

**PRODUCT MONOGRAPH**

**CIPRO<sup>®</sup>**

**(Ciprofloxacin Hydrochloride Tablets)**

**250 mg, 500 mg, 750 mg**

**U.S.P.**

**CIPRO<sup>®</sup> ORAL SUSPENSION**

**(Ciprofloxacin Oral Suspension)**

**10 g/100 mL**

**Bayer Standard**

**Antibacterial Agent**

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**THERAPEUTIC CLASSIFICATION**

Antibacterial Agent

## **ACTION AND CLINICAL PHARMACOLOGY**

### **Action**

Ciprofloxacin, a synthetic fluoroquinolone, has in vitro activity against a wide range of gram-negative and gram-positive microorganisms. Its bactericidal action is achieved through inhibition of topoisomerase II (DNA gyrase) and topoisomerase IV (both Type II topoisomerases), which are required for bacterial DNA replication, transcription, repair, and recombination.

Ciprofloxacin retained some of its bactericidal activity after inhibition of RNA and protein synthesis by rifampin and chloramphenicol, respectively. These observations suggest ciprofloxacin may possess two bactericidal mechanisms, one mechanism resulting from the inhibition of DNA gyrase and a second mechanism which may be independent of RNA and protein synthesis.

The mechanism of action of fluoroquinolones, including ciprofloxacin, is different from that of penicillins, cephalosporins, aminoglycosides, macrolides, and tetracyclines. Therefore, microorganisms resistant to these classes of drugs may be susceptible to ciprofloxacin. Conversely, microorganisms resistant to fluoroquinolones may be susceptible to these other classes of antimicrobial agents (see **MICROBIOLOGY**). There is no cross-resistance between ciprofloxacin and the mentioned classes of antibiotics.

### **Clinical Pharmacology**

(See **HUMAN PHARMACOLOGY**.)

#### **Absorption**

Following oral administration of single doses of 250 mg, 500 mg, and 750 mg of ciprofloxacin tablets, ciprofloxacin is absorbed rapidly and extensively mainly from the small intestine, reaching maximum serum concentrations 1-2 hours later.

The absolute bioavailability is approximately 70-80%. Maximum serum concentrations ( $C_{max}$ ) and total areas under serum concentration vs time curves (AUC) increased in proportion to dose.

The pharmacokinetics of ciprofloxacin oral suspension 10% are virtually identical to those of tablets.

### **Distribution**

The protein binding of ciprofloxacin is low (20-30%), and the substance is present in plasma largely in a non-ionized form. Ciprofloxacin can diffuse freely into the extravascular space. The large steady-state volume of distribution of 2-3 L/kg body weight shows that ciprofloxacin penetrates in tissues resulting in concentrations which clearly exceed the corresponding serum levels.

### **Metabolism**

Small concentrations of four metabolites have been reported. They were identified as desethyleneciprofloxacin (M1), sulphociprofloxacin (M2), oxociprofloxacin (M3) and formylciprofloxacin (M4). M1 to M3 display antibacterial activity comparable to or inferior to that of nalidixic acid. M4, with the smallest quantity, is largely equivalent to norfloxacin in its antimicrobial activity.

### **Elimination**

Ciprofloxacin is largely excreted unchanged both renally and to a smaller extent non-renally. Renal clearance is between 0.18-0.3 L/h/kg and the total body clearance between 0.48-0.60 L/h/kg. Ciprofloxacin undergoes both glomerular filtration and tubular secretion.

Non-renal clearance of ciprofloxacin is mainly due to active transintestinal secretion as well as metabolization. 1% of the dose is excreted via the biliary route. Ciprofloxacin is present in the bile in high concentrations.

## **INDICATIONS AND CLINICAL USES**

CIPRO<sup>®</sup> (ciprofloxacin hydrochloride tablets) and CIPRO<sup>®</sup> ORAL SUSPENSION (ciprofloxacin oral suspension) may be indicated for the treatment of patients with the following infections caused by susceptible strains of the indicated microorganisms:

**Respiratory Tract Infections**

Acute exacerbation of chronic bronchitis caused by:

*Haemophilus influenzae*

*Moraxella catarrhalis*

Acute pneumonia caused by:

*Enterobacter cloacae*

*Escherichia coli*

*Haemophilus influenzae*

*Klebsiella pneumoniae*

*Proteus mirabilis*

*Pseudomonas aeruginosa*

*Staphylococcus aureus*

Acute sinusitis caused by:

*Haemophilus influenzae*

*Moraxella catarrhalis*

Due to the nature of the underlying conditions which usually predispose patients to pseudomonas infections of the respiratory tract, bacterial eradications may not be achieved in patients who display clinical improvement despite evidence of in vitro sensitivity. In patients requiring subsequent courses of therapy, CIPRO<sup>®</sup> (ciprofloxacin hydrochloride tablets) and CIPRO<sup>®</sup> ORAL SUSPENSION (ciprofloxacin oral suspension) should be used alternately with other antipseudomonal agents. Some strains of *Pseudomonas aeruginosa* may develop resistance during treatment. Therefore, susceptibility testing should be performed periodically during therapy to detect the emergence of bacterial resistance.

**Urinary Tract Infections**

Upper and lower urinary tract infections, such as complicated and uncomplicated cystitis, pyelonephritis, and pyelitis caused by:

*Citrobacter diversus*

*Citrobacter freundii*

*Enterobacter cloacae*

*Escherichia coli*

*Klebsiella pneumoniae*

*Klebsiella oxytoca*

*Morganella morganii*

*Proteus mirabilis*

*Pseudomonas aeruginosa*

*Serratia marcescens*

*Staphylococcus aureus*

*Staphylococcus epidermidis*

*Staphylococcus saprophyticus*

*Streptococcus faecalis*

Acute uncomplicated cystitis:  
in females caused by *Escherichia coli*

### **Chronic Bacterial Prostatitis**

Caused by:

*Escherichia coli*

### **Skin and Soft Tissue Infections**

Caused by:

*Enterobacter cloacae*

*Escherichia coli*

*Klebsiella pneumoniae*

*Proteus mirabilis*

*Proteus vulgaris*

*Pseudomonas aeruginosa*

*Staphylococcus aureus*

*Staphylococcus epidermidis*

*Streptococcus pyogenes*

**Bone and Joint Infections**

Caused by:

*Enterobacter cloacae*

*Pseudomonas aeruginosa*

*Serratia marcescens*

*Staphylococcus aureus*

**Infectious Diarrhea (when antibacterial therapy is indicated)**

Caused by:

*Campylobacter jejuni*

*Escherichia coli* (enterotoxigenic strains)

*Shigella dysenteriae*

*Shigella flexneri*

*Shigella sonnei*

**Meningococcal Carriers**

Treatment of asymptomatic carriers of *Neisseria meningitidis* to eliminate meningococci from the nasopharynx. An MIC determination on the isolate from the index case should be performed as soon as possible. **Ciprofloxacin is not indicated for the treatment of meningococcal meningitis.**

**Typhoid Fever (enteric fever)**

Caused by:

*Salmonella paratyphi*

*Salmonella typhi*

**Uncomplicated Gonorrhoea**

Cervical/urethral/rectal/pharyngeal infections caused by *Neisseria gonorrhoea*. Because co-infection with *Chlamydia trachomatis* is common, consideration should be given to treating presumptively with an additional regimen that is effective against *C. trachomatis*.

Appropriate culture and susceptibility tests should be performed prior to initiating treatment in order to isolate and identify organisms causing the infection and to determine their susceptibilities to ciprofloxacin. Therapy with CIPRO<sup>®</sup> and CIPRO<sup>®</sup> ORAL SUSPENSION may be initiated before results of these tests are known. However, modification of this treatment may be required once results become available or if there is no clinical improvement. Culture and susceptibility testing performed periodically during therapy will provide information on the possible emergence of bacterial resistance. If anaerobic organisms are suspected to be contributing to the infection, appropriate therapy should be administered.

### **CONTRAINDICATIONS**

CIPRO<sup>®</sup> (ciprofloxacin hydrochloride tablets) and CIPRO<sup>®</sup> ORAL SUSPENSION (ciprofloxacin oral suspension) are contraindicated in patients who have shown hypersensitivity to ciprofloxacin, or other quinolone antibacterial agents or any of the excipients.

Concurrent administration of ciprofloxacin and tizanidine is contraindicated since it may result in an undesirable increase in serum tizanidine concentrations. This can be associated with clinically relevant tizanidine-induced side effects (hypotension, somnolence, drowsiness).

### **WARNINGS**

**The safety of CIPRO<sup>®</sup> (ciprofloxacin hydrochloride tablets) and CIPRO<sup>®</sup> ORAL SUSPENSION (ciprofloxacin oral suspension) in pediatric patients and adolescents (under the age of 18 years), pregnant women and nursing women has not yet been established (see [PRECAUTIONS: Pediatric Use, Pregnancy, Nursing Women](#)). Damage to juvenile weight-bearing joints and lameness were observed both in rat and dog studies but not in weaned piglets (see [TOXICOLOGY](#)). Histopathological examination of the weight-bearing joints in immature dogs revealed permanent lesions of the cartilage.**

### **Cardiac Disorders**

Ciprofloxacin has been associated with cases of QT prolongation. In general, elderly patients may be more susceptible to drug-associated effects on the QT interval. Precaution should be taken when using ciprofloxacin with concomitant drugs that can result in prolongation of the QT interval (eg, class IA or III antiarrhythmics) or in patients with risk factors for torsade de pointes (eg, known QT prolongation, uncorrected hypokalemia) (see **ADVERSE REACTIONS**).

### **CNS and Psychiatric Effects**

Convulsions, increased intracranial pressure, and toxic psychosis have been reported in patients receiving quinolones, including ciprofloxacin. Ciprofloxacin may also cause central nervous system (CNS) stimulation which may lead to tremors, restlessness, lightheadedness, confusion, hallucinations, depression, nervousness, agitation, insomnia, anxiety, paranoia, nightmares and rarely, suicidal thoughts or acts. In rare cases, depression or psychosis can progress to self-endangering behaviour. These reactions may occur following the first dose. If these reactions occur in patients receiving ciprofloxacin, the drug should be discontinued and appropriate measures instituted. As with all quinolones, ciprofloxacin should be used with caution in patients with known or suspected CNS disorders, such as severe cerebral arteriosclerosis, epilepsy, and other factors that predispose to seizures or lower the seizure threshold (see **ADVERSE REACTIONS**).

