

HIGHLIGHTS OF PRESCRIBING INFORMATION
These highlights do not include all the information needed to use Piperacillin and Tazobactam for Injection safely and effectively. See full prescribing information for Piperacillin and Tazobactam for Injection.

PIPERACILLIN AND TAZOBACTAM FOR INJECTION: single-dose vials

Initial U.S. approval: 1993
To reduce the development of drug-resistant bacteria and maintain the effectiveness of Piperacillin and Tazobactam for Injection and other antibacterial drugs, Piperacillin and Tazobactam for Injection should be used only to treat infections that are proven or strongly suspected to be caused by bacteria.

- INDICATIONS AND USAGE
- Intra-abdominal infections (1.1)
 - Skin and skin structure infections (1.2)
 - Female pelvic infections (1.3)
 - Community-acquired pneumonia (1.4)
 - Nosocomial pneumonia (1.5)

- DOSAGE AND ADMINISTRATION
- The usual daily dose of Piperacillin and Tazobactam for Injection for adults is 3.375 g every six hours totaling 13.5 g (12.0 g piperacillin/1.5 g tazobactam) (2.1)
 - Initial presumptive treatment of patients with nosocomial pneumonia should start with Piperacillin and Tazobactam for Injection at a dosage of 4.5 g every six hours plus an aminoglycoside, totaling 18.0 g (16.0 g piperacillin/2.0 g tazobactam), (2.2)
 - Dosage in patients with renal impairment (≤40 mL/min of CrCL) and dialysis patients should be reduced, based on the degree of actual renal function impairment. (2.3)
 - For children with appendicitis and/or peritonitis the recommended Piperacillin and Tazobactam for Injection dosage is 100 mg piperacillin/12.5 mg tazobactam per kilogram of body weight, every 8 hours in pediatric patients 9 months of age and older. For pediatric patients 2 to 9 months of age, the recommended dosage is 80 mg piperacillin/10 mg tazobactam per kilogram of body weight, every 8 hours. (2.4)
 - Piperacillin and Tazobactam for Injection and aminoglycosides should be reconstituted, diluted, and administered separately. Co-administration via Y-site can be done under certain conditions. (2.6)

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FULL PRESCRIBING INFORMATION

To reduce the development of drug-resistant bacteria and maintain the effectiveness of piperacillin and tazobactam for injection and other antibacterial drugs, piperacillin and tazobactam for injection should be used only to treat or prevent infections that are proven or strongly suspected to be caused by bacteria.

- 1 INDICATIONS AND USAGE
- Piperacillin and tazobactam for injection is a combination product consisting of a penicillin-class antibacterial, piperacillin, and a β -lactamase inhibitor, tazobactam, indicated for the treatment of patients with moderate to severe infections caused by susceptible isolates of the designated bacteria in the conditions listed below.

- 1.1 Intra-abdominal Infections
- Appendicitis (complicated by rupture or abscess) and peritonitis caused by β -lactamase producing isolates of *Escherichia coli* or the following members of the *Bacteroides fragilis* group: *B. fragilis*, *B. ovatus*, *B. thetaiotaomicron*, or *B. vulgatus*. The individual members of this group were studied in fewer than 10 cases.

- 1.2 Skin and Skin Structure Infections
- Uncomplicated and complicated skin and skin structure infections, including cellulitis, cutaneous abscesses and ischemic/diabetic foot infections caused by β -lactamase producing isolates of *Staphylococcus aureus*.

- 1.3 Female Pelvic Infections
- Postpartum endometritis or pelvic inflammatory disease caused by β -lactamase producing isolates of *Escherichia coli*.

- 1.4 Community-acquired Pneumonia
- Community-acquired pneumonia (moderate severity only) caused by β -lactamase producing isolates of *Haemophilus influenzae*.

- 1.5 Nosocomial Pneumonia
- Nosocomial pneumonia (moderate to severe) caused by β -lactamase producing isolates of *Staphylococcus aureus* and by piperacillin/tazobactam-susceptible *Acinetobacter baumannii*, *Haemophilus influenzae*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa* (Nosocomial pneumonia caused by *P. aeruginosa* should be treated in combination with an aminoglycoside) [see *Dosage and Administration* (2)].

To reduce the development of drug-resistant bacteria and maintain the effectiveness of piperacillin and tazobactam for injection and other antibacterial drugs, piperacillin and tazobactam for injection should be used only to treat infections that are proven or strongly suspected to be caused by 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.

- 2 DOSAGE AND ADMINISTRATION
- Piperacillin and tazobactam for injection should be administered by intravenous infusion over 30 minutes.

- 2.1 Adult Patients
- The usual total daily dose of piperacillin and tazobactam for injection for adults is 3.375 g every six hours totaling 13.5 g (12.0 g piperacillin/1.5 g tazobactam). The usual duration of piperacillin and tazobactam for injection treatment is from 7 to 10 days. Piperacillin and tazobactam for injection should be administered by intravenous infusion over 30 minutes.

- 2.2 Nosocomial Pneumonia
- Initial presumptive treatment of patients with nosocomial pneumonia should start with piperacillin and tazobactam for injection at a dosage of 4.5 g every six hours plus an aminoglycoside, totaling 18.0 g (16.0 g piperacillin/2.0 g tazobactam). The recommended duration of piperacillin and tazobactam for injection treatment for nosocomial pneumonia is 7 to 14 days. Treatment with the aminoglycoside should be continued in patients from whom *P. aeruginosa* is isolated.

