



Piperacillin and Tazobactam for Injection, USP

51744144

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, for intravenous use

Initial U.S. approval: 1993

RECENT MAJOR CHANGES

Indications and Usage (1)	5/2020
Dosage and Administration (2)	5/2020
Warnings and Precautions, Central Nervous System	
Adverse Reactions (5.4)	5/2020

INDICATIONS AND USAGE

Piperacillin and tazobactam for injection is a combination of piperacillin, a penicillin-class antibacterial and tazobactam, a beta-lactamase inhibitor, indicated for the treatment of:

- Intra-abdominal infections in adult and pediatric patients 2 months of age and older (1.1)
- Nosocomial pneumonia in adult and pediatric patients 2 months of age and older (1.2)
- Skin and skin structure infections in adults (1.3)
- Female pelvic infections in adults (1.4)
- Community-acquired pneumonia in adults (1.5)

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. (1.6)

DOSAGE AND ADMINISTRATION

- *Adult Patients With Indications Other Than Nosocomial Pneumonia:* The usual daily dosage of piperacillin and tazobactam for injection for adults is 3.375 g every six hours totaling 13.5 g (12 g piperacillin/1.5 g tazobactam). (2.1)
- *Adult Patients With 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 g (16 g piperacillin/2 g tazobactam). (2.2)
- *Adult Patients with Renal Impairment:* Dosage in patients with renal impairment (creatinine clearance \leq 40 mL/min) and dialysis patients should be reduced, based on the degree of renal impairment. (2.3)
- *Pediatric Patients by Indication and Age:* See Table below (2.4)

Age	Appendicitis and/or Peritonitis	Nosocomial Pneumonia
2 months to 9 months	90 mg/kg (80 mg piperacillin/10 mg tazobactam) every 8 (eight) hours	90 mg/kg (80 mg piperacillin/10 mg tazobactam) every 6 (six) hours
Older than 9 months	112.5 mg/kg (100 mg piperacillin/12.5 mg tazobactam) every 8 (eight) hours	112.5 mg/kg (100 mg piperacillin/12.5 mg tazobactam) every 6 (six) hours

- Administer piperacillin and tazobactam for injection by intravenous infusion over 30 minutes to both adult and pediatric patients (2.1, 2.2, 2.3, 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. (2.7)
- See the full prescribing information for the preparation and administration instructions for piperacillin and tazobactam for injection single-dose vials.

FULL PRESCRIBING INFORMATION: CONTENTS*

- 1 INDICATIONS AND USAGE
 - 1.1 Intra-abdominal Infections
 - 1.2 Nosocomial Pneumonia
 - 1.3 Skin and Skin Structure Infections
 - 1.4 Female Pelvic Infections
 - 1.5 Community-acquired Pneumonia
 - 1.6 Usage
- 2 DOSAGE AND ADMINISTRATION
 - 2.1 Dosage in Adult Patients With Indications Other Than Nosocomial Pneumonia
 - 2.2 Dosage in Adult Patients With Nosocomial Pneumonia
 - 2.3 Dosage in Adult Patients With Renal Impairment
 - 2.4 Dosage in Pediatric Patients With Appendicitis/Peritonitis or Nosocomial Pneumonia
 - 2.5 Reconstitution and Dilution of Powder Formulations
 - 2.7 Compatibility with Aminoglycosides
- 3 DOSAGE FORMS AND STRENGTHS
- 4 CONTRAINDICATIONS
- 5 WARNINGS AND PRECAUTIONS
 - 5.1 Hypersensitivity Adverse Reactions
 - 5.2 Severe Cutaneous Adverse Reactions
 - 5.3 Hematologic Adverse Reactions
 - 5.4 Central Nervous System Adverse Reactions
 - 5.5 Nephrotoxicity in Critically Ill Patients
 - 5.6 Electrolyte Effects
 - 5.7 *Clostridioides difficile*-Associated Diarrhea
 - 5.8 Development of Drug-Resistant Bacteria
- 6 ADVERSE REACTIONS
 - 6.1 Clinical Trials Experience
 - 6.2 Postmarketing Experience
 - 6.3 Additional Experience with Piperacillin