### **Cytochrome P450**

Ciprofloxacin is known to be a moderate inhibitor of the CYP450 1A2 enzymes. Care should be taken when other drugs are administered concomitantly which are metabolized via the same enzymatic pathway (eg, theophylline, methylxanthines, caffeine, duloxetine, clozapine). Increased plasma concentrations associated with drug specific side effects may be observed due to inhibition of their metabolic clearance by ciprofloxacin (see **CONTRAINDICATIONS** and **PRECAUTIONS: Drug Interactions**).

### **Gastrointestinal**

#### **Clostridium difficile-associated disease**

Clostridium difficile-associated disease (CDAD) has been reported with the use of many antibacterial agents, including ciprofloxacin. CDAD may range in severity from mild diarrhea to

fatal colitis. It is important to consider this diagnosis in patients who present with diarrhea or symptoms of colitis, pseudomembranous colitis, toxic megacolon, or perforation of the colon subsequent to the administration of any antibacterial agent. CDAD has been reported to occur over 2 months after the administration of antibacterial agents.

Treatment with antibacterial agents may alter the normal flora of the colon and many permit overgrowth of *Clostridium difficile*. *C. difficile* produces toxins A and B, which contribute to the development of CDAD. CDAD may cause significant morbidity and mortality. CDAD can be refractory to antimicrobial therapy.

If the diagnosis of CDAD is suspected or confirmed, appropriate therapeutic measures should be initiated. Mild cases of CDAD usually respond to discontinuation of antibacterial agents not directed against *Clostridium difficile*. In moderate to severe cases, consideration should be given to management with fluids and electrolytes, protein supplementation, and treatment with an antibacterial agent clinically effective against *Clostridium difficile*. Drugs that inhibit peristalsis may delay clearance of *Clostridium difficile* and its toxins, and therefore should not be used in the treatment of CDAD. Surgical evaluation should be instituted as clinically indicated since surgical intervention may be required in certain severe cases (see **ADVERSE REACTIONS**).

### **Hypersensitivity**

Serious hypersensitivity and/or anaphylactic reactions have been reported in patients receiving quinolone therapy, including ciprofloxacin. These reactions may occur within the first 30 minutes following the first dose and may require epinephrine and other emergency measures. Some reactions have been accompanied by cardiovascular collapse, hypotension/shock, seizure, loss of consciousness, tingling, angioedema (including tongue, laryngeal, throat or facial edema/swelling), airway obstruction (including bronchospasm, shortness of breath and acute respiratory distress), dyspnea, urticaria, itching and other serious skin reactions.

Ciprofloxacin should be discontinued at the first appearance of a skin rash or any other sign of hypersensitivity. Serious acute hypersensitivity reactions may require treatment with epinephrine and other resuscitative measures, including oxygen, intravenous fluids, antihistamines, corticosteroids, pressor amines and airway management, as clinically indicated.

Serious and sometimes fatal events, some due to hypersensitivity and some due to uncertain etiology, have been reported in patients receiving therapy with all antibiotics. These events may be severe and generally occur following the administration of multiple doses. Clinical manifestations may include one or more of the following: fever, rash or severe dermatologic reactions (eg, toxic epidermal necrolysis, Stevens-Johnson Syndrome), vasculitis, arthralgia, myalgia, serum sickness, allergic pneumonitis, interstitial nephritis, acute renal insufficiency or failure, hepatitis, jaundice, acute hepatic necrosis or failure, hepatic necrosis with fatal outcome, anemia including hemolytic and aplastic, thrombocytopenia including thrombotic thrombocytopenic purpura, leukopenia, agranulocytosis, pancytopenia, and/or other hematologic abnormalities.

### **Interaction With Tests**

Ciprofloxacin in vitro potency may interfere with the *Mycobacterium spp.* culture test by suppression of mycobacterial growth, causing false negative results in specimens from patients currently taking ciprofloxacin.

### **Musculoskeletal**

**Rupture of the shoulder, hand and Achilles tendons that required surgical repair or resulted in prolonged disability have been reported in patients receiving quinolones, including ciprofloxacin.** CIPRO<sup>®</sup> and CIPRO<sup>®</sup> ORAL SUSPENSION should be discontinued if the patient experiences pain, inflammation, or rupture of a tendon. Patients should rest and refrain from exercise until the diagnosis of tendinitis or tendon rupture has been confidently excluded. The risk of developing fluoroquinolone-associated tendinitis and tendon rupture is further increased in older patients usually over 60 years of age, in patients taking corticosteroid drugs, and in patients with kidney, heart, or lung transplants. Factors, in addition to age and corticosteroid use, that may independently increase the risk of tendon rupture include strenuous physical activity, renal failure, and previous tendon disorders such as rheumatoid arthritis. Tendinitis and tendon rupture have also occurred in patients taking fluoroquinolones who do not have the above risk factors. Tendon rupture can occur during or after completion of therapy; cases occurring up to several months after completion of therapy have been reported. CIPRO<sup>®</sup> and CIPRO<sup>®</sup> ORAL SUSPENSION should be discontinued if the patient experiences pain,

swelling, inflammation, or rupture of a tendon. Patients should be advised to rest at the first sign of tendinitis or tendon rupture, and to contact their healthcare provider regarding changing to a non-quinolone antimicrobial drug.

Ciprofloxacin should not be used in patients with a history of tendon disease/disorder related to previous quinolone treatment (see **ADVERSE REACTIONS**).

### **Streptococcus pneumoniae Infections**

Ciprofloxacin is not recommended for treatment of pneumococcal infections due to inadequate efficacy against *Streptococcus pneumoniae*.

## **PRECAUTIONS**

**SERIOUS AND FATAL REACTIONS HAVE BEEN REPORTED IN PATIENTS RECEIVING CONCURRENT ADMINISTRATION OF CIPROFLOXACIN AND THEOPHYLLINE.** These reactions include cardiac arrest, seizure, status epilepticus and respiratory failure. Similar serious adverse events have been noted with administration of theophylline alone; however, the possibility that ciprofloxacin may potentiate these reactions cannot be eliminated. If concomitant use cannot be avoided, the plasma levels of theophylline should be monitored and appropriate dosage adjustments should be made.

Crystalluria related to ciprofloxacin has been reported only rarely in man because human urine is usually acidic. Crystals have been observed in the urine of laboratory animals, usually from alkaline urine. Patients receiving ciprofloxacin should be well hydrated and alkalinity of the urine should be avoided. The recommended daily dose should not be exceeded.

Ciprofloxacin has been shown to produce photosensitivity reactions. Patients taking ciprofloxacin should avoid direct exposure to excessive sunlight or UV-light. Therapy should be discontinued if photosensitization (ie, sunburn-like skin reactions) occurs.

Prolonged use of CIPRO<sup>®</sup> and CIPRO<sup>®</sup> ORAL SUSPENSION may result in the overgrowth of nonsusceptible organisms. Careful observation of the patient is therefore essential, and if superinfection should occur during therapy, appropriate measures should be taken.

### **Pregnancy**

The safety of CIPRO<sup>®</sup> and CIPRO<sup>®</sup> ORAL SUSPENSION in pregnancy has not yet been established. CIPRO<sup>®</sup> and CIPRO<sup>®</sup> ORAL SUSPENSION should not be used in pregnant women unless the likely benefits outweigh the possible risk to the fetus (see **WARNINGS**). CIPRO<sup>®</sup> and CIPRO<sup>®</sup> ORAL SUSPENSION have been shown to be non-embryotoxic and non-teratogenic in animal studies.

### **Nursing Women**

Ciprofloxacin is excreted in human milk. Because of the potential for serious adverse reactions in infants nursing from women taking ciprofloxacin, a decision should be made to discontinue nursing or to discontinue the administration of CIPRO<sup>®</sup> and CIPRO<sup>®</sup> ORAL SUSPENSION, taking into account the importance of the drug to the mother and the possible risk to the infant (see **WARNINGS**).

### **Pediatric Use**

The safety and efficacy of ciprofloxacin in the pediatric population less than 18 years of age have not been established. Quinolones, including ciprofloxacin, cause arthropathy and osteochondrosis in juvenile animals of several species (see **WARNINGS, TOXICOLOGY**).

### **Elderly**

Ciprofloxacin is substantially excreted by the kidney, and the risk of adverse reactions may be greater in patients with impaired renal function (see **HUMAN PHARMACOLOGY**).

### **Renal Impairment**

Since ciprofloxacin is eliminated primarily by the kidney, CIPRO<sup>®</sup> and CIPRO<sup>®</sup> ORAL SUSPENSION should be used with caution and at a reduced dosage in patients with impaired renal function (see **DOSAGE AND ADMINISTRATION, HUMAN PHARMACOLOGY**).

### **Hepatic Impairment**

In preliminary studies in patients with stable chronic liver cirrhosis (with mild to moderate hepatic impairment), no significant changes in ciprofloxacin pharmacokinetics were observed. The kinetics of ciprofloxacin in patients with acute hepatic insufficiency and stable chronic cirrhosis (with severe hepatic impairment), however, have not been fully elucidated. An

increased incidence of nausea, vomiting, headache and diarrhea were observed in this patient population (see [HUMAN PHARMACOLOGY](#)).

### **Ability to Drive and Operate Machinery**

Fluoroquinolones including ciprofloxacin may result in an impairment of the patient's ability to drive or operate machinery due to CNS reactions. This applies particularly in combination with alcohol (see [ADVERSE REACTIONS](#)).

### **Sucrose Load for Oral Suspension Formulation**

As the oral suspension contains sucrose, it is unsuitable for patients with rare hereditary problems of fructose intolerance, glucose-galactose malabsorption or sucrase-isomaltase insufficiency (see [PHARMACEUTICAL INFORMATION](#)).

### **Drug Interactions**

#### **Caffeine and Other Xanthine Derivatives**

Caffeine has been shown to interfere with the metabolism and pharmacokinetics of ciprofloxacin. Excessive caffeine intake should be avoided.

Upon concurrent administration of ciprofloxacin and pentoxifylline (oxpentifylline)-containing products, raised serum concentrations of this xanthine derivative were reported.

#### **Class IA or III Antiarrhythmics**

Precaution should be taken when using ciprofloxacin together with class IA or III antiarrhythmics as ciprofloxacin may have an additive effect on the QT interval (see [WARNINGS](#)).

#### **Clozapine**

Following concomitant administration of 250 mg ciprofloxacin for 7 days, serum concentrations of clozapine and n-desmethylozapine were increased by 29% and 31%, respectively (see [WARNINGS](#)).