- 2.3 Renal Impairment
- In patients with renal impairment (creatinine clearance ≤ 40 mL/min) and dialysis patients (hemodialysis and CAPD), the intravenous dose of piperacillin and tazobactam for injection should be reduced to the degree of actual renal function impairment. The recommended daily doses of piperacillin and tazobactam for injection for patients with renal impairment are as follows:

Table 1: Recommended Dosing of Piperacillin and Tazobactam for Injection in Patients with Normal Renal Function and Renal Impairment (As total grams piperacillin/tazobactam)		
Renal Function (creatinine clearance, mL/min)	All Indications (except nosocomial pneumonia)	Nosocomial Pneumonia
>40 mL/min	3.375 q6h	4.5 q6h
20-40 mL/min*	2.25 q6h	3.375 q6h
<20 mL/min*	2.25 q8h	2.25 q6h
Hemodialysis**	2.25 q12h	2.25 q6h
CAPD	2.25 q12h	2.25 q6h

*Creatinine clearance for patients not receiving hemodialysis
**0.75 g (0.67 g piperacillin/0.08 g tazobactam) should be administered following each hemodialysis session on hemodialysis days

For patients on hemodialysis, the maximum dose is 2.25 g every twelve hours for all indications other than nosocomial pneumonia and 2.25 g every eight hours for nosocomial pneumonia. Since hemodialysis removes 30% to 40% of the administered dose, an additional dose of 0.75 g piperacillin and tazobactam for injection (0.67 g piperacillin/0.08 g tazobactam) should be administered following each dialysis period on hemodialysis days. No additional dosage of piperacillin and tazobactam for injection is necessary for CAPD patients.

- 2.4 Pediatric Patients
- For children with appendicitis and/or peritonitis 9 months of age or older, weighing up to 40 kg, and with normal renal function, the recommended piperacillin and tazobactam for injection dosage is 100 mg piperacillin/12.5 mg tazobactam per kilogram of body weight, every 8 hours. For pediatric patients between 2 months and 9 months of age, the recommended piperacillin and tazobactam for injection dosage based on pharmacokinetic modeling, is 80 mg piperacillin/10 mg tazobactam per kilogram of body weight, every 8 hours [see *Use in Specific Populations* (8.4) and *Clinical Pharmacology* (12.3)]. Pediatric patients weighing over 40 kg and with normal renal function should receive the adult dose. It has not been determined how to adjust piperacillin and tazobactam for injection dosage in pediatric patients with renal impairment.

- 2.5 Reconstitution and Dilution of Powder Formulations Single Dose Vials
- Reconstitute piperacillin and tazobactam for injection vials with a compatible reconstitution diluent from the list provided below.

2.25 g, 3.375 g, and 4.5 g piperacillin and tazobactam for injection should be reconstituted with 10 mL, 15 mL, and 20 mL, respectively. Swirl until dissolved.

Compatible Reconstitution Diluents for Single Dose Vials

0.9% Sodium chloride for injection

Sterile water for injection¹

Dextrose 5%

Bacteriostatic saline/parabens

Bacteriostatic water/parabens

Bacteriostatic saline/benzyl alcohol

Bacteriostatic water/benzyl alcohol

Reconstituted piperacillin and tazobactam for injection solution should be further diluted (recommended volume per dose of 50 mL to 150 mL) in a compatible intravenous solution listed below. Administer by infusion over a period of at least 30 minutes. During the infusion it is desirable to discontinue the primary infusion solution.

Compatible Intravenous Solutions for Pharmacy Bulk Package Bottles and Single Dose Vials

0.9% Sodium chloride for injection

Sterile water for injection¹

Dextran 6% in saline

Dextrose 5%

LACTATED RINGER'S SOLUTION IS NOT COMPATIBLE WITH PIPERACILLIN AND TAZOBACTAM FOR INJECTION.

¹Maximum recommended volume per dose of sterile water for injection is 50 mL.

Piperacillin and tazobactam for injection should not be mixed with other drugs in a syringe or infusion bottle since compatibility has not been established.

Piperacillin and tazobactam for injection is not chemically stable in solutions that contain only sodium bicarbonate and solutions that significantly alter the pH.

Piperacillin and tazobactam for injection should not be added to blood products or albumin hydrolysates.

Parenteral drug products should be inspected visually for particulate matter or discoloration prior to administration, whenever solution and container permit.

DOSAGE FORMS AND STRENGTHS

Piperacillin and Tazobactam for Injection: 2.25 g, 3.375 g, and 4.5 g lyophilized powder for reconstitution in single-dose vials (3)

CONTRAINDICATIONS

Patients with a history of allergic reactions to any of the penicillins, cephalosporins, or β -lactamase inhibitors. (4)

WARNINGS AND PRECAUTIONS

- Serious hypersensitivity reactions (anaphylactic/anaphylactoid) reactions have been reported in patients receiving Piperacillin and Tazobactam for Injection. Discontinue Piperacillin and Tazobactam for Injection if a reaction occurs. (5.1)
- Serious skin reactions, such as Stevens-Johnson syndrome and toxic epidermal necrolysis, have been reported (5.2). Discontinue Piperacillin and Tazobactam for Injection for progressive rashes.
- *Clostridium difficile* associated diarrhea: evaluate patients if diarrhea occurs. (5.3)
- Hematological effects (including bleeding, leukopenia and neutropenia) have occurred. Monitor hematologic tests during prolonged therapy. (5.4)

ADVERSE REACTIONS

The most common adverse reactions (incidence >5%) are diarrhea, constipation, nausea, headache and insomnia. (6.1)

To report SUSPECTED ADVERSE REACTIONS, contact WG Critical Care, LLC at 1-866-562-4708 or FDA at 1-800-FDA-1088 or www.fda.gov/medwatch.

DRUG INTERACTIONS

- Piperacillin and Tazobactam for Injection administration can significantly reduce tobramycin concentrations in hemodialysis patients. Monitor tobramycin concentrations in these patients. (7.1)
- Probenecid prolongs the half-lives of piperacillin and tazobactam and should not be co-administered with Piperacillin and Tazobactam for Injection unless the benefit outweighs the risk. (7.2)
- Monitor coagulation parameters in patients receiving Piperacillin and Tazobactam for Injection and heparin or oral anticoagulants. (7.3)
- Piperacillin and Tazobactam for Injection may prolong the neuromuscular blockade of vecuronium and other non-depolarizing muscle relaxants. Monitor for adverse reactions related to neuromuscular blockade (7.4)

USE IN SPECIFIC POPULATIONS

Dosage in patients with renal impairment (≤40 mL/min of CrCL) should be reduced to the degree of actual renal function impairment. (2.3, 8.6)

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Stability of Piperacillin and Tazobactam for Injection Powder Formulations Following Reconstitution

Piperacillin and tazobactam for injection reconstituted from single vials is stable in glass and plastic containers (plastic syringes, I.V. bags and tubing) when used with compatible diluents. Discard unused portions after storage for 24 hours at room temperature or after storage for 48 hours at refrigerated temperature 2°C to 8°C (36°F to 46°F).