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 beta-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)
- Piperacillin and tazobactam for injection may cause severe cutaneous adverse reactions, such as Stevens-Johnson syndrome, toxic epidermal necrolysis, drug reaction with eosinophilia and systemic symptoms, and acute generalized exanthematous pustulosis. Discontinue piperacillin and tazobactam for injection for progressive rashes. (5.2)
- Hematologic effects (including bleeding, leukopenia and neutropenia) have occurred. Monitor hematologic tests during prolonged therapy. (5.3)
- As with other penicillins, piperacillin and tazobactam for injection may cause neuromuscular excitability or seizures. Patients receiving higher doses, especially in the presence of renal impairment may be at greater risk. Closely monitor patients with renal impairment or seizure disorders for signs and symptoms of neurologic excitability or seizures. (5.4)
- Nephrotoxicity in critically ill patients has been observed; the use of piperacillin and tazobactam for injection was found to be an independent risk factor for renal failure and was associated with delayed recovery of renal function as compared to other beta-lactam antibacterial drugs in a randomized, multicenter, controlled trial in critically ill patients. Based on this study, alternative treatment options should be considered in the critically ill population. If alternative treatment options are inadequate or unavailable, monitor renal function during treatment with piperacillin and tazobactam for injection. (5.5)
- *Clostridioides difficile*-associated diarrhea: evaluate patients if diarrhea occurs. (5.7)

ADVERSE REACTIONS

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

To report SUSPECTED ADVERSE REACTIONS, contact Fresenius Kabi USA, LLC at 1-800-551-7176 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)
- Co-administration of piperacillin and tazobactam for injection with vancomycin may increase the incidence of acute kidney injury. Monitor kidney function in patients receiving piperacillin and tazobactam for injection and vancomycin. (7.3)
- Monitor coagulation parameters in patients receiving piperacillin and tazobactam for injection. A reversal agent, prothrombin complex concentrate, should be available in case of bleeding. Monitor for adverse reactions related to neuromuscular blockade. (7.5)

USE IN SPECIFIC POPULATIONS

Dosage in patients with renal impairment (creatinine clearance \leq 40 mL/min) should be reduced based on the degree of renal impairment. (2.3, 8.6)

See 17 for PATIENT COUNSELING INFORMATION.

Revised: 8/2020

FULL PRESCRIBING INFORMATION

1 INDICATIONS AND USAGE

1.1 Intra-abdominal Infections

Piperacillin and tazobactam for injection is indicated in adults and pediatric patients (2 months of age and older) for the treatment of appendicitis (complicated by rupture or abscess) and peritonitis caused by beta-lactamase producing isolates of *Escherichia coli* or the following *enterococci*: *Bacteroides fragilis* group. *B. fragilis*, *B. ovatus*, *B. thetaiotaomicron*, or *B. vulgatus*.

1.2 Nosocomial Pneumonia

Piperacillin and tazobactam for injection is indicated in adults and pediatric patients (2 months of age and older) for the treatment of nosocomial pneumonia (moderate to severe) caused by beta-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 (2.1, 2.2)].

1.3 Skin and Skin Structure Infections

Piperacillin and tazobactam for injection is indicated in adults for the treatment of uncomplicated and complicated skin and skin structure infections, including cellulitis, cutaneous abscesses and ischemic/diabetic foot infections caused by beta-lactamase producing isolates of *Staphylococcus aureus*.

1.4 Female Pelvic Infections

Piperacillin and tazobactam for injection is indicated in adults for the treatment of postpartum endometritis or pelvic inflammatory disease caused by beta-lactamase producing isolates of *Escherichia coli*.

1.5 Community-acquired Pneumonia

Piperacillin and tazobactam for injection is indicated in adults for the treatment of community-acquired pneumonia (moderate severity only) caused by beta-lactamase producing isolates of *Haemophilus influenzae*.

1.6 Usage

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. 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

2.1 Dosage in Adult Patients With Indications Other Than Nosocomial Pneumonia

The usual total daily dosage of piperacillin and tazobactam for injection for adult patients with indications other than nosocomial pneumonia is 3.375 g every six hours [totaling 13.5 g (12 g piperacillin/1.5 g tazobactam)], to be administered by intravenous infusion over 30 minutes. The usual duration of piperacillin and tazobactam for injection treatment is from 7 to 10 days.