#### **Cyclosporine**

Some quinolones, including ciprofloxacin, have been associated with transient increases in serum creatinine levels in patients who are concomitantly receiving cyclosporine.

**Duloxetine**

In clinical studies it was demonstrated that concomitant use of duloxetine with strong inhibitors of the CYP450 1A2 isozyme such as fluvoxamine, may result in an increase of AUC and  $C_{max}$  of duloxetine. Although no clinical data are available on a possible interaction with ciprofloxacin, similar effects can be expected upon concomitant administration.

**Ferrous Sulfate**

Oral ferrous sulfate at therapeutic doses decreases the bioavailability of oral ciprofloxacin, therefore concomitant therapy is not advised.

**Food and Dairy Products**

Although, ciprofloxacin may be taken with meals that include milk, simultaneous administration with dairy products, alone, or with calcium-fortified products should be avoided, since decreased absorption is possible. It is recommended that ciprofloxacin be administered at least 2 hours before or 2 hours after substantial calcium intake (>800 mg) (see **DOSAGE AND ADMINISTRATION**).

**Glyburide**

In particular cases, concurrent administration of ciprofloxacin and glyburide can intensify the action of glyburide (hypoglycemia).

**Histamine H2-receptor Antagonists**

Histamine H2-receptor antagonists appear to have no significant effect on the bioavailability of ciprofloxacin.

**Lidocaine**

It was demonstrated in healthy subjects that concomitant use of lidocaine with ciprofloxacin, a moderate inhibitor of CYP450 1A2 isozyme, reduces clearance of intravenous lidocaine by 22%. Ciprofloxacin may increase the systemic toxicity of lidocaine.

**Methotrexate**

Renal tubular transport of methotrexate may be inhibited by concomitant administration of ciprofloxacin, potentially leading to increased plasma levels of methotrexate. This might

increase the risk of methotrexate associated toxic reactions. Therefore, patients under methotrexate therapy should be carefully monitored when concomitant ciprofloxacin therapy is indicated.

### **Metoclopramide**

Metoclopramide accelerates the absorption of ciprofloxacin (oral), resulting in a shorter time to reach maximum plasma concentrations. No effect was seen on the bioavailability of ciprofloxacin.

### **Multivalent Cations**

Concurrent administration of a quinolone, including ciprofloxacin, with multivalent cation-containing products such as magnesium/aluminum antacids, polymeric phosphate binders such as sevelamer, lanthanum carbonate, sucralfate, Videx<sup>®</sup> (didanosine) chewable/buffered tablets or pediatric powder, mineral supplements or products containing calcium, iron, or zinc may substantially interfere with the absorption of the quinolone, resulting in serum and urine levels considerably lower than desired. Ciprofloxacin should be administered at least 2 hours before or 6 hours after these preparations.

### **NSAID**

Concomitant administration of a nonsteroidal anti-inflammatory drug (fenbufen) with a quinolone (enoxacin) has been reported to increase the risk of CNS stimulation and convulsive seizures.

### **Probenecid**

Probenecid blocks renal tubular secretion of ciprofloxacin and has been shown to produce an increase in the level of ciprofloxacin in the serum.

### **Ropinirole**

In a clinical study it was shown that concomitant use of ropinirole with ciprofloxacin, a medium inhibitor of the CYP450 1A2 isozyme, resulted in increases in the  $C_{max}$  and AUC of ropinirole of 60% and 84%, respectively. Ciprofloxacin may increase the systemic toxicity of ropinirole.

**Sildenafil**

$C_{\max}$  and AUC of sildenafil were increased approximately two-fold in healthy subjects after an oral dose of 50 mg was given concomitantly with 500 mg ciprofloxacin. Therefore, caution should be used when prescribing ciprofloxacin concomitantly with sildenafil, taking into consideration the risks and the benefits

**Theophylline**

Concurrent administration of ciprofloxacin with theophylline may lead to elevated serum concentrations of theophylline and prolongation of its elimination half-life. This may result in increased risk of theophylline-related adverse reactions. If concomitant use cannot be avoided, serum levels of theophylline should be monitored and dosage adjustments made as appropriate.

**Tizanidine**

In a clinical study in healthy subjects there was an increase in tizanidine serum concentrations ( $C_{\max}$  increase: 7-fold, range: 4- to 21-fold; AUC increase: 10-fold, range: 6- to 24-fold) when given concomitantly with ciprofloxacin. Associated with the increased serum concentrations was a potentiated hypotensive and sedative effect. Tizanidine must not be administered together with ciprofloxacin (see **CONTRAINDICATIONS, WARNINGS**).

**Vitamin K Antagonists**

Simultaneous administration of ciprofloxacin with a vitamin K antagonist may augment its anticoagulant effects. The risk may vary with the underlying infection, age, and general status of the patient so that the contribution of ciprofloxacin to the increase in INR (international normalized ratio) is difficult to assess. The INR should be monitored frequently during and shortly after co-administration of ciprofloxacin with a vitamin K antagonist (eg, warfarin and acenocoumarol).

## **ADVERSE REACTIONS**

CIPRO<sup>®</sup> (ciprofloxacin hydrochloride tablets) and CIPRO<sup>®</sup> ORAL SUSPENSION (ciprofloxacin oral suspension) are generally well tolerated. During worldwide clinical investigation (1991), 16,580 courses of ciprofloxacin treatment were evaluated for drug safety.

The incidence of adverse reactions was 8.0%. In orally treated patients enrolled in clinical trials, the most frequently reported events, possibly, probably drug-related were: nausea (1.3%), and diarrhea (1.0%).

**Events possibly, probably drug-related occurring at a frequency of less than 1% with ciprofloxacin treatment during clinical trials and subsequent post-marketing surveillance are as follows:**

**Body as a Whole:** back pain, chest pain, pain, pain in extremities, moniliasis.

**Cardiovascular System:** palpitation, phlebitis, tachycardia, thrombophlebitis. The following has been reported rarely ( $\geq 0.01\%$   $< 0.1\%$ ): hypotension. The following have been reported very rarely ( $< 0.01\%$ ): angina pectoris, atrial fibrillation, cardiac arrest, cerebrovascular disorder, electrocardiogram abnormality, hot flashes, hypertension, kidney vasculitis, myocardial infarct, pericarditis, pulmonary embolus, substernal chest pain, syncope (fainting), vasodilation (hot flashes).

**Digestive:** abdominal pain, anorexia, dry mouth, dyspepsia, dysphagia, enlarged abdomen, flatulence, gastrointestinal moniliasis, jaundice, stomatitis, vomiting, abnormal liver function test. The following have been reported rarely: moniliasis (oral), cholestatic jaundice, and pseudomembranous colitis. The following have been reported very rarely: constipation, esophagitis, gastrointestinal hemorrhage, glossitis, hepatomegaly, ileus, increased appetite, intestinal perforation, life-threatening pseudomembranous colitis with possible fatal outcome, liver damage, melena, pancreatitis, tenesmus, tooth discoloration, toxic megacolon, ulcerative stomatitis.

**Hemic and Lymphatic:** agranulocytosis, anaemia, eosinophilia, granulocytopenia, leukocytopenia, leukocytosis, pancytopenia. The following have been reported very rarely: altered prothrombin levels, haemolytic anaemia, marrow depression (life threatening), pancytopenia (life threatening), thrombocytopenia, thrombocytosis.

**Hypersensitivity:** rash. The following have been reported rarely: allergic reaction, anaphylactic/anaphylactoid reactions including facial, vascular and laryngeal edema, drug fever, haemorrhagic bullae and small nodules (papules) with crust formation showing vascular involvement (vasculitis), hepatitis, interstitial nephritis, petechiae (punctuate skin hemorrhages), pruritus, serum sickness-like reaction, Stevens-Johnson syndrome (potentially life-threatening). The following have been reported very rarely: shock (anaphylactic; life-threatening), pruritic rash, erythema multiforme (minor), erythema nodosum, major liver disorders including hepatic necrosis, (very rarely progressing to life threatening hepatic failures), epidermal necrolysis (Lyell Syndrome, potentially life-threatening).

**Metabolic and Nutritional Disorder:** creatinine increased. The following have been reported rarely: edema (face) and hyperglycemia.

**Musculoskeletal:** The following have been reported rarely in patients of all ages: achiness, arthralgia (joint pain), joint disorder (joint swelling), pain in the extremities, partial or completed tendon rupture (shoulder, hand or Achilles tendon), tendinitis (predominantly achillotendinitis), myalgia (muscular pain). The following have been reported very rarely: myasthenia (exacerbation of symptoms of myasthenia gravis) (see **WARNINGS**).

**Nervous System:** agitation, confusion, convulsion, dizziness, hallucinations, headache, hypesthesia, increased sweating, insomnia, somnolence, tremor (trembling). The following has been reported rarely: paresthesia (peripheral paralgesia). The following have been reported very rarely: abnormal dreams (nightmares), anxiety, apathy, ataxia, depersonalization, depression, diplopia, hemiplegia, hyperesthesia, hypertonia, increase of intracranial pressure, meningism, migraine, nervousness, neuritis, paresthesia, polyneuritis, sleep disorder, twitching, grand mal convulsions, abnormal (unsteady) gait, psychosis, intracranial hypertension. In some instances

these reactions occurred after the first administration of ciprofloxacin. In these instances, ciprofloxacin has to be discontinued and the doctor should be informed immediately.

**Other:** The following have been reported rarely: asthenia (general feeling of weakness, tiredness), death.

**Respiratory System:** dyspnea. The following have been reported very rarely: hiccup, hyperventilation, increased cough, larynx edema, lung edema, lung hemorrhage, pharyngitis, stridor, voice alteration.

**Skin/Appendages:** pruritus, rash, maculopapular rash. The following has been reported rarely: photosensitivity reaction. The following have been reported very rarely: alopecia, angioedema, fixed eruption, photosensitive dermatitis, petechia, urticaria.

**Special Senses:** abnormal vision (visual disturbances), taste perversion, tinnitus. The following have been reported rarely: transitory deafness (especially at higher frequencies), taste loss (impaired taste). The following have been reported very rarely: chromatopsia, colour blindness, conjunctivitis, corneal opacity, diplopia, ear pain, eye pain, parosmia (impaired smell), anosmia (usually reversible on discontinuation).

**Urogenital System:** albuminuria, hematuria. The following have been reported rarely: abnormal kidney function, acute kidney failure, dysuria, leukorrhea, nephritis interstitial, urinary retention, vaginitis, vaginal moniliasis.