Single dose vials should be used immediately after reconstitution. Discard any unused portion after 24 hours if stored at room temperature 20°C to 25°C (68°F to 77°F), or after 48 hours if stored at refrigerated temperature 2°C to 8°C (36°F to 46°F). Vials should not be frozen after reconstitution.

Stability studies in the I.V. bags have demonstrated chemical stability (potency, pH of reconstituted solution and clarity of solution) for up to 24 hours at room temperature and up to one week at refrigerated temperature. Piperacillin and tazobactam for injection contains no preservatives. Appropriate consideration of aseptic technique should be used.

Piperacillin and tazobactam for injection reconstituted from single vials can be used in ambulatory intravenous infusion pumps. Stability of piperacillin and tazobactam for injection in an ambulatory intravenous infusion pump has been demonstrated for a period of 12 hours at room temperature. Each dose was reconstituted and diluted to a volume of 37.5 mL or 25 mL. One-day supplies of dosing solution were aseptically transferred into the medication reservoir (I.V. bags or cartridge). The reservoir was fitted to a pre-programmed ambulatory intravenous infusion pump per the manufacturer's instructions. Stability of piperacillin and tazobactam for injection is not affected when administered using an ambulatory intravenous infusion pump.

- 2.6 Compatibility with Aminoglycosides
- Due to the *in vitro* inactivation of aminoglycosides by piperacillin, Piperacillin and tazobactam for injection and aminoglycosides are recommended for separate administration. Piperacillin and tazobactam for injection and aminoglycosides should be reconstituted, diluted, and administered separately when concomitant therapy with aminoglycosides is indicated [see *Drug Interactions* (7.1)].

In circumstances where co-administration via Y-site is necessary, piperacillin and tazobactam for injection is compatible for simultaneous coadministration via Y-site infusion only with the following aminoglycosides under the following conditions:

Table 2: Compatibility with Aminoglycosides				
Aminoglycoside	Piperacillin and Tazobactam Dose (grams)	Piperacillin and Tazobactam Diluent Volume (mL)	Aminoglycoside Concentration Range * (mg/mL)	Acceptable Diluents
Amikacin	2.25, 3.375, 4.5	50, 100, 150	1.75 – 7.5	0.9% sodium chloride or 5% dextrose
Gentamicin	2.25, 3.375, 4.5	50, 100 150	0.7 – 3.32	0.9% sodium chloride or 5% dextrose

*The concentration ranges in Table 2 are based on administration of the aminoglycoside in divided doses (10–15 mg/kg/day in two daily doses for amikacin and 3–5 mg/kg/day in three daily doses for gentamicin). Administration of amikacin or gentamicin in a single daily dose or in doses exceeding those stated above via Y-site with piperacillin and tazobactam has not been evaluated. See package insert for each aminoglycoside for complete Dosage and Administration instructions.

Only the concentration and diluents for amikacin or gentamicin with the dosages of piperacillin and tazobactam for injection listed above have been established as compatible for coadministration via Y-site infusion. Simultaneous co-administration via Y-site infusion in any manner other than listed above may result in inactivation of the aminoglycoside by piperacillin and tazobactam for injection.

Piperacillin and tazobactam for injection is not compatible with tobramycin for simultaneous coadministration via Y-site infusion. Compatibility of piperacillin and tazobactam with other aminoglycosides has not been established.

Parenteral drug products should be inspected visually for particulate matter and discoloration prior to administration, whenever solution and container permit.

- 3 DOSAGE FORMS AND STRENGTHS
- Piperacillin and Tazobactam for Injection is supplied as a white to off-white powder in vials of the following sizes:

Each Piperacillin and Tazobactam for Injection 2.25 g vial provides piperacillin sodium equivalent to 2 grams of piperacillin and tazobactam sodium equivalent to 0.25 g of tazobactam.

Each Piperacillin and Tazobactam for Injection 3.375 g vial provides piperacillin sodium equivalent to 3 grams of piperacillin and tazobactam sodium equivalent to 0.375 g of tazobactam.

Each Piperacillin and Tazobactam for Injection 4.5 g vial provides piperacillin sodium equivalent to 4 grams of piperacillin and tazobactam sodium equivalent to 0.5 g of tazobactam.

- 4 CONTRAINDICATIONS
- Piperacillin and tazobactam for injection is contraindicated in patients with a history of allergic reactions to any of the penicillins, cephalosporins, or β -lactamase inhibitors.

- 5 WARNINGS AND PRECAUTIONS

- 5.1 Hypersensitivity Reactions
- Serious and occasionally fatal hypersensitivity (anaphylactic/anaphylactoid) reactions (including shock) have been reported in patients receiving therapy with piperacillin and tazobactam for injection. These reactions are more likely to occur in individuals with a history of penicillin, cephalosporin, or carbapenem hypersensitivity or a history of sensitivity to multiple allergens. Before initiating therapy with piperacillin and tazobactam for injection, careful inquiry should be made concerning previous hypersensitivity reactions. If an allergic reaction occurs, piperacillin and tazobactam for injection should be discontinued and appropriate therapy instituted.

- 5.2 Serious Skin Reactions
- Serious skin reactions, such as Stevens-Johnson syndrome and toxic epidermal necrolysis, have been reported in patients receiving piperacillin and tazobactam for injection. If patients develop a skin rash they should be monitored closely and piperacillin and tazobactam for injection discontinued if lesions progress.

- 5.3 *Clostridium difficile* Associated Diarrhea
- Clostridium difficile* associated diarrhea (CDAD) has been reported with use of nearly all antibacterial agents, including piperacillin and tazobactam for injection, 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. Hypertoxin 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 drug use. Careful medical history is necessary since CDAD has been reported to occur over two months after the administration of antibacterial agents.

If CDAD is suspected or confirmed, ongoing antibacterial drug use is 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.

