

## HIGHLIGHTS OF PRESCRIBING INFORMATION

These highlights do not include all the information needed to use **DOXYCYCLINE HYCLATE DELAYED-RELEASE TABLETS safely and effectively**. See full prescribing information for **DOXYCYCLINE HYCLATE DELAYED-RELEASE TABLETS**.

**DOXYCYCLINE HYCLATE delayed-release tablets, for oral use**  
Initial U.S. Approval: 1967

To reduce the development of drug-resistant bacteria and maintain the effectiveness of doxycycline hyclate and other antibacterial drugs, doxycycline hyclate delayed-release tablets should be used only to treat or prevent infections that are proven or strongly suspected to be caused by bacteria. (1)

## RECENT MAJOR CHANGES

Warnings and Precautions (5.5) 12/2014

## INDICATIONS AND USAGE

Doxycycline hyclate delayed-release tablets are a tetracycline-class antibacterial indicated for:

- Rickettsial infections (1.1)
- Sexually transmitted infections (1.2)
- Respiratory tract infections (1.3)
- Specific bacterial infections (1.4)
- Ophthalmic infections (1.5)
- Anthrax, including inhalational anthrax (post-exposure) (1.6)
- Alternative treatment for selected infections when penicillin is contraindicated (1.7)
- Adjunctive therapy in acute intestinal amebiasis and severe acne (1.8)
- Prophylaxis of malaria (1.9)

## DOSAGE AND ADMINISTRATION

- **Adults:** the usual dose of oral doxycycline is 200 mg on the first day of treatment (administered 100 mg every 12 hours) followed by a maintenance dose of 100 mg daily. In the management of more severe infections (particularly chronic infections of the urinary tract), 100 mg every 12 hours is recommended. (2.1)
- For children above 8 years of age: The recommended dosage schedule for children weighing 45 kg or less is 4.4 mg/kg of body weight divided into two doses on the first day of treatment, followed by 2.2 mg/kg of body weight given as a single daily dose or divided into two doses on subsequent days. For more severe infections up to 4.4 mg/kg of body weight may be used. For children over 45 kg, the usual adult dose should be used. (2.1)

## DOSAGE FORMS AND STRENGTHS

Tablets: 50 mg

## FULL PRESCRIBING INFORMATION: CONTENTS\*

### 1 INDICATIONS AND USAGE

- 1.1 Rickettsial Infections
- 1.2 Sexually Transmitted Infections
- 1.3 Respiratory Tract Infections
- 1.4 Specific Bacterial Infections
- 1.5 Ophthalmic Infections
- 1.6 Anthrax Including Inhalational Anthrax (Post-Exposure)
- 1.7 Alternative Treatment for Selected Infections when Penicillin is Contraindicated
- 1.8 Adjunctive Therapy for Acute Intestinal Amebiasis and Severe Acne
- 1.9 Prophylaxis of Malaria

### 2 DOSAGE AND ADMINISTRATION

- 2.1 Usual Dosage and Administration
- 2.2 For Prophylaxis of Malaria
- 2.3 Inhalational Anthrax (Post-Exposure)
- 2.4 Sprinkling the Tablet over Applesauce

### 3 DOSAGE FORMS AND STRENGTHS

### 4 CONTRAINDICATIONS

### 5 WARNINGS AND PRECAUTIONS

- 5.1 Tooth Development
- 5.2 *Clostridium difficile* Associated Diarrhea
- 5.3 Photosensitivity
- 5.4 Superinfection
- 5.5 Intracranial Hypertension
- 5.6 Skeletal Development
- 5.7 Antianabolic Action
- 5.8 Malaria
- 5.9 Development of Drug-Resistant Bacteria
- 5.10 Laboratory Monitoring for Long-Term Therapy

## FULL PRESCRIBING INFORMATION

### 1 INDICATIONS AND USAGE

To reduce the development of drug-resistant bacteria and maintain the effectiveness of doxycycline hyclate delayed-release tablets and other antibacterial drugs, doxycycline hyclate delayed-release tablets should be used only to treat or prevent infections that are proven or strongly suspected to be caused by susceptible bacteria. When culture and susceptibility information are available, they should be considered in selecting or modifying antibacterial therapy. In the absence of such data, local epidemiology and susceptibility patterns may contribute to the empiric selection of therapy.

Doxycycline is a tetracycline-class antibacterial indicated in the following conditions or diseases:

#### 1.1 Rickettsial Infections

Rocky Mountain spotted fever, typhus fever and the typhus group, Q fever, rickettsialpox, and tick fevers caused by *Rickettsia*.

#### 1.2 Sexually Transmitted Infections

Uncomplicated urethral, endocervical or rectal infections in adults caused by *Chlamydia trachomatis*.

Nongonococcal urethritis caused by *Ureaplasma urealyticum*.

Lymphogranuloma venereum caused by *Chlamydia trachomatis*.

Granuloma inguinale caused by *Klebsiella granulomatis*.

Uncomplicated gonorrhea caused by *Neisseria gonorrhoeae*.

Chancroid caused by *Haemophilus ducreyi*.

#### 1.3 Respiratory Tract Infections

Respiratory tract infections caused by *Mycoplasma pneumoniae*.

Psittacosis (ornithosis) caused by *Chlamydophila psittaci*.

Because many strains of the following groups of microorganisms have been shown to be resistant to doxycycline, culture and susceptibility testing are recommended.

Doxycycline is indicated for treatment of infections caused by the following microorganisms, when bacteriological testing indicates appropriate susceptibility to the drug:

Respiratory tract infections caused by *Haemophilus influenzae*.

Respiratory tract infections caused by *Klebsiella* species.

Upper respiratory infections caused by *Streptococcus pneumoniae*.