**Laboratory Values:** increased alkaline phosphatase, ALT increased, AST increased, BUN (urea) increased, cholestatic parameters increased, Gamma - GT increased, lactic dehydrogenase increased, NPN increased, transaminases increased, decreased albuminuria, bilirubinemia, creatinine clearance decreased, hypercholesteremia, hyperuricemia, increased sedimentation rate. The following have been reported rarely: acidosis, increased amylase, crystalluria, electrolyte abnormality, haematuria, hypercalcemia, hypocalcemia and lipase increased.

Most of the adverse events reported were described as only mild or moderate in severity.

The following additional adverse events, in alphabetical order, regardless of incidence or relationship to drug, have been reported during clinical trials and from worldwide postmarketing experience in patients given ciprofloxacin (includes all formulations, all dosages, all drug-therapy durations, and in all indications): arrhythmia, atrial flutter, bleeding diathesis, bronchospasm, *C. difficile* associated diarrhea, candiduria, cardiac murmur, cardiopulmonary arrest, cardiovascular collapse, cerebral thrombosis, chills, delirium, drowsiness, dysphasia, edema (conjunctivae, hands, lips, lower extremities, neck), epistaxis, exfoliative dermatitis, fever, gastrointestinal bleeding, gout (flare up), gynecomastia, hearing loss, hemoptysis, hemorrhagic cystitis, hyperpigmentation, joint stiffness, lightheadedness, lymphadenopathy, manic reaction, myoclonus, nystagmus, pain (arm, breast, epigastric, foot, jaw, neck, oral mucosa), paranoia, peripheral neuropathy, phobia, pleural effusion, polyneuropathy, polyuria, postural hypotension, pulmonary embolism, purpura, QT prolongation, renal calculi, respiratory arrest, respiratory distress, restlessness, rhabdomyolysis, torsades de pointes, toxic psychosis, unresponsiveness, urethral bleeding, urination (frequent), ventricular ectopy, ventricular fibrillation, ventricular tachycardia, vesicles, visual acuity (decreased) and visual disturbances (flashing lights, change in colour perception, overbrightness of lights).

### **SYMPTOMS AND TREATMENT OF OVERDOSE**

In the event of acute, excessive oral overdosage, reversible renal toxicity, arthralgia, myalgia and CNS symptoms have been reported. Therefore, apart from routine emergency measures, it is recommended to monitor renal function and to administer magnesium- or calcium-containing antacids which reduce the absorption of ciprofloxacin and to maintain adequate hydration.

Based on information obtained from subjects with chronic renal failure, only a small amount of ciprofloxacin (< 10%) is removed from the body after hemodialysis or peritoneal dialysis.

The administration of activated charcoal as soon as possible after oral overdose may prevent excessive increase of systemic ciprofloxacin exposure.

For management of a suspected drug overdose, contact your regional Poison Control Centre.

## **DOSAGE AND ADMINISTRATION**

The determination of dosage for any particular patient must take into consideration the severity and nature of the infection, the susceptibility of the causative organism, the integrity of the patient's host-defence mechanisms, and the status of renal function.

CIPRO<sup>®</sup> (ciprofloxacin hydrochloride tablets) or CIPRO<sup>®</sup> ORAL SUSPENSION (ciprofloxacin oral suspension)<sup>a</sup> may be taken before or after meals. Absorption is faster on an empty stomach.

Patients should be advised to drink fluids liberally and avoid taking dairy products or antacids containing magnesium or aluminum.

Ciprofloxacin should be administered at least 2 hours before or 6 hours after antacids and mineral supplements containing magnesium or aluminum, as well as sucralfate, Videx<sup>®</sup> (didanosine) chewable/buffered tablets or pediatric powder, metal cations such as iron, and multivitamin preparations with zinc (see **PRECAUTIONS, Drug Interactions**).

Although ciprofloxacin may be taken with meals that include milk, simultaneous administration with dairy products alone, or with calcium-fortified products should be avoided, since decreased absorption is possible. It is recommended that ciprofloxacin be administered at least 2 hours before or 2 hours after substantial calcium intake (>800 mg) (see **PRECAUTIONS, Drug Interactions**).

### **Adults**

The recommended oral dosages for CIPRO<sup>®</sup> tablets and CIPRO<sup>®</sup> ORAL SUSPENSION are:

**Table 1: Recommended Oral Dosages**

Location of Infection	Type/Severity	Unit Dose <sup>a</sup>	Frequency	Daily Dose
Urinary Tract	Mild/Moderate	250 mg	q12h	500 mg
	Severe/Complicated	500 mg	q12h	1000 mg
Chronic Bacterial Prostatitis	Asymptomatic/Mild/Moderate	500 mg	q12h	1000 mg
Respiratory Tract Bone & Joint Skin & Soft Tissue	Mild/Moderate	500 mg	q12h	1000 mg
	Severe*/Complicated	750 mg	q12h	1500 mg
Infectious Diarrhea	Mild/Moderate/Severe	500 mg	q12h	1000 mg
Urogenital and Extragenital Gonorrhea	Uncomplicated	500 mg	once	500 mg
Typhoid Fever	Mild/Moderate	500 mg	q12h	1000 mg
Neisseria meningitidis Nasopharyngeal Colonization	Carrier State	750 mg	once	750 mg
Acute Sinusitis	Moderate	500 mg	q12h	1000 mg

\* Eg, hospital-acquired pneumonia, osteomyelitis

a One teaspoon (5 mL) of 10% oral ciprofloxacin suspension = 500 mg of ciprofloxacin

See instructions below for USE/HANDLING.

**Table 2: Use/Handling of Ciprofloxacin Suspension**

Dosage	Volume (mL) of 10% Oral Suspension
250 mg	2.5 mL
500 mg	5 mL
750 mg	7.5 mL

Depending on the severity of the infections, as well as the clinical and bacteriological responses, the average treatment period should be approximately 7 to 14 days. Generally, treatment should last 3 days beyond the disappearance of clinical symptoms or until cultures are sterile. Patients with osteomyelitis may require treatment for a minimum of 6 to 8 weeks and up to 3 months. With acute cystitis in females a 3- to 5-day treatment may be sufficient. With infectious diarrhea a five-day treatment may be sufficient. Typhoid fever should be treated for 14 days. Acute sinusitis should be treated for 10 days with 500 mg q 12h. Chronic bacterial prostatitis should be treated for 28 days with 500 mg q 12h.

**Instructions to the Pharmacist for Use/Handling of CIPRO<sup>®</sup> ORAL SUSPENSION:****Preparation of the suspension:**

1. The small bottle contains the ciprofloxacin microcapsules; the large bottle contains the diluent.
2. Open both bottles. Child-proof cap: Press down according to the instructions on the cap while turning to the left.
3. Pour the microcapsules completely into the large bottle of diluent. **Do not add water to the suspension.**
4. Close the large bottle completely according to the instructions on the cap and shake vigorously for about 15 seconds. The suspension is ready for use.

**Instructions to the Patient for Taking CIPRO<sup>®</sup> ORAL SUSPENSION****Shake vigorously each time before use for approximately 15 seconds.**

Swallow the prescribed amount of suspension. Do not chew the microcapsules. Reclose the bottle completely after use according to instruction on the cap. The suspension is stable for 14 days when stored in a refrigerator or at room temperature (5-25°C). Store in an upright position. After treatment has been completed, any remaining suspension should not be reused.

**Impaired Renal Function**

Ciprofloxacin is eliminated primarily by renal excretion. However, the drug is also metabolized and partially cleared through the biliary system of the liver and through the intestine. (See **HUMAN PHARMACOLOGY**.) This alternate pathway of drug elimination appears to compensate for the reduced renal excretion of patients with renal impairment. Nonetheless, some modification of dosage is recommended, particularly for patients with severe renal dysfunction. The following table provides a guideline for dosage adjustment of CIPRO<sup>®</sup> and CIPRO<sup>®</sup> ORAL SUSPENSION. However, monitoring of serum drug levels provides the most reliable basis for dosage adjustments.

**Table 3: Maximum Daily Oral Dose With Stated Creatinine Clearance or Serum Creatinine**

<b>Creatinine Clearance mL/min/1.73m<sup>2</sup></b>	<b>Maximum Daily Oral Dose</b>	<b>Serum Creatinine Concentration mg/100 mL</b>
31-60	1000 mg	1.4 -1.9
≤ 30	500 mg	≥ 2.0

Maximum daily doses are not to be exceeded when either creatinine clearance or serum creatinine are in the ranges stated.

### ***Hemodialysis***

Only a small amount of ciprofloxacin (< 10%) is removed from the body after hemodialysis or peritoneal dialysis. For hemodialysis patients, please follow dosing recommendations as described in **Table 3**. On dialysis days, the dose should be administered after dialysis.

When only the serum creatinine concentration is available, the following formula (based on sex, weight and age of the patient) may be used to convert this value into creatinine clearance. The serum creatinine should represent a steady state of renal function:

Creatinine Clearance mL/sec =

Males:  $\frac{\text{Weight (kg)} \times (140 - \text{age})}{49 \times \text{serum creatinine } (\mu\text{mol/L})}$

Females: 0.85 x the above value

In traditional units mL/min =

Males:  $\frac{\text{Weight (kg)} \times (140 - \text{age})}{72 \times \text{serum creatinine (mg/100 mL)}}$

Females: 0.85 x the above value

### **Impaired Hepatic Function**

No dosage adjustment is required.

**Pediatric Use**

The safety and efficacy of CIPRO<sup>®</sup> and CIPRO<sup>®</sup> ORAL SUSPENSION in individuals less than 18 years of age has not been established. CIPRO<sup>®</sup> and CIPRO<sup>®</sup> ORAL SUSPENSION should not be used in pediatric patients and adolescents (see **WARNINGS**).