- 5.4 Hematologic Effects
- Bleeding manifestations have occurred in some patients receiving β -lactam drugs, including piperacillin. These reactions have sometimes been associated with abnormalities of coagulation tests such as clotting time, platelet aggregation and prothrombin time, and are more likely to occur in patients with renal failure. If bleeding manifestations occur, piperacillin and tazobactam for injection should be discontinued and appropriate therapy instituted.

The leukopenia/neutropenia associated with piperacillin and tazobactam for injection administration appears to be reversible and most frequently associated with prolonged administration.

Periodic assessment of hematopoietic function should be performed, especially with prolonged therapy, ie, ≥ 21 days [see *Adverse Reactions* (6.1)].

- 5.5 Central Nervous System Effects
- As with other penicillins, patients may experience neuromuscular excitability or convulsions if higher than recommended doses are given intravenously (particularly in the presence of renal failure).

- 5.6 Electrolyte Effects
- Piperacillin and tazobactam for injection contains a total of 2.35 mEq (54 mg) of Na⁺ per gram of piperacillin in the combination product. This should be considered when treating patients requiring restricted salt intake. Periodic electrolyte determinations should be performed in patients with low potassium reserves, and the possibility of hypokalemia should be kept in mind with patients who have potentially low potassium reserves and who are receiving cytotoxic therapy or diuretics.

- 5.7 Development of Drug-Resistant Bacteria
- Prescribing piperacillin and tazobactam for injection in the absence of a proven or strongly suspected bacterial infection is unlikely to provide benefit to the patient and increases the risk of development of drug-resistant bacteria.

- 6 ADVERSE REACTIONS

- 6.1 Clinical Trials Experience
- Because clinical trials are conducted under widely varying conditions, adverse reaction rates observed in the clinical trials of a drug cannot be directly compared to the rates in the clinical trials of another drug and may not reflect the rates observed in practice.

During the initial clinical investigations, 2621 patients worldwide were treated with piperacillin and tazobactam for injection in phase 3 trials. In the key North American monotherapy clinical trials (n=830 patients), 90% of the adverse events reported were mild to moderate in severity and transient in nature. However, in 3.2% of the patients treated worldwide, piperacillin and tazobactam for injection was discontinued because of adverse events primarily involving the skin (1.3%), including rash and pruritus; the gastrointestinal system (0.9%), including diarrhea, nausea, and vomiting; and allergic reactions (0.5%).

Table 3: Adverse Reactions from Piperacillin and Tazobactam for Injection Monotherapy Clinical Trials	
System Organ Class	Adverse Reaction
Gastrointestinal disorders	Diarrhea (11.3%)
	Constipation (7.7%)
	Nausea (6.9%)
	Vomiting (3.3%)
	Dyspepsia (3.3%)
	Abdominal pain (1.3%)
	Pseudomembranous colitis (≤1%)
General disorders and administration site conditions	
	Fever (2.4%)
	Injection site reaction (≤1%)
	Rigors (≤1%)
Immune system disorders	
	Anaphylaxis (≤1%)
Infections and infestations	
	Candidiasis (1.6%)
Metabolism and nutrition disorders	
	Hypoglycemia (≤1%)
Musculoskeletal and connective tissue disorders	
	Myalgia(≤1%)
	Arthralgia (≤1%)
Nervous system disorders	
	Headache (7.7%)
	Insomnia (6.6%)
Skin and subcutaneous tissue disorders	
	Rash (4.2%, including maculopapular, bullous, and urticarial)
	Pruritus (3.1%)
Vascular disorders	
	Phlebitis (1.3%)
	Thrombophlebitis (≤1%)
	Hypotension (≤1%)
	Purpura (≤1%)
	Epistaxis (≤1%)
	Flushing (≤1%)

Nosocomial Pneumonia Trials

Two trials of nosocomial lower respiratory tract infections were conducted. In one study, 222 patients were treated with piperacillin and tazobactam for injection in a dosing regimen of 4.5 g every 6 hours in combination with an aminoglycoside and 215 patients were treated with imipenem/clastatin (500 mg/500 mg q6h) in combination with an aminoglycoside. In this trial, treatment-emergent adverse events were reported by 402 patients, 204 (91.9%) in the piperacillin/tazobactam group and 198 (92.1%) in the imipenem/clastatin group. Twenty-five (11.0%) patients in the piperacillin/tazobactam group and 14 (6.5%) in the imipenem/clastatin group (p > 0.05) discontinued treatment due to an adverse event.

The second trial used a dosing regimen of 3.375 g given every 4 hours with an aminoglycoside.

Table 4: Adverse Reactions from Piperacillin and Tazobactam for Injection Plus Aminoglycoside Clinical Trials*	
System Organ Class	Adverse Reaction
Blood and lymphatic system disorders	
	Thrombocythemia (1.4%)
	Anemia (≤1%)
	Thrombocytopenia (≤1%)
	Eosinophilia (≤1%)
Gastrointestinal disorders	
	Diarrhea (20%)
	Constipation (8.4%)
	Nausea (5.8%)
	Vomiting (2.7%)
	Dyspepsia (1.9%)
	Abdominal pain (1.8%)
	Stomatitis (≤1%)
General disorders and administration site conditions	
	Fever (3.2%)
	Injection site reaction (≤1%)
Infections and infestations	
	Oral candidiasis (3.9%)
	Candidiasis (1.8%)
Investigations	
	BUN increased (1.8%)
	Blood creatinine increased (1.8%)
	Liver function test abnormal (1.4%)
	Alkaline phosphatase increased (≤1%)
	Aspartate aminotransferase increased (≤1%)
	Alanine aminotransferase increased (≤1%)
Metabolism and nutrition disorders	
	Hypoglycemia (≤1%)
	Hypokalemia (≤1%)
Nervous system disorders	
	Headache (4.5%)
	Insomnia (4.5%)
Renal and urinary disorders	
	Renal failure (≤1%)
Skin and subcutaneous tissue disorders	
	Rash (3.9%)
	Pruritus (3.2%)
Vascular disorders	
	Thrombophlebitis (1.3%)
	Hypotension (1.3%)

*For adverse drug reactions that appeared in both studies the higher frequency is presented.