2.2 Dosage in Adult Patients With Nosocomial Pneumonia

Initial presumptive treatment of adult 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 g (16 g piperacillin/2 g tazobactam)], administered by intravenous infusion over 30 minutes. 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 Dosage in Adult Patients With Renal Impairment

In adult patients with renal impairment (creatinine clearance \leq 40 mL/min) and dialysis patients (hemodialysis and CAPD), the intravenous dose of piperacillin and tazobactam for injection should be reduced based on the degree of renal impairment. The recommended daily dosage of piperacillin and tazobactam for injection for patients with renal impairment administered by intravenous infusion over 30 minutes is described in Table 1.

Table 1: Recommended Dosage of Piperacillin and Tazobactam for Injection in Patients With Normal Renal Function and Renal Impairment (As total grams piperacillin/tazobactam)*			
Creatinine clearance, mL/min	All Indications (except nosocomial pneumonia)	Nosocomial Pneumonia	
Greater than 40 mL/min	3.375 every 6 hours	4.5 every 6 hours	
20 to 40 mL/min [†]	2.25 every 6 hours	3.375 every 6 hours	
Less than 20 mL/min**	2.25 every 8 hours	2.25 every 6 hours	
Hemodialysis**	2.25 every 12 hours	2.25 every 8 hours	
CAPD	2.25 every 12 hours	2.25 every 8 hours	
* Administer piperacillin and tazobactam for injection by intravenous infusion over 30 minutes.			
† 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 Dosage in Pediatric Patients With Appendicitis/Peritonitis or Nosocomial Pneumonia

The recommended dosage for pediatric patients with appendicitis and/or peritonitis or nosocomial pneumonia aged 2 months of age

and older, weighing up to 40 kg, and with normal renal function, is described in Table 2 [see *Use in Specific Populations* (8.4) and *Clinical Pharmacology* (12.3)].

Table 2: Recommended Dosage of Piperacillin and Tazobactam for Injection in Pediatric Patients 2 Months of Age and Older, Weighing Up to 40 kg, and With Normal Renal Function*			
Age	Appendicitis and/or Peritonitis	Nosocomial Pneumonia	
2 months to 9 months	90 mg/kg (80 mg piperacillin/10 mg tazobactam) every 8 (eight) hours	90 mg/kg (80 mg piperacillin/10 mg tazobactam) every 6 (six) hours	
Older than 9 months of age	112.5 mg/kg (100 mg piperacillin/12.5 mg tazobactam) every 8 (eight) hours	112.5 mg/kg (100 mg piperacillin/12.5 mg tazobactam) every 6 (six) hours	

* Administer piperacillin and tazobactam for injection by intravenous infusion over 30 minutes. Pediatric patients weighing over 40 kg and with normal renal function should receive the adult dose [see Dosage and Administration (2.1, 2.2)].

Dosage of piperacillin and tazobactam for injection in pediatric patients with renal impairment has not been determined.

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 injection

Dextrose 5%

Bacteriostatic saline/parabens

Bacteriostatic saline/benzyl alcohol

Bacteriostatic water/benzyl alcohol

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

Compatible Intravenous Solutions for Single Dose Vials

0.9% sodium chloride for injection

Sterile water for injection[†]

Dextran 6% in saline

Dextrose 5%

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

[†] Maximum 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.

Stability of Piperacillin and Tazobactam for Injection Powder Formulations Following Reconstitution

Piperacillin and tazobactam for injection reconstituted single dose 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 single dose 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 preprogrammed ambulatory intravenous infusion pump per the manufacturer's instruction. Stability of piperacillin and tazobactam for injection is not affected when administered using an ambulatory intravenous infusion pump.

2.7 Compatibility with Aminoglycosides

Due to the *in vitro* inactivation of aminoglycosides by piperacillin, piperacillin and tazobactam for injection and aminoglycosides are not 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 are compatible for

simultaneous co-administration via Y-site infusion only with the following aminoglycosides under the following conditions:

Table 3: Compatibility with Aminoglycosides

Aminoglycoside	Piperacillin and Tazobactam for Injection Dose (grams)	Piperacillin and Tazobactam for Injection Diluent Volume* (mL)	Aminoglycoside Concentration Range (mg/mL)	Acceptable Diluents
Amikacin	2.25	50	1.75 - 7.5	0.9% sodium chloride or 5% dextrose
	3.375	100		
	4.5	150		
Gentamicin	2.25	50	0.7 - 3.32	0.9% sodium chloride or 5% dextrose
	3.375	100		
	4.5	150		

^a Diluent volumes apply only to single dose vials.