#### 1.4 Specific Bacterial Infections

Relapsing fever due to *Borrelia recurrentis*.

Plague due to *Yersinia pestis*.

Tularemia due to *Francisella tularensis*.

Cholera caused by *Vibrio cholerae*.

Campylobacter fetus infections caused by *Campylobacter fetus*.

Brucellosis due to *Brucella* species (in conjunction with streptomycin).

Bartonellosis due to *Bartonella bacilliformis*.

Because many strains of the following groups of microorganisms have been shown to be resistant to doxycycline, culture and susceptibility testing are recommended.

## CONTRAINDICATIONS

Doxycycline is contraindicated in persons who have shown hypersensitivity to any of the tetracyclines. (4)

## WARNINGS AND PRECAUTIONS

- The use of drugs of the tetracycline-class during tooth development (last half of pregnancy, infancy and childhood to the age of 8 years) may cause permanent discoloration of the teeth (yellow-gray-brown). (5.1)
- *Clostridium difficile*-associated diarrhea. Evaluate patients if diarrhea occurs. (5.2)
- Photosensitivity manifested by an exaggerated sunburn reaction has been observed in some individuals taking tetracyclines. Limit sun exposure. (5.3)
- Overgrowth of non-susceptible organisms, including fungi, may occur. Re-evaluate therapy if superinfection occurs. (5.4)

## ADVERSE REACTIONS

Adverse reactions observed in patients receiving tetracyclines include anorexia, nausea, vomiting, diarrhea, rash, photosensitivity, urticaria, and hemolytic anemia. (6)

To report SUSPECTED ADVERSE REACTIONS, contact Mylan Pharmaceuticals Inc. at 1-877-446-3679 (1-877-4-INFO-RX) or FDA at 1-800-FDA-1088 or www.fda.gov/medwatch.

## DRUG INTERACTIONS

- Patients who are on anticoagulant therapy may require downward adjustment of their anticoagulant dosage (7.1)
- Avoid co-administration of tetracyclines with penicillin (7.2)
- Absorption of tetracyclines is impaired by antacids containing aluminum, calcium, or magnesium, bismuth subsalicylate and iron-containing preparations (7.3)
- Concurrent use of tetracycline may render oral contraceptives less effective (7.4)
- Barbiturates, carbamazepine, and phenytoin decrease the half-life of doxycycline (7.5)

## USE IN SPECIFIC POPULATIONS

- Pregnancy Category D (8.1)
- Tetracyclines are excreted in human milk; however, the extent of absorption of doxycycline in the breastfed infant is not known. Doxycycline use during nursing should be avoided if possible. (8.3)

## See 17 for PATIENT COUNSELING INFORMATION

Revised: 4/2016  
DXYDR50-R1

## 6 ADVERSE REACTIONS

- 6.1 Postmarketing Experience

## 7 DRUG INTERACTIONS

- 7.1 Anticoagulant Drugs
- 7.2 Penicillin
- 7.3 Antacids and Iron Preparations
- 7.4 Oral Contraceptives
- 7.5 Barbiturates and Anti-Epileptics
- 7.6 Penthrane
- 7.7 Drug/Laboratory Test Interactions

## 8 USE IN SPECIFIC POPULATIONS

- 8.1 Pregnancy
- 8.3 Nursing Mothers
- 8.4 Pediatric Use
- 8.5 Geriatric Use

## 10 OVERDOSAGE

## 11 DESCRIPTION

- 12 CLINICAL PHARMACOLOGY
  - 12.1 Mechanism of Action
  - 12.3 Pharmacokinetics
  - 12.4 Microbiology

## 13 NONCLINICAL TOXICOLOGY

- 13.1 Carcinogenesis, Mutagenesis, Impairment of Fertility
- 13.2 Animal Toxicology and/or Pharmacology

## 15 REFERENCES

## 16 HOW SUPPLIED/STORAGE AND HANDLING

## 17 PATIENT COUNSELING INFORMATION

Sections or subsections omitted from the full prescribing information are not listed.

Doxycycline is indicated for treatment of infections caused by the following gram-negative microorganisms, when bacteriological testing indicates appropriate susceptibility to the drug:

*Escherichia coli*

*Enterobacter aerogenes*

*Shigella* species

*Acinetobacter* species

Urinary tract infections caused by *Klebsiella* species.

#### 1.5 Ophthalmic Infections

Trachoma caused by *Chlamydia trachomatis*, although the infectious agent is not always eliminated as judged by immunofluorescence.

Inclusion conjunctivitis caused by *Chlamydia trachomatis*.

#### 1.6 Anthrax Including Inhalational Anthrax (Post-Exposure)

Anthrax due to *Bacillus anthracis*, including inhalational anthrax (post-exposure): to reduce the incidence or progression of disease following exposure to aerosolized *Bacillus anthracis*.

#### 1.7 Alternative Treatment for Selected Infections when Penicillin is Contraindicated

When penicillin is contraindicated, doxycycline is an alternative drug in the treatment of the following infections:

Syphilis caused by *Treponema pallidum*.

Yaws caused by *Treponema pallidum* subspecies *pertenue*.

Vincent's infection caused by *Fusobacterium fusiforme*.

Actinomycosis caused by *Actinomyces israelii*.

Infections caused by *Clostridium* species.

#### 1.8 Adjunctive Therapy for Acute Intestinal Amebiasis and Severe Acne

In acute intestinal amebiasis, doxycycline may be a useful adjunct to amebicides. In severe acne, doxycycline may be useful adjunctive therapy.

#### 1.9 Prophylaxis of Malaria

Doxycycline is indicated for the prophylaxis of malaria due to *Plasmodium falciparum* in short-term travelers (less than 4 months) to areas with chloroquine and/or pyrimethamine-sulfadoxine resistant strains *[See Dosage and Administration (2.2) and Patient Counseling Information (17)]*.