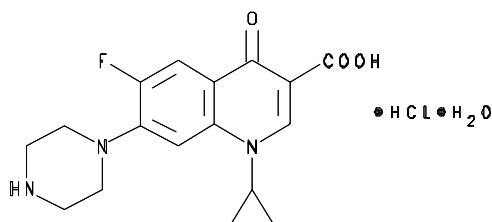
## PHARMACEUTICAL INFORMATION

### DRUG SUBSTANCE

**Proper Name:** Ciprofloxacin hydrochloride

**Chemical Name:** 1-cyclopropyl-6-fluoro-1,4-dihydro-4-oxo-7-(1-piperazinyl)-3-quinolinecarboxylic acid  
hydrochloride monohydrate

**Structural Formula:**



**Molecular Formula:** C<sub>17</sub>H<sub>18</sub>FN<sub>3</sub>O<sub>3</sub> HCl H<sub>2</sub>O

**Molecular Weight:** 385.8

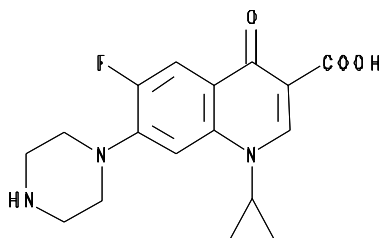
**Description:** Ciprofloxacin hydrochloride is a pale yellow crystalline powder. It is soluble in water. Its solubility in aqueous buffer of pH 7.4 at 21°C is 0.19 g/L, while the solubility is considerably higher at slightly acidic or slightly alkaline pH. At 140°C water of crystallization is lost. At 307°C decomposition takes place. The pH of ciprofloxacin hydrochloride is between 3 and 4.5 in a solution (1 in 40). The pK<sub>a1</sub> is 6.5 and pK<sub>a2</sub> is 8.9 determined using a 3 x 10<sup>-4</sup> M solution of 25°C.

**DRUG SUBSTANCE**

**Proper Name:** Ciprofloxacin

**Chemical Name:** 1-cyclopropyl-6-fluoro-1,4-dihydro-4-oxo-7-(piperazinyl)-3-quinolinecarboxylic acid

**Structural Formula:**



**Molecular Formula:** C<sub>17</sub>H<sub>18</sub>FN<sub>3</sub>O<sub>3</sub>

**Molecular Weight:** 331.4

**Description:** Ciprofloxacin is a pale yellow to white crystalline powder which is soluble in dilute (0.1 N) hydrochloric acid and is practically insoluble in water and ethanol. Decomposition occurs between 261°C - 265°C. pH of ciprofloxacin is 7.6 at 0.1 g/L water at 20°C. It has a pK<sub>a1</sub> of 6.5 and pK<sub>a2</sub> of 8.9 determined using a 3 x 10<sup>-4</sup>M solution at 25°C.

## **COMPOSITION**

### **Tablets**

Ciprofloxacin Hydrochloride  
Microcrystalline Cellulose  
Maize Starch  
Colloidal Silicon Dioxide  
Purified Water  
Crospovidone  
Magnesium Stearate  
Titanium Dioxide  
Methyl-hydroxypropylcellulose 2910-15  
Polyethylene Glycol

### **Oral Suspension**

- A. Microcapsules  
Ciprofloxacin “oral, new” micronized  
Poly (ethyl acrylate methyl methacrylate) - dispersion 30%  
Magnesium Stearate  
Methyl-hydroxypropylcellulose  
Polysorbate 20  
Polyvidone 25
- B. Diluent  
Strawberry flavour 52312  
Strawberry flavour 54267  
Lecithin NF/Medium chain triglycerides  
Medium chain triglycerides  
Sucrose micronized  
Water, purified

## **STABILITY AND STORAGE RECOMMENDATIONS**

**Tablets:** Store below 30°C (86°F)

**Oral Suspension:** The trade pack supplied to the Pharmacist (microcapsules and diluent in separate bottles) is to be stored at room temperature (15-25°C) and protected from freezing. Store in an upright position.

The freshly reconstituted suspension is stable for 14 days when stored in the refrigerator or at room temperature (5-25°C). Store in an upright position.

**Shake vigorously for 15 seconds each time before use.**

## **AVAILABILITY OF DOSAGE FORMS**

### **Coated Tablets**

CIPRO<sup>®</sup> 250 each round tablet is white to slightly yellowish. One side of the tablet is engraved with "CIP score 250" and the Bayer Cross on the other and contains ciprofloxacin hydrochloride equivalent to 250 mg ciprofloxacin. Bottles of 100.

CIPRO<sup>®</sup> 500 each oblong tablet is white to slightly yellowish. One side of the tablet is engraved with "CIP score 500" and Bayer on the other and contains ciprofloxacin hydrochloride equivalent to 500 mg ciprofloxacin. Bottles of 100 and unit dose packages of 100.

CIPRO<sup>®</sup> 750 each oblong tablet is white to slightly yellowish. One side of the tablet is engraved with "CIP score 750" and Bayer on the other and contains ciprofloxacin hydrochloride equivalent to 750 mg ciprofloxacin. Bottles of 50 and unit dose packages of 100.

**CIPRO® ORAL SUSPENSION**

Ciprofloxacin Oral Suspension is supplied as a 10% (10 g ciprofloxacin in 100 mL) strength. The drug product is composed of two components (microcapsules and diluent) which are mixed prior to dispensing (see [Instructions to the Pharmacist for Use/Handling of CIPRO® ORAL SUSPENSION](#)).

**Table 4: CIPRO® ORAL SUSPENSION**

Total Volume After Reconstitution	Ciprofloxacin Contents After Reconstitution	Ciprofloxacin Contents per Bottle
100 mL	500 mg/5 mL	10,000 mg

**Store at room temperature (15-25°C) in an upright position.** Protect from freezing.

**Reconstituted product may be stored in a refrigerator or at room temperature (5-25°C) for 14 days.** Store in an upright position. A teaspoon is provided for the patient.

**MICROBIOLOGY**

The in vitro activity of ciprofloxacin against clinical isolates of gram-positive and gram-negative aerobic and anaerobic bacteria is shown in [Table 5](#). Its bactericidal action is achieved through inhibition of topoisomerase II (DNA gyrase) and topoisomerase IV (both Type II topoisomerases), which are required for bacterial DNA replication, transcription, repair, and recombination. Susceptibility was determined by both agar and broth dilution tests, pH 7.1-7.4, using inoculum sizes ranging from  $10^4$  to  $10^5$  colony forming units per mL.

The mechanism of action of fluoroquinolones, including ciprofloxacin, is different from that of penicillins, cephalosporins, aminoglycosides, macrolides, and tetracyclines. Therefore, microorganisms resistant to these classes of drugs may be susceptible to ciprofloxacin. Conversely, microorganisms resistant to fluoroquinolones may be susceptible to these other classes of antimicrobial agents. There is no cross-resistance between ciprofloxacin and the mentioned classes of antibiotics.

Most strains of *Pseudomonas cepacia*, some strains of *Pseudomonas maltophilia* and most anaerobic bacteria (including *Bacteroides fragilis* and *Clostridium difficile* but excluding *Clostridium perfringens*) are resistant to ciprofloxacin.



**Table 5: Cumulative Percent of Strains Inhibited at the Indicated Concentration of Ciprofloxacin (as of 1986)**

Genera or Species	(Number of Strains)	mg/L												
		0.015	0	0.1	0.12	0.25	0.5	1	2	4	8	16	32	64
<i>Providencia stuartii</i>	16	6	25	38	50	56	75		100					
<i>Pseudomonas aeruginosa</i>	187	1	2	7	41	65	83	89	96		98	100		
<i>Pseudomonas aeruginosa</i> (Fibrocystic mucoid strain)	(30)		3	20	43	63	80	100						
<i>Pseudomonas aeruginosa</i> (Fibrocystic non-mucoid strain)				13	50	93	100							
<i>Pseudomonas aeruginosa</i> (Bacteremic non-cystic strain)			3	57	88	100								
<i>Pseudomonas cepacia</i>	10							50	100					
<i>Pseudomonas fluorescens</i>	8				50	75	100							
<i>Pseudomonas maltophilia</i>	11			9			36	55	64	82	91	100		
<i>Salmonella</i> spp.	81		33	68	96	100								
<i>Serratia marcescens</i>	12		50	100										
<i>Shigella</i> spp.	59		97	98	98	100								
<i>Shigella sonnei</i>	45	100												
<i>Staphylococcus aureus</i>	101		2	5	15	52	95	100						
<i>Staphylococcus epidermidis</i>	64	5		6	28	84	95	100						
<i>Streptococcus faecalis</i>	39				2.4	28.6	88.1	92.9	100					
<i>Ureaplasma urealyticum</i>	10						20	50	100					

The minimum inhibitory concentrations (MICs) of ciprofloxacin against aerobic bacteria are not significantly affected by changes in inoculum size in the range of  $5 \times 10^3$  to  $5 \times 10^6$  cfu/spot. Five bacterial species, *Staphylococcus aureus* K734, *Staphylococcus epidermidis* H846, *Streptococcus faecalis* 7149, *Escherichia coli* 2345, and *Proteus mirabilis* 2349 were tested for MICs with inoculum size of  $5 \times 10^3$  to  $5 \times 10^6$ . *Streptococcus faecalis* showed a four-fold increase while the remainder showed only a two- to three-fold increase (**Table 6**). There were no differences between MICs determined in Mueller Hinton and Isosensitest broth.

MIC values 8- to 16-fold higher were seen when these organisms were tested in Mueller Hinton broth at pH 4.8 compared to values obtained at pH 7.3 (**Table 6**). This reduction in antibacterial activity suggests a significant pH effect.

Some studies have demonstrated that increasing the concentration of magnesium in the medium used for in vitro testing reduces the antibacterial activity of ciprofloxacin. Neither zinc nor calcium supplementation had the same effect. The mechanism by which magnesium antagonizes the activity of ciprofloxacin is unclear.

**Table 6: Effect of Culture Medium Composition, pH and Inoculum Size On Antibacterial Activity of Ciprofloxacin**

Organism/Strain		MIC (mg/L)				
		pH <sup>a</sup>			Inoculum Size (cfu) <sup>b</sup>	
		4.8	7.3	8.8	$5 \times 10^3$	$5 \times 10^6$
<i>Staphylococcus aureus</i>	K 734	4.0	0.5	0.5	0.25	0.5
<i>Staphylococcus epidermidis</i>	H 846	2.0	0.25	0.25	0.125	0.25
<i>Streptococcus faecalis</i>	7149	8.0	1.0	1.0	0.5	2.0
<i>Escherichia coli</i>	2345	0.5	0.016	0.016	0.008	0.016
<i>Proteus mirabilis</i>	2349	1.0	0.03	0.016	0.008	0.03

a Mueller Hinton broth (BBL)  $5 \times 10^5$  cfu/mL.

b No difference between the MIC's determined in Mueller Hinton (BBL) and Isosensitest broth (Oxiod).

