

980 tracheostomy or intubation. In some settings, pseudomembranes can be removed surgically. Treatment with glucocorticoids has not been shown to reduce the risk of myocarditis or polyneuropathy.

PROGNOSIS

Fatal pseudomembranous diphtheria typically occurs in patients with nonprotective antibody titers and in unimmunized patients. The pseudomembrane may actually increase in size from the time it is first noted. Risk factors for death include bullneck diphtheria; myocarditis with ventricular tachycardia; atrial fibrillation; complete heart block; an age of >60 years or <6 months; alcoholism; extensive pseudomembrane elongation; and laryngeal, tracheal, or bronchial involvement. Another important predictor of fatal outcome is the interval between the onset of local disease and the administration of antitoxin. Cutaneous diphtheria has a low mortality rate and is rarely associated with myocarditis or peripheral neuropathy.

PREVENTION

Vaccination Sustained campaigns for vaccination of children and adequate boosting vaccination of adults are responsible for the exceedingly low incidence of diphtheria in most developed nations. Currently, diphtheria toxoid vaccine is coadministered with tetanus vaccine (with or without acellular pertussis). DTaP (a full-level diphtheria and tetanus toxoids and acellular pertussis vaccine) is currently recommended for children up to the age of 7; DTaP replaced the earlier whole-cell pertussis vaccine DTP in 1997. Tdap is a tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis vaccine formulated for adolescents and adults. Tdap was licensed for use in the United States in 2005 and is the recommended booster vaccine for children 11–12 years old and the recommended catch-up vaccine for children 7–10 and 13–18 years of age. It is recommended that all adults (i.e., persons >19 years old) receive a single dose of Tdap if they have not received it previously, regardless of the interval since the last dose of Td (tetanus and reduced-dose diphtheria toxoids, adsorbed). Tdap vaccination is a priority for health care workers, pregnant women, adults anticipating contact with infants, and adults not previously vaccinated for pertussis. Adults who have received acellular pertussis vaccine should continue to receive decennial Td booster vaccinations. **The vaccine schedule is detailed in Chap. 148.**

Prophylaxis Administration to Contacts Close contacts of diphtheria patients should undergo throat culture to determine whether they are carriers. After samples for throat culture are obtained, antimicrobial prophylaxis should be considered for all contacts, even those whose cultures are negative. The options are 7–10 days of oral erythromycin or one dose of IM benzathine penicillin G (1.2 million units for persons ≥6 years of age or 600,000 units for children <6 years of age).

Contacts of diphtheria patients whose immunization status is uncertain should receive the appropriate diphtheria toxoid-containing vaccine. The Tdap vaccine (rather than Td) is now the booster vaccine of choice for adults who have not recently received an acellular pertussis-containing vaccine. Carriers of *C. diphtheriae* in the community should be treated and vaccinated when identified.

OTHER CORYNEBACTERIAL AND RHODOCOCCLUS INFECTIONS

Nondiphtherial corynebacteria, referred to as *diphtheroids* or *coryneforms*, are frequently considered colonizers or contaminants; however, they have been associated with invasive disease, particularly in immunocompromised patients. These organisms have been isolated from the bloodstream, particularly in association with catheter infection, endocarditis, prosthetic valve infection, meningitis, neurosurgical shunt infection, brain abscess, and peritonitis and often in the setting of chronic ambulatory peritoneal dialysis, osteomyelitis, septic arthritis, urinary tract infection, empyema, and pneumonia, among other infections. Patients infected with these organisms usually have significant medical comorbidity or are immunosuppressed. The nondiphtherial coryneforms are a diverse collection of bacteria that

are taxonomically grouped together in the genus *Corynebacterium* on the basis of their 16S rDNA signature nucleotides. Despite the shared rDNA signatures, these isolates are quite diverse. For example, their guanine-cytosine content ranges from 45% to 70%. Several nondiphtheroid corynebacteria, including *Corynebacterium jeikeium* and *Corynebacterium urealyticum*, are associated with resistance to multiple antibiotics. *Rhodococcus equi* is associated with necrotizing pneumonia and granulomatous infection, particularly in immunocompromised individuals.

MICROBIOLOGY AND LABORATORY DIAGNOSIS

These organisms are non-acid-fast, catalase-positive, aerobic or facultatively anaerobic rods. Their colonial morphologies vary widely; some species are small and α-hemolytic (similar to lactobacilli), whereas others form large white colonies (similar to yeasts). Many nondiphtherial coryneforms require special media, such as Löffler's, Tinsdale's, or telluride medium. These cultivation idiosyncrasies have led to a complex taxonomic categorization of the organisms.

EPIDEMIOLOGY

Humans are the natural reservoirs for several nondiphtherial coryneforms, including *C. xerosis*, *C. pseudodiphtheriticum*, *C. striatum*, *C. minutissimum*, *C. jeikeium*, *C. urealyticum*, and *Arcanobacterium haemolyticum*. Animal reservoirs are responsible for carriage of *Arcanobacterium pyogenes*, *C. ulcerans*, and *C. pseudotuberculosis*. Soil is the natural reservoir for *R. equi*.

C. pseudodiphtheriticum is a component of the normal flora of the human pharynx and skin. *C. xerosis* is found on the skin, nasopharynx, and conjunctiva; *C. auris* in the external auditory canal; and *C. striatum* in the anterior nares and on the skin. *C. jeikeium* and *C. urealyticum* are found in the axilla, groin, and perineum, particularly in hospitalized patients. Infections with *C. ulcerans* and *C. pseudotuberculosis* have been associated with the consumption of raw milk from infected cattle.

C. ulcerans This organism causes a diphtheria-like illness and produces both diphtheria toxin and a dermonecrotic toxin. The organism is a commensal in horses and cattle and has been isolated from cow's milk. *C. ulcerans* causes exudative pharyngitis, primarily during summer months, in rural areas, and among individuals exposed to cattle. In contrast to diphtheria, this infection is considered a zoonosis whose person-to-person transmission has not been documented. Nevertheless, treatment with antitoxin and antibiotics should be initiated when respiratory *C. ulcerans* is identified, and a contact investigation (including throat cultures to determine the need for antimicrobial prophylaxis and, in unimmunized contacts, administration of the appropriate diphtheria toxoid-containing vaccine) should be conducted. The organism grows on Löffler's, Tinsdale's, and telluride agars as well as blood agar. In addition to exudative pharyngitis, cutaneous disease due to *C. ulcerans* has been reported. *C. ulcerans* is susceptible to a wide panel of antibiotics. Erythromycin and macrolides appear to be the first-line agents.

C. pseudotuberculosis (ovis) Infection caused by *C. pseudotuberculosis* is rare and is reported almost exclusively from Australia. *C. pseudotuberculosis* causes suppurative granulomatous lymphadenitis and an eosinophilic pneumonia syndrome among individuals who handle horses, cattle, goats, and deer or who drink raw milk. The organism is an important veterinary pathogen, causing suppurative lymphadenitis, abscesses, and pneumonia, but is rarely a human pathogen. Successful treatment with erythromycin or tetracycline has been reported, with surgery also performed when indicated.

C. jeikeium (Group JK) Originally described in American hospitals, *C. jeikeium* infection was subsequently reported in Europe. After a 1976 survey of diseases caused by nondiphtherial corynebacteria, CDC group JK emerged as an important opportunistic pathogen among neutropenic and HIV-infected patients. The organism has now been designated a separate species. *C. jeikeium* forms small,