^b The concentration ranges in Table 3 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 tobramycin or gentamicin in a single daily dose or in doses exceeding those stated above via Y-site with piperacillin and tazobactam for injection 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 co-administration 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 co-administration via Y-site infusion. Compatibility of piperacillin and tazobactam for injection 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, USP is supplied as a white to off-white powder in single dose vials in the following sizes:

Each piperacillin and tazobactam for injection, USP 2.25 g single dose 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, USP 3.375 g single dose 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, USP 4.5 g single dose 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 beta-lactamase inhibitors.

5 WARNINGS AND PRECAUTIONS

5.1 Hypersensitivity Adverse 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 Severe Cutaneous Adverse Reactions

Piperacillin and tazobactam for injection may cause severe cutaneous adverse reactions, such as Stevens-Johnson syndrome, toxic epidermal necrolysis, drug reaction with eosinophilia and systemic symptoms, and acute generalized exanthematous pustulosis. If patients develop a skin rash they should be monitored closely and piperacillin and tazobactam for injection discontinued if lesions progress.

5.3 Hematologic Adverse Reactions

Bleeding manifestations have occurred in some patients receiving beta-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, i.e., \geq 21 days [see Adverse Reactions (6.1)].

5.4 Central Nervous System Adverse Reactions

As with other penicillins, piperacillin and tazobactam may cause neuromuscular excitability or seizures. Patients receiving higher doses, especially patients with renal impairment may be at greater risk for central nervous system adverse reactions. Closely monitor patients with renal impairment or seizure disorders for signs and symptoms of neuromuscular excitability or seizures [see Adverse Reactions (6.2)].

5.5 Nephrotoxicity in Critically Ill Patients

The use of piperacillin and tazobactam for injection was found to be an independent risk factor for renal failure and was associated with delayed recovery of renal function compared to other beta-lactam antibacterial drugs in a randomized, multicenter, controlled trial in critically ill patients [see Adverse Reactions (6.1)].

Based on this study, alternative treatment options should be considered in the critically ill population. If alternative treatment options are inadequate or unavailable, monitor renal function during treatment with piperacillin and tazobactam for injection [see Dosage and Administration (2.3)].

Combined use of piperacillin/tazobactam and vancomycin may be associated with an increased incidence of acute kidney injury [see Drug Interactions (7.3)].

5.6 Electrolyte Effects

Piperacillin and tazobactam for injection contains a total of 2.35 mEq (54 mg) of Na⁺ (sodium) 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 Clostridioides difficile-Associated Diarrhea

Clostridioides difficile-associated diarrhea (CDAD) has been reported with use of nearly all antibiologic agents, including piperacillin and tazobactam for injection, and may range in severity from mild diarrhea to fatal colitis. Treatment with antibiologic 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 antibiologic drug use. Careful medical history is necessary since CDAD has been reported to occur over two months after the administration of antibiologic agents.

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

5.8 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 rates in the clinical trials of another drug and may not reflect the rates observed in practice.

Clinical Trials in Adult Patients

In a retrospective, cohort study, 140 pediatric patients 2 months to less than 18 years of age with nosocomial pneumonia were treated with piperacillin and tazobactam for injection and 287 patients were treated with comparators (which included ticarcillin-clavulanate, carapenems, ceftazidime, cefepime, or ciprofloxacin). The rates of serious adverse reactions were generally similar between the piperacillin and tazobactam for injection and comparator groups, including patients aged 2 months to 9 months treated with piperacillin and tazobactam for injection 90 mg/kg IV every 6 hours and patients older than 9 months and less than 18 years of age treated with piperacillin and tazobactam for injection 112.5 mg/kg IV every 6 hours.

6.2 Postmarketing Experience

In addition to the adverse drug reactions identified in clinical trials in Table 4 and Table 5, the following adverse reactions have been identified during post-approval use of piperacillin and tazobactam for injection. Because these reactions are reported voluntarily from a population of uncertain size, it is not always possible to reliably estimate their frequency or establish a causal relationship to drug exposure.

Hepatobiliary—hepatitis, jaundice
Hematologic—hemolytic anemia, agranulocytosis, pancytopenia
Immune—hypersensitivity reactions, anaphylactic/anaphylactoid reactions (including shock)
Renal—interstitial nephritis
Nervous system disorders—seizures
Psychiatric disorders—delirium
Respiratory—eosinophilic pneumonia
Skin and Appendages—erythema multiforme, Stevens-Johnson syndrome, toxic epidermal necrolysis, drug reaction with eosinophilia and systemic symptoms, (DRESS), acute generalized exanthematous pustulosis (AGEP), dermatitis exfoliative

Postmarketing experience with piperacillin and tazobactam for injection in pediatric patients suggests a similar safety profile to that seen in adults.