Pediatrics

Studies of piperacillin and tazobactam for injection in pediatric patients suggest a similar safety profile to that seen in adults. In a prospective, randomized, comparative, open-label clinical trial of pediatric patients with severe intra-abdominal infections (including appendicitis and/or peritonitis), 273 patients were treated with piperacillin

In vitro inactivation:

Due to the *in vitro* inactivation of aminoglycosides by piperacillin, piperacillin and tazobactam for injection and aminoglycosides are recommended for separate administration. Piperacillin and tazobactam for injection and aminoglycosides should be reconstituted, diluted, and administered separately when concomitant therapy with aminoglycosides is indicated. Piperacillin and tazobactam for injection is compatible with amikacin and gentamicin for simultaneous Y-site infusion in certain diluents and at specific concentrations. Piperacillin and tazobactam for injection is not compatible with tobramycin for simultaneous Y-site infusion [see *Dosage and Administration* (2.6)].

7.2 Probenecid

Probenecid administered concomitantly with piperacillin and tazobactam prolongs the half-life of piperacillin by 21% and that of tazobactam by 71% because probenecid inhibits tubular renal secretion of both piperacillin and tazobactam. Probenecid should not be co-administered with piperacillin and tazobactam for injection unless the benefit outweighs the risk.

7.3 Anticoagulants

Coagulation parameters should be tested more frequently and monitored regularly during simultaneous administration of high doses of heparin, oral anticoagulants, or other drugs that may affect the blood coagulation system or the thrombocyte function [see *Warnings and Precautions* (5.4)].

7.4 Vecuronium

Piperacillin when used concomitantly with vecuronium has been implicated in the prolongation of the neuromuscular blockade of vecuronium. Piperacillin and tazobactam for injection could produce the same phenomenon if given along with vecuronium. Due to their similar mechanism of action, it is expected that the neuromuscular blockade produced by any of the non-depolarizing muscle relaxants could be prolonged in the presence of piperacillin. Monitor for adverse reactions related to neuromuscular blockade (See package insert for vecuronium bromide).

7.5 Methotrexate

Limited data suggests that co-administration of methotrexate and piperacillin may reduce the clearance of methotrexate due to competition for renal secretion. The impact of tazobactam on the elimination of methotrexate has not been evaluated. If concurrent therapy is necessary, serum concentrations of methotrexate as well as the signs and symptoms of methotrexate toxicity should be frequently monitored.

7.6 Effects on Laboratory Tests

There have been reports of positive test results using the Bio-Rad Laboratories Platelia *Aspergillus* EIA test in patients receiving piperacillin/tazobactam injection who were subsequently found to be free of *Aspergillus* infection. Cross-reactions with non-*Aspergillus* polysaccharides and polyfurans with the Bio-Rad Laboratories Platelia *Aspergillus* EIA test have been reported. Therefore, positive test results in patients receiving piperacillin/tazobactam should be interpreted cautiously and confirmed by other diagnostic methods.

As with other penicillins, the administration of piperacillin and tazobactam for injection may result in a false-positive reaction for glucose in the urine using a copper-reduction method (CLINITEST®). It is recommended that glucose tests based on enzymatic glucose oxidase reactions be used.

8 USE IN SPECIFIC POPULATIONS

8.1 Pregnancy

Teratogenic effects—Pregnancy Category B

Piperacillin/Tazobactam

Teratology studies have been performed in mice and rats and have revealed no evidence of harm to the fetus when piperacillin/tazobactam is administered intravenously up to a dose of 3000/750 mg/kg piperacillin/tazobactam which is 1 to 2 times and 2 to 3 times the human dose of piperacillin and tazobactam, respectively, based on body-surface area (mg/m²).

Piperacillin and tazobactam cross the placenta in humans. There are, however, no adequate and well-controlled studies with the piperacillin/tazobactam combination or with piperacillin or tazobactam alone in pregnant women. Because animal reproduction studies are not always predictive of the human response, this drug should be used during pregnancy only if clearly needed.

8.3 Nursing Mothers

Piperacillin is excreted in low concentrations in human milk; tazobactam concentrations in human milk have not been studied. Caution should be exercised when piperacillin and tazobactam for injection is administered to a nursing woman.

8.4 Pediatric Use

Use of piperacillin and tazobactam for injection in pediatric patients 2 months of age or older with appendicitis and/or peritonitis is supported by evidence from well-controlled studies and pharmacokinetic studies in adults and in pediatric patients. This includes a prospective, randomized, comparative, open-label clinical trial with 542 pediatric patients 2-12 years of age with complicated intra-abdominal infections, in which 273 pediatric patients received piperacillin/tazobactam. Safety and efficacy in pediatric patients less than 2 months of age have not been established [see *Clinical Pharmacology* (12) and *Dosage and Administration* (2)].

It has not been determined how to adjust piperacillin and tazobactam for injection dosage in pediatric patients with renal impairment.

8.5 Geriatric Use

Patients over 65 years are not at an increased risk of developing adverse effects solely because of age. However, dosage should be adjusted in the presence of renal impairment [see *Dosage and Administration* (2)].

In general, dose selection for an elderly patient should be cautious, usually starting at the low end of the dosing range, reflecting the greater frequency of decreased hepatic, renal, or cardiac function, and of concomitant disease or other drug therapy.

Piperacillin and tazobactam for injection contains 54 mg (2.35 mEq) of sodium per gram of piperacillin in the combination product. At the usual recommended doses, patients would receive between 648 and 864 mg/day (28.2 and 37.6 mEq) of sodium. The geriatric population may respond with a blunted natriuresis to salt loading. This may be clinically important with regard to such diseases as congestive heart failure.

This drug is known to be substantially excreted by the kidney, and the risk of toxic reactions to this drug may be greater in patients with impaired renal function. Because elderly patients are more likely to have decreased renal function, care should be taken in dose selection, and it may be useful to monitor renal function.