## 2 DOSAGE AND ADMINISTRATION

### 2.1 Usual Dosage and Administration

THE USUAL DOSAGE AND FREQUENCY OF ADMINISTRATION OF DOXYCYCLINE DIFFERS FROM THAT OF THE OTHER TETRACYCLINES. EXCEEDING THE RECOMMENDED DOSAGE MAY RESULT IN AN INCREASED INCIDENCE OF SIDE EFFECTS.

**Adults:** The usual dose of oral doxycycline is 200 mg on the first day of treatment (administered 100 mg every 12 hours), followed by a maintenance dose of 100 mg daily. The maintenance dose may be administered as a single dose or as 50 mg every 12 hours. In the management of more severe infections (particularly chronic infections of the urinary tract), 100 mg every 12 hours is recommended.

**For Pediatric Patients Above 8 Years of Age:** The recommended dosage schedule for children weighing 45 kg or less is 4.4 mg/kg of body weight divided into two doses on the first day of treatment, followed by 2.2 mg/kg of body weight given as a single daily dose or divided into two doses on subsequent days. For more severe infections up to 4.4 mg/kg of body weight may be used. For children over 45 kg, the usual adult dose should be used.

Administration of adequate amounts of fluid along with capsule and tablet forms of drugs in the tetracycline-class is recommended to wash down the drugs and reduce the risk of esophageal irritation and ulceration *[See Adverse Reactions (6.1)]*.

If gastric irritation occurs, doxycycline may be given with food or milk *[see Clinical Pharmacology (12)]*.

When used in streptococcal infections, therapy should be continued for 10 days.

**Uncomplicated Urethral, Endocervical, or Rectal Infection in Adults Caused by Chlamydia Trachomatis:** 100 mg by mouth twice a day for 7 days.

**Uncomplicated Gonococcal Infections in Adults (Except Anorectal Infections in Men):** 100 mg, by mouth, twice-a-day for 7 days. As an alternative single visit dose, administer 300 mg stat followed in an hour by a second 300 mg dose.

**Nongonococcal Urethritis (NGU) Caused by U. Urealyticum:** 100 mg by mouth twice-a-day for 7 days.

**Syphilis—Early:** Patients who are allergic to penicillin should be treated with doxycycline 100 mg by mouth twice-a-day for 2 weeks.

**Syphilis of More Than One Year's Duration:** Patients who are allergic to penicillin should be treated with doxycycline 100 mg by mouth twice-a-day for 4 weeks.

**Acute Epididymo-Orchitis Caused by C. Trachomatis:** 100 mg, by mouth, twice-a-day for at least 10 days.

#### 2.2 For Prophylaxis of Malaria

For adults, the recommended dose is 100 mg daily. For children over 8 years of age, the recommended dose is 2 mg/kg given once daily up to the adult dose. Prophylaxis should begin 1 or 2 days before travel to the malarious area. Prophylaxis should be continued daily during travel in the malarious area and for 4 weeks after the traveler leaves the malarious area.

#### 2.3 Inhalational Anthrax (Post-Exposure)

**Adults:** 100 mg, of doxycycline, by mouth, twice-a-day for 60 days.

**Children:** weighing less than 45 kg, 2.2 mg/kg of body weight, by mouth, twice-a-day for 60 days. Children weighing 45 kg or more should receive the adult dose.

#### 2.4 Sprinkling the Tablet over Applesauce

Doxycycline hyclate delayed-release tablets may also be administered by carefully breaking up the tablet and sprinkling the tablet contents (delayed-release beads) on a spoonful of applesauce. The delayed-release beads must not be crushed or damaged when breaking up the tablet. Any loss of beads in the transfer would prevent using the dose. The applesauce/doxycycline mixture should be swallowed immediately without chewing and may be followed by a glass of water if desired. The applesauce should not be hot, and it should be soft enough to be swallowed without chewing. In the event that a prepared dose of applesauce/doxycycline cannot be taken immediately, the mixture should be discarded and not stored for later use.

## 3 DOSAGE FORMS AND STRENGTHS

Doxycycline Hyclate Delayed-Release Tablets, USP are available containing delayed-release beads of doxycycline hyclate, USP equivalent to 50 mg of doxycycline.

- Doxycycline Hyclate Delayed-Release Tablets USP, 50 mg are white, round, unscored tablets containing yellow beads debossed with **M** on one side of the tablet and **D36** on the other side. Each tablet contains specially coated beads of doxycycline hyclate, USP equivalent to 50 mg of doxycycline.

## 4 CONTRAINDICATIONS

The drug is contraindicated in persons who have shown hypersensitivity to any of the tetracyclines.

## 5 WARNINGS AND PRECAUTIONS

### 5.1 Tooth Development

The use of drugs of the tetracycline-class during tooth development (last half of pregnancy, infancy and childhood to the age of 8 years) may cause permanent discoloration of the teeth (yellow-gray-brown). This adverse reaction is more common during long-term use of the drugs but it has been observed following repeated short-term courses. Enamel hypoplasia has also been reported. Doxycycline should not be used in this age group, except for anthrax, including inhalational anthrax (post-exposure), unless other drugs are not likely to be effective or are contraindicated.

### 5.2 Clostridium difficile Associated Diarrhea

*Clostridium difficile* associated diarrhea (CDAD) has been reported with use of nearly all antibacterial agents, including doxycycline hyclate delayed-release tablets, and may range in severity from mild diarrhea to fatal colitis. Treatment with antibacterial agents alters the normal flora of the colon leading to overgrowth of *C. difficile*.