6.3 Additional Experience with Piperacillin

The following adverse reaction has also been reported for piperacillin for injection:

Skeletal—prolonged muscle relaxation [see *Drug Interactions* (7.5)].

7 DRUG INTERACTIONS

7.1 Aminoglycosides

Piperacillin may inactivate aminoglycosides by converting them to microbiologically inert amides.

In vivo inactivation.

When aminoglycosides are administered in conjunction with piperacillin to patients with end-stage renal disease requiring hemodialysis, the concentrations of the aminoglycosides (especially tobramycin) may be significantly reduced and should be monitored.

Sequential administration of piperacillin and tazobactam for injection and tobramycin to patients with either normal renal function or mild to moderate renal impairment has been shown to modestly decrease serum concentrations of tobramycin but no dosage adjustment is considered necessary.

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* (2.7)].

7.2 Probenecid

Probenecid administered concomitantly with piperacillin and tazobactam for injection 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 Vancomycin

Studies have detected an increased incidence of acute kidney injury in patients concomitantly administered piperacillin/tazobactam and vancomycin as compared to vancomycin alone [see *Warnings and Precautions* (5.5)].

Monitor kidney function in patients concomitantly administered with piperacillin/tazobactam and vancomycin.

No pharmacokinetic interactions have been noted between piperacillin/tazobactam and vancomycin.

7.4 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* (5.3)].

7.5 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).

7.6 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.

7.7 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 polyfuranoses 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 in the urine using a copper-reduction method (CLINTEST®). It is recommended that glucose tests based on enzymatic glucose oxidase reactions be used.

8 USE IN SPECIFIC POPULATIONS

8.1 Pregnancy

Risk Summary

Piperacillin and tazobactam cross the placenta in humans. However, there are insufficient data with piperacillin and/or tazobactam in pregnant women to inform a drug-associated risk for major birth defects and miscarriage. No fetal structural abnormalities were observed in rats or mice when piperacillin/tazobactam was administered intravenously during organogenesis in doses 1 to 2 times and 2 to 3 times the human dose of piperacillin and tazobactam, respectively, based on body-surface area (mg/m²). However, fetotoxicity in the presence of maternal toxicity was observed in developmental toxicity and peri/postnatal studies conducted in rats (intrapraperitoneal administration prior to mating and throughout gestation or from gestation day 17 through lactation day 21) at doses less than the maximum recommended human daily dose based on body-surface area (mg/m²) [see *Data*].

The background risk of major birth defects and miscarriage for the indicated population is unknown. In the U.S. general population, the estimated background risk of major birth defects and miscarriage in clinically recognized pregnancies is 2-4% and 15-20%, respectively.

Data

Animal Data

In embryo-fetal development studies in mice and rats, pregnant animals received intravenous doses of piperacillin/tazobactam up to 3,000/750 mg/kg/day during the period of organogenesis. There was no evidence of teratogenicity up to the highest dose evaluated, which is 1 to 2 times and 2 to 3 times the human dose of piperacillin and tazobactam, in mice and rats respectively, based on body-surface area (mg/m²). Fetal body weights were reduced in rats at maternally toxic doses at or above 500/62.5 mg/kg/day, minimally representing 0.4 times the human dose of both piperacillin and tazobactam based on body-surface area (mg/m²).

A fertility and general reproductive study in rats using intraperitoneal administration of tazobactam or the combination piperacillin/tazobactam prior to mating and through the end of gestation, reported a decrease in litter size in the presence of maternal toxicity at 640 mg/kg/day tazobactam (4 times the human dose of tazobactam based on body-surface area), and decreased litter size and an increase in fetuses with ossification delays and variations of ribs, concurrent with maternal toxicity at ≥ 640/160 mg/kg/day piperacillin/tazobactam (0.5 times and 1 times the human dose of piperacillin and tazobactam, respectively, based on body-surface area).

