing them decreases aerosolization. Because *C. psittaci* may be common among seabirds, consideration should be given to protecting humans at rescue centers, especially when large numbers of birds under stress (e.g., after an oil spill) are being handled. This might also apply to other avian species. Children should be warned not to touch sick or dead birds. Asymptomatic birds can shed *C. psittaci*, and anyone who has been in contact with birds and develops symptoms consistent with psittacosis should consult a physician. Humans can be infected during even a transient exposure.

Strict precautions should be taken during any contact with birds known to be infected with *C. psittaci*. Personal protective equipment (PPE) should be used when handling birds or cleaning their cages. A respirator (N95 or higher rating) protects the wearer from inhaled organisms. Gloves and protective clothing should also be worn. Carcasses, tissues and contaminated fomites should be handled carefully. Dead birds should be immersed in disinfectant solutions to reduce the risk of aerosolization. Carcasses should be wet with disinfectant, or detergent and water, during necropsy. Necropsies should be done in a laminar flow hood. If a hood is unavailable, PPE should be worn.

Standard infection-control practices and droplet transmission precautions have been recommended for hospitalized human patients, and isolation has not generally been thought necessary. However, significant person-to-person transmission has been reported from a few severely ill people. This suggests that additional precautions such as isolation may sometimes be advisable.

Morbidity and Mortality

The risk of psittacosis is greatest among people who are exposed to birds or their tissues. Among others, this group includes bird owners, veterinarians, laboratory workers, pet shop employees and poultry workers (including workers on farms, in hatcheries and poultry processing plants). While most human cases have been associated with psittacine birds, pigeons and poultry (especially turkeys and ducks), clinical cases also occur after contact with other birds. In the 1930s, large outbreaks in Iceland and the Faroe Islands were associated with hunting fulmars (*Fulmarus glacialis*) for food. These birds were thought to have been infected from parrots being transported from South America to Europe. An outbreak in Australia was probably caused by organisms carried in wild birds, and spread when organisms in bird droppings became aerosolized during activities such as lawn mowing. An increase in psittacosis cases in Sweden in the winter of 2013 was also linked to wild birds, apparently through exposure to wild bird droppings. Most cases were associated with tending bird feeders.

How frequently infections become symptomatic in people is unclear. Some reports suggest that human infections may be relatively common after exposure to infected birds. In one outbreak, 31% of households that received pet birds from an infected flock either became ill or developed antibodies to *C. psittaci.* Since 1996, countries around the world have reported psittacosis cases ranging from fewer than 10 to more than 200 per year. However, this disease resembles other illnesses, and it may be underdiagnosed. A recent study from Germany found that *C. psittaci* was responsible for 2.1% of community-acquired pneumonia cases, while the common human pathogen *C. pneumoniae* accounted for 1.4%. Some studies suggest that inapparent infections (or contamination) by *C. psittaci* may be relatively frequent in people who work on poultry farms and in poultry hatcheries and abattoirs in Europe. *S*poradic clinical cases may be seen concurrently in these situations, especially among new employees. People who work with turkeys and ducks are thought to be at highest risk. One study from Belgium reported that *C. psittaci* was also common in workers on subclinically infected chicken farms. Some of these workers had respiratory signs that might be related to psittacosis, while others were healthy.

Cases of psittacosis in humans may be mild or severe, depending on the age and health of the individual, as well as other factors; more serious cases are usually seen in the elderly and those who are debilitated or immunocompromised. Before the use of antibiotics, the case fatality rate was generally 15-20% in the general population. It was reported to be 80% among pregnant women in one outbreak. Properly treated cases without complications are rarely fatal, but severely ill people may die despite treatment. The case fatality rate is reported to be high in cases with endocarditis. Convalescence may be slow after severe disease.

Internet Resources

Centers for Disease Control and Prevention (CDC). Psittacosis.
https://www.cdc.gov/pneumonia/atypical/psittacosis.html

European Centre for Disease Control and Prevention. Chlamydia
http://ecdc.europa.eu/en/healthtopics/chlamydia/Pages/index.aspx

National Association of State Public Health Veterinarians (NASPHV)
http://www.nasphv.org

NASPHV Compendium of Measures to Control *Chlamydophila psittaci* Infection among Humans (Psittacosis) and Pet Birds (Avian Chlamydiosis)
http://www.nasphv.org/documentsCompendiaPsittacosis.html

The Merck Veterinary Manual
http://www.merckvetmanual.com/

Public Health Agency of Canada. Pathogen Safety Data Sheets
http://www.phac-aspc.gc.ca/lab-bio/res/psds-ftss/index-eng.php

World Organization for Animal Health (OIE)
http://www.oie.int/

OIE Manual of Diagnostic Tests and Vaccines for Terrestrial Animals
http://www.oie.int/international-standard-setting/terrestrial-manual/access-online

OIE Terrestrial Animal Health Code
http://www.oie.int/international-standard-setting/terrestrial-code/access-online/

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*Link defunct