8.6 Renal Impairment

In patients with creatinine clearance ≤ 40 mL/min and dialysis patients (hemodialysis and CAPD), the intravenous dose of piperacillin and tazobactam for injection should be reduced to the degree of renal function impairment [see *Dosage and Administration* (2)].

8.7 Hepatic Impairment

Dosage adjustment of piperacillin and tazobactam for injection is not warranted in patients with hepatic cirrhosis [See *Clinical Pharmacology* (12.3)].

8.8 Patients with Cystic Fibrosis

As with other semisynthetic penicillins, piperacillin therapy has been associated with an increased incidence of fever and rash in cystic fibrosis patients.

10 OVERDOSAGE

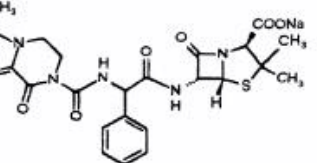
There have been postmarketing reports of overdose with piperacillin/tazobactam. The majority of those events experienced, including nausea, vomiting, and diarrhea, have also been reported with the usual recommended dosages. Patients may experience neuromuscular excitability or convulsions if higher than recommended doses are given intravenously (particularly in the presence of renal failure) [see *Warnings and Precautions* (5.5)].

Treatment should be supportive and symptomatic according to the patient's clinical presentation. Excessive serum concentrations of either piperacillin or tazobactam may be reduced by hemodialysis. Following a single 3.375 g dose of piperacillin/tazobactam, the percentage of the piperacillin and tazobactam dose removed by hemodialysis was approximately 31% and 39%, respectively [see *Clinical Pharmacology* (12)].

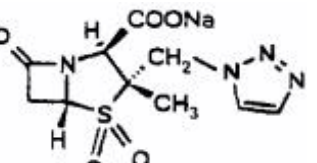
11 DESCRIPTION

Piperacillin and tazobactam for injection is an injectable antibacterial combination product consisting of the semisynthetic antibacterial piperacillin sodium and the β-lactamase inhibitor tazobactam sodium for intravenous administration.

Piperacillin sodium is derived from D(-)-α-aminobenzyln-penicillin. The chemical name of piperacillin sodium is sodium (2S,3S,5R)-6-[(R)-2-(4-ethyl-2,3-dioxo-1-piperazinecarboxamido)-2-phenylacetamido]-3,3-dimethyl-7-oxo-4-thia-1-azabicyclo[3.2.0]heptane-2-carboxylate. The chemical formula is C₂₄H₃₄N₄NaO₈S and the molecular weight is 539.5. The chemical structure of piperacillin sodium is:



Tazobactam sodium, a derivative of the penicillin nucleus, is a penicillanic acid sulfone. Its chemical name is sodium (2S,3S,5R)-3-methyl-7-oxo-3-(1H-1,2,3-triazol-1-ylmethyl)-4-thia-1-azabicyclo[3.2.0]heptane-2-carboxylate-4,4-dioxide. The chemical formula is C₁₄H₁₄N₄NaO₈S and the molecular weight is 322.3. The chemical structure of tazobactam sodium is:



Piperacillin and tazobactam for injection, piperacillin/tazobactam parenteral combination, is a white to off-white sterile, cryodesiccated powder consisting of piperacillin and tazobactam as their sodium salts packaged in glass vials. The product does not contain excipients or preservatives.

Each piperacillin and tazobactam for injection 2.25 g single dose vial contains an amount of drug sufficient for withdrawal of piperacillin sodium equivalent to 2 grams of piperacillin and tazobactam sodium equivalent to 0.25 g of tazobactam. Each vial contains 4.7 mEq (108 mg) of sodium.

Each piperacillin and tazobactam for injection 3.375 g single dose vial contains an amount of drug sufficient for withdrawal of piperacillin sodium equivalent to 3 grams of piperacillin and tazobactam sodium equivalent to 0.375 g of tazobactam. Each vial contains 7.0 mEq (162 mg) of sodium.

Each piperacillin and tazobactam for injection 4.5 g single dose vial contains an amount of drug sufficient for withdrawal of piperacillin sodium equivalent to 4 grams of piperacillin and tazobactam sodium equivalent to 0.5 g of tazobactam. Each vial contains 9.4 mEq (216 mg) of sodium.

Piperacillin and tazobactam for injection is a monosodium salt of piperacillin and a monosodium salt of tazobactam containing a total of 2.35 mEq (54 mg) of sodium (Na⁺) per gram of piperacillin in the combination product.

12 CLINICAL PHARMACOLOGY

12.1 Mechanism of Action

Piperacillin and tazobactam for injection is an antibacterial drug [see *Microbiology* (12.4)].

12.2 Pharmacodynamics

The pharmacodynamic parameter for piperacillin/tazobactam that is most predictive of clinical and microbiological efficacy is time above MIC.

12.3 Pharmacokinetics

The mean and coefficients of variation (CV%) for the pharmacokinetic parameters of piperacillin and tazobactam after multiple intravenous doses are summarized in Table 5.

Table 5: Mean (CV%) Piperacillin and Tazobactam PK Parameters Piperacillin							
Piperacillin							
Piperacillin/Tazobactam	C _{max}	AUC ₀	CL	V	T _{1/2}	CL _R	
Dose ^a	mcg/mL	mcg•h/mL	mL/min	L	h	mL/min	
2.25 g	134	131 (14)	257	17.4	0.79	-	
3.375 g	242	242 (10)	207	15.1	0.84	140	
4.5 g	298	322 (16)	210	15.4	0.84	-	

Tazobactam							
Piperacillin/Tazobactam	C _{max}	AUC ₀	CL	V	T _{1/2}	CL _R	
Dose ^a	mcg/mL	mcg•h/mL	mL/min	L	h	mL/min	
2.25 g	15	16.0 (21)	258	17.0	0.77	-	
3.375 g	24	25.0 (8)	251	14.8	0.68	166	
4.5 g	34	39.8 (15)	206	14.7	0.82	-	

^aPiperacillin and tazobactam were given in combination, infused over 30 minutes.

^bNumbers in parentheses are coefficients of variation (CV%).