### **Development of Resistance**

Resistance to ciprofloxacin in vitro develops slowly via multiple-step mutation. Resistance to ciprofloxacin due to spontaneous mutations occurs at a general frequency of between  $<1 \times 10^{-9}$  to

$1 \times 10^{-6}$ . The prevalence of resistance may vary geographically and with time for selected species. Local information on resistance is desirable, particularly when treating severe infections.

### **Susceptibility Testing**

**Dilution Techniques:** Quantitative methods are used to determine antimicrobial minimal inhibitory concentrations (MICs). These MICs provide estimates of the susceptibility of bacteria to antimicrobial compounds. The MICs should be determined using a standardized procedure. Standardized procedures are based on a dilution method (broth or agar) or equivalent with standardized inoculum concentrations and standardized concentrations of ciprofloxacin. The MIC values should be interpreted according to the following criteria:

For testing *Enterobacteriaceae*, *Enterococcus* species, and *Staphylococcus* species:

<b><u>MIC (µg/mL)</u></b>	<b><u>Interpretation</u></b>
≤ 1	Susceptible (S)
2	Intermediate (I)
≥ 4	Resistant (R)

A report of “Susceptible” indicates that the pathogen is likely to be inhibited if the antimicrobial compound in the blood reaches the concentrations usually achievable. A report of “Intermediate” indicates that the result should be considered equivocal, and, if the microorganism 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 which prevents small uncontrolled technical factors from causing major discrepancies in interpretation. A report of “Resistant” indicates that the pathogen is not likely to be inhibited if the antimicrobial compound in the blood reaches the concentrations usually achievable; other therapy should be selected. Standardized susceptibility test procedures require the use of laboratory control microorganisms to control the technical aspects of the laboratory procedures. Standard ciprofloxacin powder should provide the following MIC values:

<u>Microorganism</u>		<u>MIC (mg/L)</u>
<i>Enterococcus faecalis</i>	ATCC 29212	0.25 - 2.0
<i>Escherichia coli</i>	ATCC 25922	0.004 - 0.015
<i>Staphylococcus aureus</i>	ATCC 25923	0.12 - 0.5

**Diffusion Techniques:** Quantitative methods that require measurement of zone diameters also provide reproducible estimates of the susceptibility of bacteria to antimicrobial compounds. One such standardized procedure requires the use of standardized inoculum concentrations. This procedure uses paper disks impregnated with 5- $\mu$ g ciprofloxacin to test the susceptibility of microorganisms to ciprofloxacin.

Reports from the laboratory providing results of the standard single-disk susceptibility test with a 5  $\mu$ g ciprofloxacin disk should be interpreted according to the following criteria:

<u>Zone Diameter (mm)</u>	<u>Interpretation</u>
$\geq 21$	Susceptible (S)
16 - 20	Intermediate (I)
$\leq 15$	Resistant (R)

Interpretation should be as stated above for results using dilution techniques. Interpretation involves correlation of the diameter obtained in the disk test with the MIC for ciprofloxacin.

As with standardized dilution techniques, diffusion methods require the use of laboratory control microorganisms that are used to control the technical aspects of the laboratory procedures. For the diffusion technique, the 5- $\mu$ g ciprofloxacin disk should provide the following zone diameters in these laboratory test quality control strains:

**Table 7: Daily Ranges for Ciprofloxacin for Quality Control Strains**

<u>QC Strains</u>	<u>Disk Zone Diameter (mm)</u>
<i>S. aureus</i> (ATCC 25923)	22 - 30
<i>S. aureus</i> (ATCC 29213)	-
<i>E. coli</i> (ATCC 25922)	30 - 40
<i>P. aeruginosa</i> (ATCC 27853)	25 - 33
<i>N. gonorrhoeae</i> (ATCC 49226)	48 - 58

## **PHARMACOLOGY**

### **ANIMAL PHARMACOLOGY**

#### **Effects on Histamine Release**

Ciprofloxacin was administered intravenously to 9 anaesthetized dogs (initially with thiopental sodium at 25 mg/kg IV, followed by continuous infusion of a mixture of fentanyl 0.04 mg/kg/h and dehydrobenzperidol 0.25 mg/kg/h) at a single dose of 3, 10 or 30 mg/kg. Ciprofloxacin treatment resulted in circulatory changes similar to those caused by histamine release. These were reductions in blood pressure, cardiac output and maximum rate of pressure increase in the left ventricle ( $dp/dt_{max}$ ), and increase in heart rate. This histamine-liberating effect was counteracted by the simultaneous intravenous administration of 0.01 mg/kg pyrilamine maleate. No signs of histamine liberation were observed on conscious animals.

In vitro experiments on isolated rat mast cells also indicate that ciprofloxacin at concentrations of 0.1 to 100 mg/L has histamine liberating properties.

#### **Bronchodilatory Effects**

Ciprofloxacin was tested on isolated guinea-pig trachea at concentrations of 0.0001 to 10 mg/L. It produced a dose-related small but significant relaxation of respiratory airway smooth muscle. It has, however, no effect on leukotriene D4 and histamine-induced contractions at these doses.

#### **CNS Effects**

Ciprofloxacin was administered orally to 4 groups of 1 cat each under chloralose-urethane anaesthesia at doses of 0, 10, 20, and 100 mg/kg. No effects were observed on neuromuscular transmission, flexor reflex, or blood pressure.

#### **Gastrointestinal Effects**

Ciprofloxacin was administered orally to 4 groups of 20 mice each at doses of 0, 10, 30, and 100 mg/kg, 40 minutes prior to a 15% charcoal suspension. No effect was observed in intestinal charcoal transit time. When given to 3 groups of 20 rats each at doses of 0, 30 or 100 mg/kg, no gastric lesions were observed on sacrificing the animals after 5 hours.

When given intraduodenally to 3 groups of 8 rats each at doses of 0, 10, and 100 mg/kg, no increase in basal gastric acid secretion was observed on perfusion of the stomach.

### **Effect on Blood Glucose and Serum Triglycerides**

Four groups of six fasting rats each were given intravenous injections of 0, 3, 10, and 30 mg/kg respectively. A slight but significant increase in blood glucose concentrations 60 minutes and 240 minutes post dose was observed in the 3 and 10 mg/kg groups but not in the 30 mg/kg group in comparison to controls.

At 60 minutes post dose, the serum triglyceride concentrations were slightly but significantly reduced in all three groups. This effect was not dose-related. At 120 minutes, the concentration was slightly elevated in the 30 mg/kg group.

## **HUMAN PHARMACOLOGY**

### **Pharmacokinetics**

The relative bioavailability of oral ciprofloxacin, given as a tablet, is between 70 and 80 per cent compared to an equivalent dose of IV ciprofloxacin.

Following oral administration of single doses of 250 mg, 500 mg, and 750 mg of CIPRO<sup>®</sup> respectively to groups of 3 healthy male volunteers (age:  $22.8 \pm 3.5$  years, weight:  $68.5 \pm 9.4$  kg), ciprofloxacin was absorbed rapidly and extensively from the gastrointestinal tract.

Maximum serum concentrations ( $C_{max}$ ) increased dose-proportionally and were attained 1 to 2 hours after oral dosing. The total areas under the serum concentration-time curves (AUC) were also increased in proportion to dose. Mean concentrations 12 hours after dosing with 250 mg, 500 mg, or 750 mg were 0.1, 0.2, and 0.4 mg/L, respectively. The serum elimination half-lives ( $t_{1/2}$ ) were between 4 and 6 hours. (See [Table 8](#) and [Figure 1](#).)

**Table 8: Pharmacokinetic Parameters Following a Single Oral Dose of Ciprofloxacin Tablets in Healthy Volunteers**

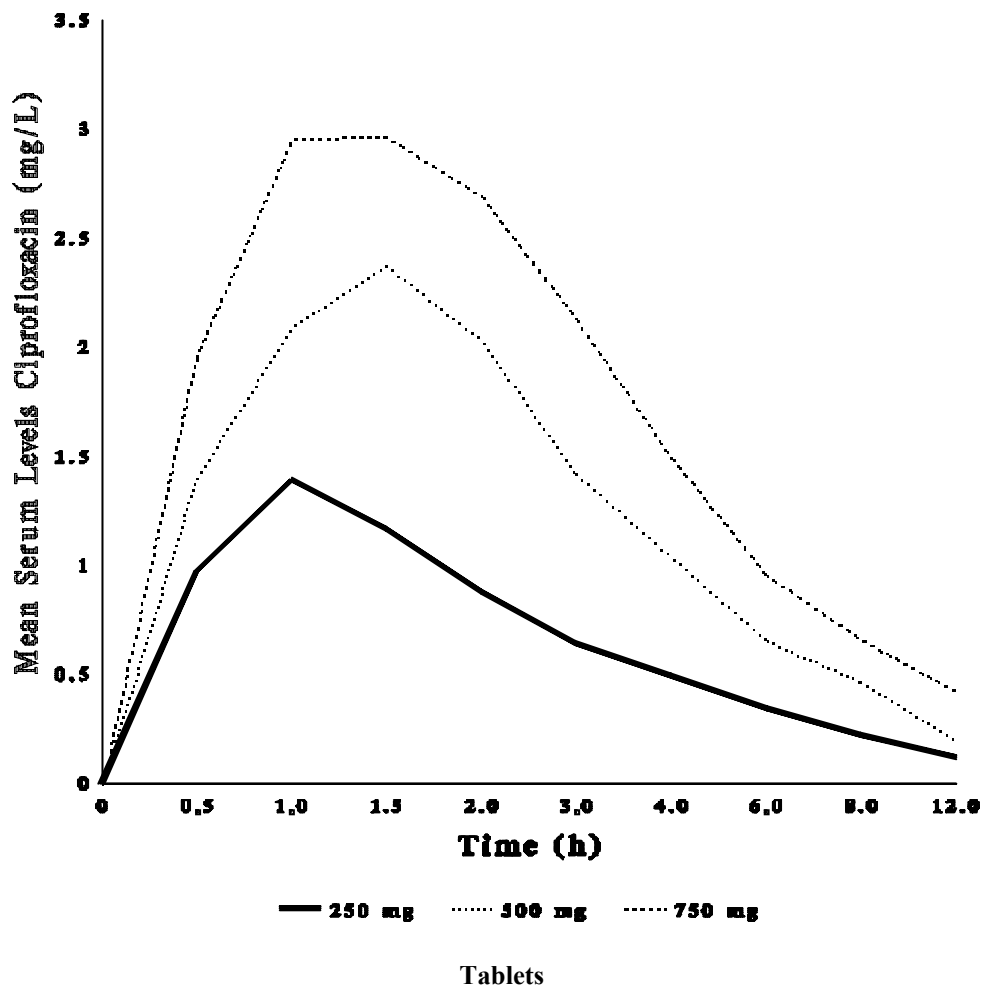
Dose	250 mg	500 mg	750 mg
$C_{max}$ (mg/L)	1.42	2.60	3.41
$t_{1/2}$ (h)	4.19	4.87	5.34
AUC <sub>0-∞</sub> (mg•h/L)	5.43	10.60	15.03
$t_{max}$ (h)	1.11	1.11	1.56

Similar values were obtained following the oral administration of multiple doses every 12 hours for 7 days (see [Table 9](#)).