*C. difficile* produces toxins A and B which contribute to the development of CDAD. Hypertxin producing strains of *C. difficile* cause increased morbidity and mortality, as these infections can be refractory to antimicrobial therapy and may require colectomy. CDAD must be considered in all patients who present with diarrhea following antibacterial use. Careful medical history is necessary since CDAD has been reported to occur over 2 months after the administration of antibacterial agents.

If CDAD is suspected or confirmed, ongoing antibacterial use not directed against *C. difficile* may need to be discontinued. Appropriate fluid and electrolyte management, protein supplementation, antibacterial treatment of *C. difficile*, and surgical evaluation should be instituted as clinically indicated.

### 5.3 Photosensitivity

Photosensitivity manifested by an exaggerated sunburn reaction has been observed in some individuals taking tetracyclines. Patients apt to be exposed to direct sunlight or ultraviolet light should be advised that this reaction can occur with tetracycline drugs, and treatment should be discontinued at the first evidence of skin erythema.

### 5.4 Superinfection

As with other antibacterial preparations, use of doxycycline may result in overgrowth of non-susceptible organisms, including fungi. If superinfection occurs, the antibacterial should be discontinued and appropriate therapy instituted.

### 5.5 Intracranial Hypertension

Intracranial hypertension (IH, pseudotumor cerebri) has been associated with the use of tetracycline including doxycycline. Clinical manifestations of IH include headache, blurred vision, diplopia, and vision loss; papilledema can be found on funduscopy. Women of childbearing age who are overweight or have a history of IH are at greater risk for developing tetracycline associated IH. Avoid concomitant use of isotretinoin and doxycycline because isotretinoin is also known to cause pseudotumor cerebri.

Although IH typically resolves after discontinuation of treatment, the possibility for permanent visual loss exists. If visual disturbance occurs during treatment, prompt ophthalmologic evaluation is warranted. Since intracranial pressure can remain elevated for weeks after drug cessation patients should be monitored until they stabilize.

### 5.6 Skeletal Development

All tetracyclines form a stable calcium complex in any bone-forming tissue. A decrease in fetal growth rate has been observed in prematures given oral tetracycline in doses of 25 mg/kg every 6 hours. This reaction was shown to be reversible when the drug was discontinued.

Results of animal studies indicate that tetracyclines cross the placenta, are found in fetal tissues, and can have toxic effects on the developing fetus (often related to retardation of skeletal development). Evidence of embryotoxicity also has been noted in animals treated early in pregnancy. If any tetracycline is used during pregnancy or if the patient becomes pregnant while taking these drugs, the patient should be apprised of the potential hazard to the fetus.

### 5.7 Antianabolic Action

The antianabolic action of the tetracyclines may cause an increase in BUN. Studies to date indicate that this does not occur with the use of doxycycline in patients with impaired renal function.

## 5.8 Malaria

Doxycycline offers substantial but not complete suppression of the asexual blood stages of *Plasmodium* strains.

Doxycycline does not suppress *P. falciparum*'s sexual blood stage gametocytes. Subjects completing this prophylactic regimen may still transmit the infection to mosquitoes outside endemic areas.

### 5.9 Development of Drug-Resistant Bacteria

Prescribing doxycycline hyclate delayed-release tablets in the absence of a proven or strongly suspected bacterial infection or a prophylactic indication is unlikely to provide benefit to the patient and increases the risk of the development of drug-resistant bacteria.

### 5.10 Laboratory Monitoring for Long-Term Therapy

In long-term therapy, periodic laboratory evaluation of organ systems, including hematopoietic, renal, and hepatic studies should be performed.

## 6 ADVERSE REACTIONS

### 6.1 Postmarketing Experience

The following adverse reactions have been identified during post-approval use of doxycycline. Because these reactions are reported voluntarily from a population of uncertain size, it is not always possible to reliably estimate their frequency or establish a causal relationship to drug exposure.

Due to oral doxycycline's virtually complete absorption, side effects to the lower bowel, particularly diarrhea, have been infrequent. The following adverse reactions have been observed in patients receiving tetracyclines:

**Gastrointestinal:** Anorexia, nausea, vomiting, diarrhea, glossitis, dysphagia, enterocolitis, and inflammatory lesions (with monilial overgrowth) in the anogenital region. Hepatotoxicity has been reported. These reactions have been caused by both the oral and parenteral administration of tetracyclines. Esophagitis and esophageal ulcerations have been reported in patients receiving capsule and tablet forms of drugs in the tetracycline-class. Most of these patients took medications immediately before going to bed *[See Dosage and Administration (2.1)]*.

**Skin:** Maculopapular and erythematous rashes, Stevens-Johnson syndrome, toxic epidermal necrolysis, exfoliative dermatitis, and erythema multiforme have been reported. Photosensitivity is discussed above *[See Warnings and Precautions (5.3)]*.

**Renal:** Rise in BUN has been reported and is apparently dose-related *[see Warnings and Precautions (5.7)]*.

**Hypersensitivity Reactions:** Urticaria, angioneurotic edema, anaphylaxis, anaphylactoid purpura, serum sickness, pericarditis, and exacerbation of systemic lupus erythematosus.

**Blood:** Hemolytic anemia, thrombocytopenia, neutropenia, and eosinophilia have been reported.

**Intracranial Hypertension:** Intracranial hypertension (IH, pseudotumor cerebri) has been associated with the use of tetracycline *[see Warnings and Precautions (5.5)]*.

**Thyroid Gland Changes:** When given over prolonged periods, tetracyclines have been reported to produce brown-black microscopic discoloration of thyroid glands. No abnormalities of thyroid function are known to occur.

## 7 DRUG INTERACTIONS

### 7.1 Anticoagulant Drugs

Because tetracyclines have been shown to depress plasma prothrombin activity, patients who are on anticoagulant therapy may require downward adjustment of their anticoagulant dosage.