Peak plasma concentrations of piperacillin and tazobactam are attained immediately after completion of an intravenous infusion of piperacillin and tazobactam for injection. Piperacillin plasma concentrations, following a 30-minute infusion of piperacillin and tazobactam for injection, were similar to those attained when equivalent doses of piperacillin were administered alone. Steady-state plasma concentrations of piperacillin and tazobactam were similar to those attained after the first dose due to the short half-lives of piperacillin and tazobactam.

Distribution Both piperacillin and tazobactam are approximately 30% bound to plasma proteins. The protein binding of either piperacillin or tazobactam is unaffected by the presence of the other compound. Protein binding of the tazobactam metabolite is negligible.

Piperacillin and tazobactam are widely distributed into tissues and body fluids including intestinal mucosa, gallbladder, lung, female reproductive tissues (uterus, ovary, and fallopian tube), interstitial fluid, and bile. Mean tissue concentrations are generally 50% to 100% of those in plasma. Distribution of piperacillin and tazobactam into cerebrospinal fluid is low in subjects with non-inflamed meninges, as with other penicillins (see Table 6).

Table 6: Piperacillin/Tazobactam Concentrations in Selected Tissues and Fluids after Single 4 g/0.5 g 30-min IV Infusion of Piperacillin and Tazobactam for Injection							
Tissue or Fluid	N ^a	Sampling period ^b (h)	Mean PIP Concentration Range (mg/L)	Tissue: Plasma Range	Tazo Concentration Range (mg/L)	Tazo Tissue: Plasma Range	
Skin	35	0.5 – 4.5	34.8 – 94.2	0.60 – 1.1	4.0 – 7.7	0.49 – 0.93	
Fatty Tissue	37	0.5 – 4.5	4.0 – 10.1	0.097 – 0.115	0.7 – 1.5	0.10 – 0.13	
Muscle	36	0.5 – 4.5	9.4 – 23.3	0.29 – 0.18	1.4 – 2.7	0.18 – 0.30	
Proximal Intestinal Mucosa	7	1.5 – 2.5	31.4	0.55	10.3	1.15	
Distal Intestinal Mucosa	7	1.5 – 2.5	31.2	0.59	14.5	2.1	
Appendix	22	0.5 – 2.5	26.5 – 64.1	0.43 – 0.53	9.1 – 18.6	0.80 – 1.35	

^a Each subject provided a single sample.

^b Time from the start of the infusion

Metabolism

Piperacillin is metabolized to a minor microbiologically active desethyl metabolite. Tazobactam is metabolized to a single metabolite that lacks pharmacological and antibacterial activities.

Excretion

Following single or multiple piperacillin and tazobactam for injection doses to healthy subjects, the plasma half-life of piperacillin and of tazobactam ranged from 0.7 to 1.2 hours and was unaffected by dose or duration of infusion.

Both piperacillin and tazobactam are eliminated via the kidney by glomerular filtration and tubular secretion. Piperacillin is excreted rapidly as unchanged drug with 68% of the administered dose excreted in the urine. Tazobactam and its metabolite are eliminated primarily by renal excretion with 80% of the administered dose excreted as unchanged drug and the remainder as the single metabolite. Piperacillin, tazobactam and desethyl piperacillin are also secreted into the bile.

Specific Populations

Renal impairment

After the administration of single doses of piperacillin/tazobactam to subjects with renal impairment, the half-life of piperacillin and of tazobactam increases with decreasing creatinine clearance. At creatinine clearance below 20 mL/min, the increase in half-life is twofold for piperacillin and fourfold for tazobactam compared to subjects with normal renal function. Dosage adjustments for piperacillin and tazobactam for injection are recommended when creatinine clearance is below 40 mL/min in patients receiving the usual recommended daily dose of piperacillin and tazobactam for injection. See *Dosage and Administration* (2) for specific recommendations for the treatment of patients with renal impairment.

Hemodialysis removes 30% to 40% of a piperacillin/tazobactam dose with an additional 5% of the tazobactam dose removed as the tazobactam metabolite. Peritoneal dialysis removes approximately 6% and 21% of the piperacillin and tazobactam doses, respectively, with up to 16% of the tazobactam dose removed as the tazobactam metabolite. For dosage recommendations for patients undergoing hemodialysis [see *Dosage and Administration* (2)].

Hepatic Impairment

The half-life of piperacillin and of tazobactam increases by approximately 25% and 18%, respectively, in patients with hepatic cirrhosis compared to healthy subjects. However, this difference does not warrant dosage adjustment of piperacillin and tazobactam for injection due to hepatic cirrhosis.

Pediatrics

Piperacillin and tazobactam pharmacokinetics were studied in pediatric patients 2 months of age and older. The clearance of both compounds is slower in the younger patients compared to older children and adults.

In a population PK analysis, estimated clearance for 9 month-old to 12 year-old patients was comparable to adults, with a population mean (SE) value of 5.64 (0.34) mL/min/kg. The piperacillin clearance estimate is 80% of this value for pediatric patients 2-9 months old. In patients younger than 2 months of age, clearance of piperacillin is slower compared to older children; however, it is not adequately characterized for dosing recommendations. The population mean (SE) for piperacillin distribution volume is 0.243 (0.011) L/kg and is independent of age.

Geriatrics

The impact of age on the pharmacokinetics of piperacillin and tazobactam was evaluated in healthy male subjects, aged 18-35 years (n=6) and aged 65 to 80 years (n=12). Mean half-life for piperacillin and tazobactam was 32% and 55% higher, respectively, in the elderly compared to the younger subjects. This difference may be due to age-related changes in creatinine clearance.

Race

The effect of race on piperacillin and tazobactam was evaluated in healthy male volunteers. No difference in piperacillin or tazobactam pharmacokinetics was observed between Asian (n=9) and Caucasian (n=9) healthy volunteers who received single 4/0.5 g doses.

Drug Interactions

The potential for pharmacokinetic drug interactions between piperacillin and tazobactam for injection and aminoglycosides, probenecid, vancomycin, heparin, vecuronium, and methotrexate has been evaluated [see *Drug Interactions* (7)].