**Table 9: Mean Pharmacokinetic Parameters of Ciprofloxacin at Steady State in Healthy Volunteers**

Regimen	AUC <sub>0-12h</sub> (mg•h/L)	C <sub>max</sub> (mg/L)	t <sub>max</sub> (h)
Ciprofloxacin 500 mg PO q12h	13.7	2.97	1.23

Figure 1: Mean Ciprofloxacin Serum Concentration After Single **Oral** Doses



A 500 mg oral dose, given as 10 mL of the 5% suspension (containing 250 mg ciprofloxacin/ 5 mL) is bioequivalent to the 500 mg tablet. A 10 mL volume of the 5% suspension (containing 250 mg ciprofloxacin/5 mL) is bioequivalent to a 5 mL volume of the 10% suspension (containing 500 mg ciprofloxacin/5 mL) (See [Table 10](#)).

**Table 10: Summary Table of the Comparative Bioavailability Data Ciprofloxacin Oral Suspension vs Tablet, Geometric Mean and Arithmetic Mean (CV%)\*, Single Doses in Healthy Volunteers**

Parameter	500 mg Oral Suspension	500 mg Tablet	% Ratio of Geometric Means
AUC <sub>0-∞</sub> (µg•h/mL)	11.81 12.19 (22.6)	12.04 12.28 (19.4)	0.98
AUC <sub>1</sub> (µg•h/mL)	11.29 11.68 (23.1)	11.51 11.75 (19.9)	0.98
C <sub>max</sub> (µg/mL)	2.18 2.23 (23.1)	2.36 2.39 (17.9)	0.92
t <sub>max</sub> (h)*	1.62	1.22	-

\* Arithmetic mean only

### **Metabolism and Excretion**

Ciprofloxacin is largely excreted unchanged both renally and, to a small extent, extra-renally. Small concentrations of 4 metabolites have been reported: Desethyleneciprofloxacin (M1) (1.8%), sulphociprofloxacin (M2) (5.0%), oxociprofloxacin (M3) (9.6%) and formylciprofloxacin (M4) (0.1%).

Following the oral administration of a single 259 mg dose of 14C-labelled ciprofloxacin to six healthy male volunteers (age: 25.0 ± 1.46 years, weight: 70.0 ± 3.39 kg), approximately 94% of the dose was recovered in the urine and feces over five days. Most of the radioactivity was recovered in the urine (55.4%). Unchanged ciprofloxacin was the major radioactive moiety identified in both urine and feces, accounting for 45% and 25% of the dose, respectively. Total (urine and feces) excretion of all metabolites was 18.8%.

**Table 11** shows urinary recovery data from another trial where healthy subjects were administered a single dose of ciprofloxacin in tablet form (see **Table 11**).

**Table 11: Mean Urinary Excretion of Ciprofloxacin**

	Hours After Oral Administration of a Single Tablet			
	0 - 2	2 - 4	4 - 8	8 - 12
<b>Urine Concentration mg/L (± S.D.)</b>				
250 mg PO	205 (±89)	163 (±145)	101 (±65)	32 (±28)
500 mg PO	255 (±204)	358 (±206)	117 (±86)	26 (±10)
750 mg PO	243 (±143)	593 (±526)	169 (±131)	55 (±36)
<b>Amount Excreted mg (± S.D.)</b>				
250 mg dose	54.38 (±36.22)	26.79 (±11.78)	22.84 (±6.79)	8.90 (±4.25)
500 mg dose	64.51 (±25.06)	47.37 (±15.65)	39.54 (±11.17)	15.52 (±5.39)
750 mg dose	68.90 (±41.85)	72.43 (±33.13)	61.07 (±21.68)	28.11 (±7.64)

Following the intravenous administration of a single 107 mg dose of  $^{14}\text{C}$ -labelled ciprofloxacin to six healthy male volunteers (age:  $23.7 \pm 1.89$  years, weight:  $80.2 \pm 3.45$  kg), 15% of unchanged ciprofloxacin was recovered in the feces, suggesting that hepatic extraction and biliary excretion is an extra-renal clearance pathway for ciprofloxacin. Direct evidence of biliary excretion of ciprofloxacin was obtained in 12 patients (age 28-58) with T-tube drainage. A peak biliary concentration of 16 mg/L was seen 4 hours after a single oral dose of ciprofloxacin 500 mg.

## FACTORS INFLUENCING THE PHARMACOKINETICS

### Age (Elderly)

In 4 females and 6 males, (age:  $67 \pm 4$  years, weight:  $65 \pm 6$  kg) with normal renal function for their age, given a single oral dose of 250 mg, maximum ciprofloxacin serum concentrations and areas under the serum concentration time curves were significantly higher than in 10 male younger volunteers (age:  $24 \pm 3$  years, weight:  $72 \pm 9$  kg). The time to peak serum concentrations, overall elimination half-life and urinary recovery of ciprofloxacin were similar in both age groups.

**Table 12: Comparison of Pharmacokinetic Parameters Between Healthy Elderly and Healthy Younger Volunteers Following Oral Administration of a Single 250 mg Tablet**

Parameter	Elderly Volunteers (Mean $\pm$ S.D.)	Younger Volunteers (Mean $\pm$ S.D.)
$C_{\max}$ (mg/L)	$1.8 \pm 0.5$	$1.3 \pm 0.4$
$t_{\max}$ (h)	$1.2 \pm 0.3$	$1.2 \pm 0.1$
$t_{1/2}$ (h)	$3.7 \pm 0.9$	$3.3 \pm 0.6$
Total AUC (mg•h/L)	$7.25 \pm 2.45$	$5.29 \pm 1.21$
% Dose Urinary Recovery after 24 hours	43	43

### Impaired Renal Function

Ciprofloxacin is eliminated primarily by renal excretion. However, the drug is also metabolized and partially cleared through the biliary system of the liver and through the intestine. This alternate pathway of drug elimination appears to compensate for the reduced renal excretion of patients with renal impairment. Nonetheless, some modification of dosage is recommended, particularly for patients with severe renal dysfunction.

The pharmacokinetics of ciprofloxacin following a single oral dose of 250 mg in 6 patients (5 male, 1 female, age:  $51 \pm 9$  years) with normal renal function (see Group I, **Table 13**) were compared to 6 patients (3 male, 3 female, age:  $63 \pm 6$  years) with renal impairment (see Group II, **Table 13**) and to 5 patients (2 male, 3 female, age:  $63 \pm 6$  years) with end-stage renal failure, treated by haemodialysis (see Group III, **Table 13**). Patients with renal insufficiency had significantly increased AUCs, prolonged (about 2-fold) elimination half-lives, and decreased renal clearances.

Haemodialysis resulted in a minimal decrease in plasma levels. From the dialysate concentrations, it can be estimated that no more than 2% of the dose was removed by dialysis over 4 hours, which was less than the amount lost in the urine over 24 hours in patients of Group II (see **Table 13**).

**Table 13: Mean Pharmacokinetic Parameters for Ciprofloxacin Following Oral Administration of a Single 250 mg Tablet in Healthy Volunteers and in Patients with Renal Insufficiency**

Group	Creatinine Clearance (mL/s/1.73 m <sup>2</sup> ) (mL/min/1.73 m <sup>2</sup> )	Parameter					
		C <sub>max</sub> (mg/L)	t <sub>max</sub> (h)	Half-Life (h)	Total AUC (mg•h/mL)	Renal Clearance (mL/min)	% Dose Urinary Recovery (0-24 h)
I	> 1.0 (> 60)	1.52 (± 0.21)	1.0 (± 0.0)	4.4 (±0.2)	6.94 (± 0.97)	232.9 (± 44.8)	37.0 (± 3.7)
II	< 0.33 (< 20)	1.70 (± 0.41)	1.7 (± 0.5)	8.7 (±0.9)	14.36 (± 3.5)	18.3 (± 3.5)	5.3 (± 1.7)
III	End-Stage Renal Failure Treated by Hemodialysis	2.07 (± 0.23)	1.6 (± 0.2)	5.8 (± 0.9)	15.87 (± 2.0)		

**Hepatic Impairment**

In studies in patients with stable chronic cirrhosis (with mild to moderate hepatic impairment), no significant changes in ciprofloxacin pharmacokinetics have been observed. In a study of 7 cirrhotic patients and healthy volunteers given CIPRO<sup>®</sup> 750 mg every 12 hours for a total of nine doses followed by a 1-week washout and then a 30-minute infusion of CIPRO<sup>®</sup> I.V. 200 mg, there was no difference in pharmacokinetics between patients with stable chronic cirrhosis (with mild to moderate hepatic impairment) and healthy volunteers.

**Food**

The administration of ciprofloxacin with food delayed absorption, as shown by an increase of approximately 50% in time to peak concentrations, but did not cause other changes in the pharmacokinetics of ciprofloxacin.

**Drug Interactions****Theophylline**

Studies with immediate-release ciprofloxacin have shown that concomitant administration of ciprofloxacin with theophylline decreases the clearance of theophylline, resulting in elevated serum theophylline levels and increased risk of a patient developing CNS or other adverse reactions.

**Caffeine and Other Xanthine Derivatives**

Ciprofloxacin decreases caffeine clearance and inhibits the formation of paraxanthine after caffeine administration.

Upon concurrent administration of ciprofloxacin and pentoxifylline (oxpentifylline)-containing products, raised serum concentrations of this xanthine derivative were reported.

**Class IA or III Antiarrhythmics**

Precaution should be taken when using ciprofloxacin together with class IA or III antiarrhythmics as ciprofloxacin may have an additive effect on the QT interval (see

**WARNINGS**).

**Multivalent Cations**

Absorption of ciprofloxacin is significantly reduced by concomitant administration of multivalent cation-containing products such as magnesium/aluminum antacids, lanthanum carbonate, sucralfate, Videx<sup>®</sup> (didanosine) chewable/buffered tablets or pediatric powder, mineral supplements or products containing calcium, iron, or zinc.