### 7.2 Penicillin

Since bacteriostatic drugs may interfere with the bactericidal action of penicillin, it is advisable to avoid giving tetracyclines in conjunction with penicillin.

### 7.3 Antacids and Iron Preparations

Absorption of tetracyclines is impaired by antacids containing aluminum, calcium, or magnesium, bismuth subsalicylate, and iron-containing preparations.

### 7.4 Oral Contraceptives

Concurrent use of tetracycline may render oral contraceptives less effective.

### 7.5 Barbiturates and Anti-Epileptics

Barbiturates, carbamazepine, and phenytoin decrease the half-life of doxycycline.

### 7.6 Penthrane

The concurrent use of tetracycline and Penthrane®† (methoxyflurane) has been reported to result in fatal renal toxicity.

### 7.7 Drug/Laboratory Test Interactions

False elevations of urinary catecholamines may occur due to interference with the fluorescence test.

## 8 USE IN SPECIFIC POPULATIONS

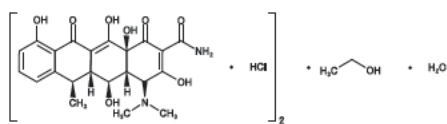
### 8.1 Pregnancy



## 11 DESCRIPTION

Doxycycline hyclate delayed-release tablets, USP, for oral administration, contain specially coated beads of doxycycline hyclate, a broad-spectrum antibacterial synthetically derived from oxytetracycline, in a delayed-release formulation for oral administration.

The structural formula for doxycycline hyclate is:



with a molecular formula of  $(C_{22}H_{24}N_2O_9 \cdot HCl)_2 \cdot C_{12}H_{18}O_4 \cdot H_2O$  and a molecular weight of 1025.87. The chemical designation for doxycycline hyclate is 4-(Dimethylamino)-1,4,4a,5,5a,6,11,12a-octahydro-3,5,10,12,12a-pentahydroxy-6-methyl-1,11-dioxo-2-naphthacene-carboxamide monohydrochloride, compound with ethyl alcohol (2:1), monohydrate. Doxycycline hyclate, USP is a yellow to light yellow crystalline powder soluble in water and in solutions of alkali hydroxides and carbonates. Doxycycline has a high degree of lipid solubility and a low affinity for calcium binding. It is highly stable in normal human serum. Doxycycline will not degrade into an epianhydro form. Inactive ingredients in the tablet formulation are: anhydrous lactose, colloidal silicon dioxide, croscopovidone, hypromellose phthalate, lactose monohydrate, povidone, pregelatinized starch (corn), sodium chloride, sodium lauryl sulfate, stearic acid, talc, and triethyl citrate.

USP Dissolution Test Pending.

## 12 CLINICAL PHARMACOLOGY

### 12.1 Mechanism of Action

Doxycycline is an antibacterial drug [see Microbiology (12.4)].

### 12.2 Pharmacokinetics

Doxycycline is virtually completely absorbed after oral administration. Following administration of a single 200 mg dose to adult volunteers, average serum doxycycline levels were 2.6 mcg/mL at 2 hours decreasing to 1.45 mcg/mL at 24 hours. The mean  $C_{max}$  and  $AUC_{0-\infty}$  of doxycycline are 24% and 13% lower, respectively, following single dose administration of doxycycline hyclate delayed-release tablets, 100 mg with a high fat meal (including milk) compared to fasted conditions. The mean  $C_{max}$  of doxycycline is 19% lower and the  $AUC_{0-\infty}$  is unchanged following single dose administration of doxycycline hyclate tablets, 150 mg with a high fat meal (including milk) compared to fasted conditions. The clinical significance of these differences is unknown.

When doxycycline hyclate delayed-release tablets are sprinkled over applesauce and taken with or without water, the extent of doxycycline absorption is unchanged, but the rate of absorption is increased slightly.

Tetracyclines are concentrated in bile by the liver and excreted in the urine and feces at high concentrations and in a biologically active form. Excretion of doxycycline by the kidney is about 40%/72 hours in individuals with a creatinine clearance of about 75 mL/min. This percentage may fall as low as 1% to 5%/72 hours in individuals with a creatinine clearance below 10 mL/min.

Studies have shown no significant difference in the serum half-life of doxycycline (range 18 to 22 hours) in individuals with normal and severely impaired renal function. Hemodialysis does not alter the serum half-life.

### 12.4 Microbiology

**Mechanism of Action:** Doxycycline inhibits bacterial protein synthesis by binding to the 30S ribosomal subunit. Doxycycline has bacteriostatic activity against a broad range of Gram-positive and Gram-negative bacteria. Cross-resistance between tetracyclines is common.

Doxycycline has been shown to be active against most isolates of the following bacteria, both *in vitro* and in clinical infections as described in the INDICATIONS AND USAGE section of the package insert for doxycycline hyclate delayed-release tablets [see Indications and Usage (1)].

#### Gram-Negative Bacteria

*Acinetobacter* species  
*Bartonella bacilliformis*  
*Brucella* species  
*Campylobacter fetus*  
*Enterobacter aerogenes*  
*Escherichia coli*  
*Francisella tularensis*  
*Haemophilus ducreyi*  
*Haemophilus influenzae*  
*Klebsiella granulomatis*  
*Klebsiella* species  
*Neisseria gonorrhoeae*  
*Shigella* species  
*Vibrio cholerae*  
*Yersinia pestis*

#### Gram-Positive Bacteria

*Bacillus anthracis*  
*Streptococcus pneumoniae*

#### Anaerobic Bacteria

*Clostridium* species  
*Fusobacterium fusiforme*  
*Propionibacterium acnes*

#### Other Bacteria

*Nocardiae* and other aerobic *Actinomyces* species  
*Borrelia recurrentis*  
*Chlamydia psittaci*  
*Chlamydia trachomatis*  
*Mycoplasma pneumoniae*  
*Rickettsiae*  
*Treponema pallidum*  
*Treponema pallidum* subspecies *pertenue*  
*Ureaplasma urealyticum*

#### Parasites

*Balantidium coli*  
*Entamoeba* species  
*Plasmodium falciparum*\*

\*Doxycycline has been found to be active against the asexual erythrocytic forms of *Plasmodium falciparum* but not against the gametocytes of *P. falciparum*. The precise mechanism of action of the drug is not known.