12.4 Microbiology

Mechanism of Action

Piperacillin sodium exerts bactericidal activity by inhibiting septum formation and cell wall synthesis of susceptible bacteria. *In vitro*, piperacillin is active against a variety of Gram-positive and Gram-negative aerobic and anaerobic bacteria. Tazobactam sodium has little clinically relevant *in vitro* activity against bacteria due to its reduced affinity to penicillin-binding proteins. It is, however, a β-lactamase inhibitor of the Molecular class A enzymes, including Richmond-Sykes class II (Bush class 2b & 2b) penicillinases and cephalosporinases. It varies in its ability to inhibit class II and IV (2a & 4) penicillinases. Tazobactam does not induce chromosomally-mediated β-lactamases at tazobactam concentrations achieved with the recommended dosage regimen.

Spectrum of Activity

Piperacillin/tazobactam has been shown to be active against most isolates of the following microorganisms both *in vitro* and in clinical infections [see *Indications and Usage* (1)].

Gram-positive bacteria:

Staphylococcus aureus (methicillin susceptible isolates only)

Gram-negative bacteria:

Acinetobacter baumannii
Escherichia coli
Haemophilus influenzae (excluding β-lactamase negative, ampicillin-resistant isolates)
Klebsiella pneumoniae
Pseudomonas aeruginosa (given in combination with an aminoglycoside to which the isolate is susceptible)

Anaerobic bacteria:

Bacteroides fragilis group (*B. fragilis*, *B. ovatus*, *B. thetaiotaomicron*, and *B. vulgatus*)

The following *in vitro* data are available, **but their clinical significance is unknown.**

At least 90% of the following microorganisms exhibit an *in vitro* minimum inhibitory concentration (MIC) less than or equal to the susceptible breakpoint for piperacillin/tazobactam. However, the safety and effectiveness of piperacillin/tazobactam in treating clinical infections due to these bacteria have not been established in adequate and well-controlled clinical trials.

Gram-positive bacteria:

Enterococcus faecalis (ampicillin or penicillin-susceptible isolates only)
Staphylococcus epidermidis (methicillin susceptible isolates only)
Streptococcus agalactiae^a
Streptococcus pneumoniae^a (penicillin-susceptible isolates only)
Streptococcus pyogenes^a
Viridans group streptococci^a

Gram-negative bacteria:

Citrobacter koseri
Moraxella catarrhalis
Neisseria meningitidis
Neisseria gonorrhoeae
Proteus mirabilis
Proteus vulgaris
Serratia marcescens
Providencia stuartii
Providencia rettgeri
Salmonella enterica

Anaerobic bacteria:

Clostridium perfringens
Bacteroides distans
Prevotella melaninogenica

^aThese are not β-lactamase producing bacteria and, therefore, are susceptible to piperacillin alone.

Susceptibility Testing Methods

As is recommended with all antimicrobials, the results of *in vitro* susceptibility tests, when available, should be provided to the physician as periodic reports, which 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 procedure. Standardized procedures are based on a dilution method (broth or agar) or equivalent with standardized inoculum concentrations and standardized

concentrations of piperacillin and tazobactam powders.^{1,2} MIC values should be determined using serial dilutions of piperacillin combined with a fixed concentration of 4 mcg/mL tazobactam. The MIC values obtained should be interpreted according to criteria provided in Table 7.

Dilution Technique:

Quantitative methods that require measurement of zone diameters also provide reproducible estimates of the susceptibility of bacteria to antimicrobial compounds. The zone size provides an estimate of the susceptibility of bacteria to antimicrobial compounds. The zone size should be determined using a standardized test method^{1,3} and requires the use of standardized inoculum concentrations. This procedure uses paper disks impregnated with 100 mcg of piperacillin and 10 mcg of tazobactam to test the susceptibility of microorganisms to piperacillin/tazobactam. The disk diffusion interpreted criteria are provided in Table 7.

Anaerobic Techniques

For anaerobic bacteria, the susceptibility to piperacillin/tazobactam can be determined by the reference agar dilution method.⁴

Table 7: Susceptibility Interpretive Criteria for Piperacillin/Tazobactam							
Susceptibility Test Result Interpretive Criteria							
Pathogen	Minimal Inhibitory Concentration (MIC in mcg/mL)			Disk Diffusion (Zone Diameter in mm)			
	S	I	R	S	I	R	
<i>Enterobacteriaceae</i>	≤ 16	32 – 64	≥ 128	≥ 21	18 – 20	≤ 17	
<i>Acinetobacter baumannii</i>	≤ 16	32 – 64	≥ 128	≥ 21	18 – 20	≤ 17	
<i>Haemophilus influenzae</i> ^a	≤ 1	-	≥ 2	≥ 21	-	-	
<i>Pseudomonas aeruginosa</i>	≤ 16	32 – 64	≥ 128	≥ 21	15 – 20	≤ 14	
<i>Bacteroides fragilis</i> group	≤ 32	64	≥ 128	-	-	-	

^aThese interpretive criteria for *Haemophilus influenzae* are applicable only to tests performed using Haemophilus Test Medium inoculated with a direct colony suspension and incubated at 35°C in ambient air for 20 to 24 hours. Note: Susceptibility of staphylococci to piperacillin/tazobactam may be deduced from testing only penicillin and either cefoxitin or oxacillin.

A report of S (“Susceptible”) indicates that the pathogen is likely to be inhibited if the antimicrobial compound in the blood reaches the concentration at the infection site necessary to inhibit growth of the pathogen. A report of I (“Intermediate”) indicates that the results 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 major discrepancies in interpretation. A report of R (“Resistant”) indicates that the pathogen is not likely to be inhibited even if the antimicrobial compound in the blood reaches the concentration usually achievable at the infection site; other therapy should be considered.

Quality Control

Standardized susceptibility test procedures require the use of quality controls to monitor and ensure the accuracy and precision of supplies and reagents used in the assay, and the techniques of the individuals performing the test procedures.^{1,2,3,4} Standard piperacillin/tazobactam powder should provide the following ranges of values noted in Table 8. Quality control bacteria are specific strains of bacteria with intrinsic biological properties relating to resistance mechanisms and their genetic expression within the microorganism; the specific strains used for microbiological quality control are not clinically significant.