**Probenecid**

Co-administration of probenecid (1000 mg) with ciprofloxacin (500 mg) orally resulted in about 50% reduction in the ciprofloxacin renal clearance and a 50% increase in its concentration in the systemic circulation.

**Clozapine**

Following concomitant administration of 250 mg ciprofloxacin for 7 days, serum concentrations of clozapine and n-desmethylozapine were increased by 29% and 31%, respectively (see **WARNINGS**).

**Lidocaine**

It was demonstrated in healthy subjects that concomitant use of lidocaine with ciprofloxacin, a moderate inhibitor of CYP450 1A2 isozyme, reduces clearance of intravenous lidocaine by 22%. Ciprofloxacin may increase the systemic toxicity of lidocaine.

**Ropinirole**

In a clinical study it was shown that concomitant use of ropinirole with ciprofloxacin, a medium inhibitor of the CYP450 1A2 isozyme, resulted in increases in the  $C_{max}$  and AUC of ropinirole of 60% and 84%, respectively. Ciprofloxacin may increase the systemic toxicity of ropinirole.

**Sildenafil**

$C_{max}$  and AUC of sildenafil were increased approximately two-fold in healthy subjects after an oral dose of 50 mg was given concomitantly with 500 mg ciprofloxacin. Therefore, caution should be used prescribing ciprofloxacin concomitantly with sildenafil, taking into consideration the risks and the benefits.

### **Vitamin K Antagonists**

Simultaneous administration of ciprofloxacin with a vitamin K antagonist may augment its anticoagulant effects. The risk may vary with the underlying infection, age, and general status of the patient so that the contribution of ciprofloxacin to the increase in INR (international normalized ratio) is difficult to assess. The INR should be monitored frequently during and shortly after co-administration of ciprofloxacin with a vitamin K antagonist (eg, warfarin and acenocoumarol).

### **Serum Protein Binding**

Serum protein binding of ciprofloxacin is between 19% to 40%, which is not likely to be high enough to cause significant protein binding interactions with other drugs.

### **Tissue Concentrations**

In one study, the apparent volume of distribution ( $V_{d_{area}}$ ) of ciprofloxacin was estimated from the kinetic data recorded after oral doses and found to be approximately 3.5 L/kg, which suggests substantial tissue penetration.

The distribution of ciprofloxacin was observed to be rapid in healthy volunteers receiving various single and multiple intravenous doses. Fitting the serum profile to a two-compartment model provides a distribution phase with a half-life between 0.2 and 0.4 hours. The volume of distribution at steady state ( $V_{d_{ss}}$ ) and  $V_{d_{area}}$  were between 1.7 and 2.7 L/kg respectively. The volume of the central compartment was between 0.16 and 0.63 L/kg, which approximates the total volume of extracellular water.

Single intravenous doses of 100, 150, and 200 mg ciprofloxacin were administered to nine healthy volunteers to determine the excretion and distribution of ciprofloxacin following intravenous administration and to assess the effect of dose size on pharmacokinetic parameters.

Analysis with a three-compartmental pharmacokinetic model quantified approximate sizes and kinetics of distribution into two peripheral compartments: a rapidly equilibrating compartment ( $V_2$ ) with a high intercompartmental clearance rate, accounting for the rapid decline in ciprofloxacin concentrations in serum immediately following drug infusion; and a second, slowly equilibrating tissue compartment with relatively slow intercompartmental clearance. This would contribute to the prolonged terminal half-life (4 to 5 h) of ciprofloxacin IV.

The results of this study were as follows: volume of distribution at steady state ( $V_{ss}$ ) was determined to be between 2.0 and 2.9 L/kg. Volumes in each compartment were determined to be: central compartment 0.2 - 0.4, peripheral  $V_2$  0.6 - 0.8 and peripheral  $V_3$  1.2 - 1.6 L/kg.

**Table 14** summarizes the results of tissue and fluid penetration of ciprofloxacin in man.

**Table 14: Distribution of Ciprofloxacin in Human Tissue/Fluid**

Tissue/Fluid	No. of Patients	Single Dose of Ciprofloxacin	Peak Concentration (mg/kg or mg/L)	Mean Serum Concentration (mg/L)	Time After Dose (h)
Skin Blister Fluid	6	500 mg PO	1.4 ± 0.36	2.3 ± 0.7	1 - 6
Bone	4	750 mg PO	1.4 ± 1.0	2.9 ± 2.2	2 - 4
Gynecological Tissue	18	500 mg PO	1.3 ± 0.66 to 1.6 ± 0.97	1.4 ± 0.87	2 - 4
Prostatic Tissue	1	500 mg PO	3.76	1.84	2.5
Muscle	4	250 mg PO	2.4 ± 1.0	2.9 ± 2.2	2 - 4
Nasal Secretions	20	500 mg PO	1.4 ± 0.81	1.8 ± 0.48	1 - 3
Bronchial Tissues	10	200 mg IV	3.94 ± 2.5	1.62 ± 0.7	0.97
Vagina	18	100 mg IV	1.13 ± 0.2	0.61 ± 0.12	0.5
Ovary	18	100 mg IV	1.00 ± 0.23	0.61 ± 0.12	0.5

## TOXICOLOGY

### Acute Toxicity

<u>Species</u>	<u>Mode of Administration</u>	<u>LD<sub>50</sub> (mg/kg)</u>
Mouse	PO	Approx. 5000
Rat	PO	Approx. 5000
Rabbit	PO	Approx. 2500
Mouse	IV	Approx. 290
Rat	IV	Approx. 145
Rabbit	IV	Approx. 125
Dog	IV	Approx. 250

### Chronic Toxicity

#### **Subacute Tolerability Studies Over 4 Weeks**

Oral administration: Doses up to and including 100 mg/kg were tolerated without damage by rats. Pseudoallergic reactions due to histamine release were observed in dogs.

Parenteral administration: In the highest-dose group in each case (rats 80 mg/kg and monkeys 30 mg/kg), crystals containing ciprofloxacin were found in the urine sediment. There were also changes in individual renal tubules, with typical foreign-body reactions due to crystal-like precipitates. These changes are considered secondary inflammatory foreign-body reactions due to the precipitation of a crystalline complex in the distal renal tubule system.

#### **Subchronic Tolerability Studies over 3 Months**

Oral administration: All doses up to and including 500 mg/kg were tolerated without damage by rats. In monkeys, crystalluria and changes in the renal tubules were observed in the highest-dose group (135 mg/kg).

Parenteral administration: Although the changes in the renal tubules observed in rats were in some cases very slight, they were present in every dose group. In monkeys they were found only in the highest-dose group (18 mg/kg) and were associated with slightly reduced erythrocyte counts and hemoglobin values.

### **Chronic Tolerability Studies Over 6 Months**

Oral administration: Doses up to and including 500 mg/kg and 30 mg/kg were tolerated without damage by rats and monkeys, respectively. Changes in the distal renal tubules were again observed in some monkeys in the highest-dose group (90 mg/kg).

Parenteral administration: In monkeys slightly elevated urea and creatinine concentrations and changes in the distal renal tubules were recorded in the highest-dose group (20 mg/kg).

### **Carcinogenicity**

In carcinogenicity studies in mice (21 months) and rats (24 months) with doses up to approximately 1000 mg/kg bw/day in mice and 125 mg/kg bw/day in rats (increased to 250 mg/kg bw/day after 22 weeks), there was no evidence of a carcinogenic potential at any dose level.

### **Reproduction Toxicology**

Fertility studies in rats: Fertility, the intrauterine and postnatal development of the young, and the fertility of F1 generation were not affected by ciprofloxacin.

Embryotoxicity studies: These yielded no evidence of any embryotoxic or teratogenic action of ciprofloxacin.

Perinatal and postnatal development in rats: No effects on the perinatal or postnatal development of the animals were detected. At the end of the rearing period histological investigations did not bring to light any sign of articular damage in the young.

### **Mutagenicity**

Eight in vitro mutagenicity tests have been conducted with ciprofloxacin. Test results are listed below:

Salmonella: Microsome Test (Negative)

*E. coli*: DNA Repair Assay (Negative)

Mouse Lymphoma Cell Forward Mutation Assay (Positive)

Chinese Hamster V79 Cell HGPRT Test (Negative)

Syrian Hamster Embryo Cell Transformation Assay (Negative)

*Saccharomyces cerevisiae*: Point Mutation Assay (Negative)

Mitotic Crossover and Gene Conversion Assay (Negative)

Rat Hepatocyte Primary Culture DNA Repair Assay (LIDS) (Positive)

Two of the eight tests were positive, but results of the following four *in vivo* test systems gave negative results:

Rat Hepatocyte DNA Repair Assay

Micronucleus Test (Mice)

Dominant Lethal Test (Mice)

Chinese Hamster Bone Marrow

### **Special Tolerability Studies**

It is known from comparative studies in animals, both with the older gyrase inhibitors and the more recent ones, that this substance class produces a characteristic damage pattern. Kidney damage, cartilage damage in weight-bearing joints of immature animals, and eye damage may be encountered.

Renal tolerability: The crystallization observed in the animal studies occurred preferentially under pH conditions that do not apply in man.

Compared to rapid infusion, a slow infusion of ciprofloxacin reduces the danger of crystal precipitation.

The precipitation of crystals in renal tubules does not immediately and automatically lead to kidney damage. In the animal studies, damage occurred only after high doses, with correspondingly high levels of crystalluria. For example, although they always caused

crystalluria, even high doses were tolerated over 6 months without damage and without foreign-body reactions occurring in individual distal renal tubules.

Damage to the kidneys without the presence of crystalluria has not been observed. The renal damage observed in animal studies must not, therefore, be regarded as a primary toxic action of ciprofloxacin on the kidney tissue, but as typical secondary inflammatory foreign-body reactions due to the precipitation of a crystalline complex of ciprofloxacin, magnesium, and protein.

Articular tolerability studies: As it is also known for other gyrase inhibitors, ciprofloxacin causes damage to the large, weight-bearing joints in immature animals.

The extent of the cartilage damage varies according to age, species, and dose; the damage can be reduced by taking the weight off the joints. Studies with mature animals (rat, dog) revealed no evidence of cartilage lesions.

Retina tolerability studies: Ciprofloxacin binds to the melanin containing structures including the retina. Potential effects of ciprofloxacin on the retina were assessed in various pigmented animal species. Ciprofloxacin treatment had no effect on the morphological structures of the retina and on electroretinographic findings.

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