**Susceptibility Test Methods:** When available, the clinical microbiology laboratory should provide the results of *in vitro* susceptibility test results for antimicrobial drugs used in resident hospitals to the physician as periodic reports that describe the susceptibility profile of nosocomial and community-acquired pathogens. These reports should aid the physician in selecting the most effective antimicrobial.

**Dilution Techniques:** Quantitative methods are used to determine antimicrobial minimum inhibitory concentrations (MICs). These MICs provide estimates of the susceptibility of bacteria to antimicrobial compounds. The MICs should be determined using a standardized test method (broth and/or agar).<sup>5,6,8</sup> The MIC values should be interpreted according to the criteria provided in Table 1.

**Diffusion Techniques:** Quantitative methods that require measurement of zone diameters can also provide reproducible estimates of the susceptibility of bacteria to antimicrobial compounds. Zone size provides an estimate of the susceptibility of bacteria to antimicrobial compounds. The zone size should be determined using a standard test method.<sup>5,7,8</sup> This procedure uses paper disks impregnated with 30 mcg doxycycline to test the susceptibility of bacteria to doxycycline. The disk diffusion interpretive criteria are provided in Table 1.

**Anaerobic Techniques:** For anaerobic bacteria, the susceptibility to doxycycline can

be determined by a standardized test method.<sup>9</sup> The MIC values obtained should be interpreted according to the criteria provided in Table 1.

Table 1: Susceptibility Test Interpretive Criteria for Doxycycline and Tetracycline

Bacteria*	Minimal Inhibitory Concentration (mcg/mL)			Zone Diameter (mm)			Agar Dilution (mcg/mL)		
	S	I	R	S	I	R	S	I	R
<i>Acinetobacter</i> sp.									
Doxycycline	≤ 4	8	≥ 16	≥ 13	10 to 12	≤ 9	-	-	-
Tetracycline	≤ 4	8	≥ 16	≥ 15	12 to 14	≤ 11	-	-	-
Anaerobes									
Tetracycline	-	-	-	-	-	-	≤ 4	8	≥ 16
<i>Bacillus anthracis</i> <sup>4b</sup>									
Doxycycline	≤ 1	-	-	-	-	-	-	-	-
Tetracycline	≤ 1	-	-	-	-	-	-	-	-
<i>Bacillus</i> species <sup>4b</sup>									
Doxycycline	≤ 1	-	-	-	-	-	-	-	-
Tetracycline	≤ 1	-	-	-	-	-	-	-	-
<i>Enterobacteriaceae</i>									
Doxycycline	≤ 4	8	≥ 16	≥ 14	11 to 13	≤ 10	-	-	-
Tetracycline	≤ 4	8	≥ 16	≥ 15	12 to 14	≤ 11	-	-	-
<i>Francisella tularensis</i> <sup>4b</sup>									
Doxycycline	≤ 4	-	-	-	-	-	-	-	-
Tetracycline	≤ 4	-	-	-	-	-	-	-	-
<i>Haemophilus influenzae</i>									
Tetracycline	≤ 2	4	≥ 8	≥ 29	26 to 28	≤ 25	-	-	-
<i>Mycoplasma pneumoniae</i>									
Tetracycline	-	-	-	-	-	-	≤ 2	-	-
<i>Nocardiae</i> and other aerobic <i>Actinomyces</i> species <sup>4b</sup>									
Doxycycline	≤ 1	2 to 4	≥ 8	-	-	-	-	-	-
<i>Neisseria gonorrhoeae</i> <sup>6</sup>									
Tetracycline	-	-	-	≥ 38	31 to 37	≤ 30	≤ 0.25	0.5 to 1	≥ 2
<i>Streptococcus pneumoniae</i>									
Doxycycline	≤ 0.25	0.5	> 1	> 28	25 to 27	< 24	-	-	-
Tetracycline	≤ 1	2	> 4	> 28	25 to 27	< 24	-	-	-
<i>Vibrio cholerae</i>									
Doxycycline	≤ 4	8	≥ 16	-	-	-	-	-	-
Tetracycline	≤ 4	8	≥ 16	-	-	-	-	-	-
<i>Yersinia pestis</i>									
Doxycycline	≤ 4	8	≥ 16	-	-	-	-	-	-
Tetracycline	≤ 4	8	≥ 16	-	-	-	-	-	-
<i>Ureaplasma urealyticum</i>									
Tetracycline	-	-	-	-	-	-	≤ 1	-	≥ 2

\*Organisms susceptible to tetracycline are also considered susceptible to doxycycline. However, some organisms that are intermediate or resistant to tetracycline may be susceptible to doxycycline.

<sup>4b</sup>The current absence of resistance isolates precludes defining any results other than "susceptible". If isolates yielding MIC results other than susceptible, they should be submitted to a reference laboratory for further testing.

<sup>6</sup>Gonococci with 30 mcg tetracycline disk zone diameters of less than 19 mm usually indicate a plasmid-mediated tetracycline resistant *Neisseria gonorrhoeae* isolate. Resistance in these strains should be confirmed by a dilution test (MIC greater than or equal to 16 mcg/mL).

A report of *Susceptible* (S) indicates that the antimicrobial is likely to inhibit growth of the pathogen if the antimicrobial compound reaches the concentrations at the infection site necessary to inhibit growth of the pathogen. A report of *Intermediate* (I) indicates that the result should be considered equivocal, and, if the bacteria is not fully susceptible to alternative, clinically feasible drugs, the test should be repeated. This category implies possible clinical applicability in body sites where the drug is physiologically concentrated or in situations where high dosage of drug can be used. This category also provides a buffer zone that prevents small uncontrolled technical factors from causing major discrepancies in interpretation. A report of *Resistant* (R) indicates that the antimicrobial is not likely to inhibit growth of the pathogen if the antimicrobial compound reaches the concentrations usually achievable at the infection site; other therapy should be selected.

**Quality Control:** Standardized susceptibility test procedures require the use of laboratory controls to monitor and ensure the accuracy and precision of the supplies and reagents used in the assay, and the techniques of the individuals performing the test.<sup>5,6,7,8,9,10,11</sup> Standard doxycycline and tetracycline powders should provide the following range of MIC values noted in Table 2. For the diffusion technique using the 30 mcg doxycycline disk the criteria noted in Table 2 should be achieved.

Table 2: Acceptable Quality Control Ranges for Susceptibility Testing for Doxycycline and Tetracycline

QC Strain	Minimal Inhibitory Concentration (mcg/mL)	Zone Diameter (mm)	Agar Dilution (mcg/mL)
<i>Enterococcus faecalis</i> ATCC 29212			
Doxycycline	2 to 8	-	-
Tetracycline	8 to 32	-	-
<i>Escherichia coli</i> ATCC 25922			
Doxycycline	0.5 to 2	18 to 24	-
Tetracycline	0.5 to 2	18 to 25	-
<i>Eubacterium lentum</i> ATCC 43055			
Doxycycline	2 to 16	-	-
<i>Haemophilus influenzae</i> ATCC 49247			
Tetracycline	4 to 32	14 to 22	-
<i>Neisseria gonorrhoeae</i> ATCC 49226			
Tetracycline	-	30 to 42	0.25 to 1
<i>Staphylococcus aureus</i> ATCC 25923			
Doxycycline	-	23 to 29	-
Tetracycline	-	24 to 30	-
<i>Staphylococcus aureus</i> ATCC 29213			
Doxycycline	0.12 to 0.5	-	-
Tetracycline	0.12 to 1	-	-
<i>Streptococcus pneumoniae</i> ATCC 49619			
Doxycycline	0.015 to 0.12	25 to 34	-
Tetracycline	0.06 to 0.5	27 to 31	-
<i>Bacteroides fragilis</i> ATCC 25285			
Tetracycline	-	-	0.125 to 0.5
<i>Bacteroides thetaiotaomicron</i> ATCC 29741			
Doxycycline	2 to 8	-	-
Tetracycline	-	-	8 to 32
<i>Mycoplasma pneumoniae</i> ATCC 29342			
Tetracycline	0.06 to 0.5	-	0.06 to 0.5
<i>Ureaplasma urealyticum</i> ATCC 33175			
Tetracycline	-	-	≥ 8

## 13 NONCLINICAL TOXICOLOGY

### 13.1 Carcinogenesis, Mutagenesis, Impairment of Fertility

Long-term studies in animals to evaluate carcinogenic potential of doxycycline have not been conducted. However, there has been evidence of oncogenic activity in rats in studies with the related antibiotics, oxytetracycline (adrenal and pituitary tumors) and minocycline (thyroid tumors). Likewise, although mutagenicity studies of doxycycline have not been conducted, positive results in *in vitro* mammalian cell assays have been reported for related antibacterials (tetracycline, oxytetracycline). Doxycycline administered orally at dosage levels as high as 250 mg/kg/day had no apparent effect on the fertility of female rats. Effect on male fertility has not been studied.

### 13.2 Animal Toxicology and/or Pharmacology

Hyperpigmentation of the thyroid has been produced by members of the tetracycline class in the following species: in rats by oxytetracycline, doxycycline, tetracycline P<sub>04</sub>, and methacycline; in minipigs by doxycycline, minocycline, tetracycline P<sub>04</sub>, and methacycline; in dogs by doxycycline and minocycline; in monkeys by minocycline.

Minocycline, tetracycline P<sub>04</sub>, methacycline, doxycycline, tetracycline base, oxytetracycline hydrochloride, and tetracycline hydrochloride, were goitrogenic in rats fed a low iodine diet. This goitrogenic effect was accompanied by high radioactive iodine uptake. Administration of minocycline also produced a large goiter with high radioactive iodine uptake in rats fed a relatively high iodine diet.

Treatment of various animal species with this class of drugs has also resulted in the induction of thyroid hyperplasia in the following: in rats and dogs (minocycline); in chickens (chlortetracycline); and in rats and mice (oxytetracycline). Adrenal gland hyperplasia has been observed in goats and rats treated with oxytetracycline.

Results of animal studies indicate that tetracyclines cross the placenta and are found in fetal tissues.

## 15 REFERENCES

- Friedman JM, Polifka JE. *Teratogenic Effects of Drugs: A Resource for Clinicians (TERS)*. Baltimore, MD: The Johns Hopkins University Press; 2000: 149-195.
- Czizek AE and Rockenbauer M. Teratogenic study of doxycycline. *Obstet Gynecol* 1997; 89: 524-528.
- Horne HW Jr. and Kundsinn RB. The role of mycoplasma among 81 consecutive pregnancies: a prospective study. *Int J Fertil* 1980; 25:315-317.
- Hale T. *Medications and Mothers Milk*. 9th edition. Amarillo, TX: Pharmasoft Publishing 2000; 225-226.
- Clinical and Laboratory Standards Institute (CLSI). *Performance Standards for Antimicrobial Susceptibility Testing; Twenty-fourth Informational Supplement*. CLSI document M100-S24, Clinical Laboratory Standards Institute, 950 West Valley Road, Suite 2500, Wayne Pennsylvania 19087, USA, 2014.
- Clinical and Laboratory Standards Institute (CLSI). *Methods for Dilution Antimicrobial Susceptibility Tests for Bacteria that Grow Aerobically; Approved Standard – Ninth Edition*. CLSI document M07-A9, Clinical Laboratory Standards Institute, 950 West Valley Road, Suite 2500, Wayne Pennsylvania 19087, USA, 2012.
- Clinical and Laboratory Standards Institute (CLSI). *Performance Standards for Antimicrobial Disk Diffusion Susceptibility Tests; Approved Standard – Eleventh Edition*. CLSI document M02-A11, Clinical Laboratory Standards Institute, 950 West Valley Road, Suite 2500, Wayne Pennsylvania 19087, USA, 2012.
- Clinical and Laboratory Standards Institute (CLSI). *Methods for Antimicrobial Dilution and Disk Susceptibility Testing of Infrequently Isolated or Fastidious Bacteria; Approved Guideline – Second Edition*. CLSI document M45-A2, Clinical Laboratory Standards Institute, 950 West Valley Road, Suite 2500, Wayne Pennsylvania 19087, USA, 2010.
- Clinical and Laboratory Standards Institute (CLSI). *Methods for Antimicrobial Susceptibility Testing of Anaerobic Bacteria; Approved Standard – Eighth Edition*. CLSI document M11-A8, Clinical Laboratory Standards Institute, 950 West Valley Road, Suite 2500, Wayne Pennsylvania 19087, USA, 2012.
- Clinical and Laboratory Standards Institute (CLSI). *Methods for Mycobacteria, Nocardiae, and Other Aerobic Actinomyces; Approved Standard – Second Edition*. CLSI document M24-A2, Clinical Laboratory Standards Institute, 950 West Valley Road, Suite 2500, Wayne Pennsylvania 19087, USA, 2011.
- Clinical and Laboratory Standards Institute (CLSI). *Methods for Antimicrobial Susceptibility Testing for Human Mycoplasmas; Approved Guideline*. CLSI document M43-A, Clinical Laboratory Standards Institute, 950 West Valley Road, Suite 2500, Wayne Pennsylvania 19087, USA, 2011.

## 16 HOW SUPPLIED/STORAGE AND HANDLING

Doxycycline Hyclate Delayed-Release Tablets, USP are available containing delayed-release beads of doxycycline hyclate, USP equivalent to 50 mg of doxycycline.

The 50 mg tablets are white, round, unscored tablets containing yellow beads debossed with M on one side of the tablet and D36 on the other side. They are available as follows:

NDC 0378-4535-91  
bottles of 60 tablets  
NDC 0378-4535-78  
bottles of 120 tablets  
NDC 0378-4535-05  
bottles of 500 tablets

Store at 20° to 25°C (68° to 77°F). [See USP Controlled Room Temperature.]

Dispense in a tight, light-resistant container as defined in the USP using a child-resistant closure.

## 17 PATIENT COUNSELING INFORMATION

Patients taking doxycycline for malaria prophylaxis should be advised:

- that no present-day antimalarial agent, including doxycycline, guarantees protection against malaria.
  - to avoid being bitten by mosquitoes by using personal protective measures that help avoid contact with mosquitoes, especially from dusk to dawn (for example, staying in well-screened areas, using mosquito nets, covering the body with clothing, and using an effective insect repellent).
  - that doxycycline prophylaxis:
    - should begin 1 to 2 days before travel to the malarious area,
    - should be continued daily while in the malarious area and after leaving the malarious area,
    - should be continued for 4 further weeks to avoid development of malaria after returning from an endemic area,
    - should not exceed 4 months.
- All patients taking doxycycline should be advised:
- to avoid excessive sunlight or artificial ultraviolet light while receiving doxycycline and to discontinue therapy if phototoxicity (for example, skin eruptions, etc.) occurs. Sunscreen or sunblock should be considered [see Warnings and Precautions (5.3)].
  - to drink fluids liberally along with doxycycline to reduce the risk of esophageal irritation and ulceration [see Adverse Reactions (6.1)].
  - that the absorption of tetracyclines is reduced when taken with foods, especially those that contain calcium. However, the absorption of doxycycline is not markedly influenced by simultaneous ingestion of food or milk [see Drug Interactions (7.3)].
  - that the absorption of tetracyclines is reduced when taken with antacids containing aluminum, calcium or magnesium, bismuth subsalicylate, and iron-containing preparations [see Drug Interactions (7.3)].
  - that the use of doxycycline might increase the incidence of vaginal candidiasis. Diarrhea is a common problem caused by antibacterials which usually ends when the antibacterial is discontinued. Sometimes after starting treatment with antibacterials,

patients can develop watery and bloody stools (with or without stomach cramps and fever) even as late as 2 or more months after having taken the last dose of antibacterial. If this occurs, patients should contact their physician as soon as possible.

Patients should be counseled that antibacterial drugs including doxycycline hyclate delayed-release tablets should only be used to treat bacterial infections. They do not treat viral infections (for example, the common cold). When doxycycline hyclate delayed-release tablets are prescribed to treat a bacterial infection, patients should be told that although it is common to feel better early in the course of therapy, the medication should be taken exactly as directed. Skipping doses or not completing the full course of therapy may (1) decrease the effectiveness of the immediate treatment and (2) increase the likelihood that bacteria will develop resistance and will not be treatable by doxycycline hyclate delayed-release tablets or other antibacterial drugs in the future.

† The brands listed are trademarks of their respective owners.



Mylan Pharmaceuticals Inc.  
Morgantown, WV 26505 U.S.A.

Revised: 4/2016  
DKYDR50-R1