Peri/postnatal development in rats was impaired with reduced pup weights, increased stillbirths, and increased pup mortality concurrent with maternal toxicity after intraperitoneal administration of tazobactam alone at doses ≥ 320 mg/kg/day (2 times the human dose based on body surface area) or of the combination piperacillin/tazobactam at doses ≥ 640/160 mg/kg/day (0.5 times and 1 times the human dose of piperacillin and tazobactam, respectively, based on body-surface area) from gestation day 17 through lactation day 21.

8.2 Lactation

Risk Summary

Piperacillin is excreted in human milk; tazobactam concentrations in human milk have not been studied. No information is available on the effects of piperacillin and tazobactam on the breastfed child or on milk production. The developmental and health benefits of breastfeeding should be considered along with the mother's clinical need for piperacillin and tazobactam for injection and any potential adverse effects on the breastfed child from piperacillin and tazobactam for injection or from the underlying maternal condition.

8.4 Pediatric Use

The safety and effectiveness of piperacillin and tazobactam for injection for intra-abdominal infections, and nosocomial pneumonia have been established in pediatric patients 2 months of age and older.

Use of piperacillin and tazobactam for injection in pediatric patients 2 months of age and older with intra-abdominal infections including 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, controlled, active, open-label clinical trial with 542 pediatric patients 2 to 12 years of age with intra-abdominal infections (including appendicitis and/ or peritonitis), in which 273 pediatric patients received piperacillin/tazobactam [see *Adverse Reactions* (6.1) and *Clinical Pharmacology* (12.3)].

Use of piperacillin and tazobactam for injection in pediatric patients 2 months of age and older with nosocomial pneumonia is supported by evidence from well-controlled studies in adults with nosocomial pneumonia, a simulation study performed with a population pharmacokinetic model, and a retrospective, cohort study of pediatric patients with nosocomial pneumonia in which 140 pediatric patients were treated with piperacillin and tazobactam for injection and 267 patients treated with comparators (which included ticarcillin-clavulanate, carapenems, ceftazidime, cefepime, or ciprofloxacin) [see *Adverse Reactions* (6.1) and *Clinical Pharmacology* (12.3)].

The safety and effectiveness of piperacillin and tazobactam for injection have not been established in pediatric patients less than 2 months of age [see *Clinical Pharmacology* (12) and *Dosage and Administration* (2)].

Dosage of piperacillin and tazobactam for injection in pediatric patients with renal impairment has not been determined.

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

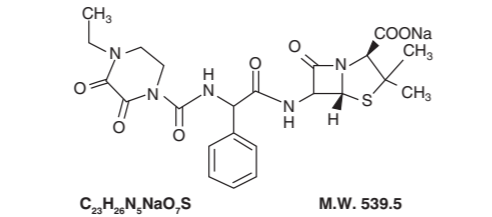
There have been postmarketing reports of overdose with piperacillin/tazobactam. The majority of these events experienced, including nausea, vomiting, and diarrhea, have also been reported with the usual recommended dosages. Patients may experience neuromuscular excitability or seizures if higher than recommended doses are given intravenously (particularly in the presence of renal failure) [see *Warnings and Precautions* (5.4)].

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

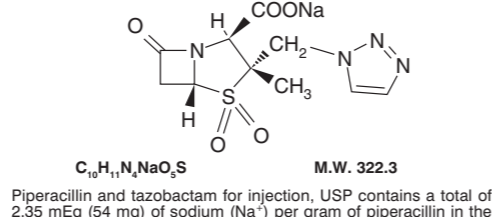
Piperacillin and tazobactam for injection, USP is an injectable antibacterial combination product consisting of the semisynthetic antibacterial piperacillin sodium and the beta-lactamase inhibitor tazobactam sodium for intravenous administration.

Piperacillin sodium is derived from D(-)-α-aminobenzyl-penicillin. The chemical name of piperacillin sodium is sodium (2S,5R,6R)-6-(1R)-2-(4-(ethyl-2,3-dioxo-1-piperazine-carboxamido)-2-phenylacetamido)-3,3-dimethyl-7-oxo-4-thia-1-azabicyclo[3.2.0]heptane-2-carboxylate. The structure of piperacillin sodium is:



M.W. 539.5

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 structure of tazobactam sodium is:



M.W. 322.3

Piperacillin and tazobactam for injection, USP contains a total of 2.35 mEq (54 mg) of sodium (Na⁺) per gram of piperacillin in the combination product.

Piperacillin and tazobactam for injection, USP is a white to off-white limited, 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 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 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.

Meets USP Organic Impurities, Procedure 1.

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 7.

Piperacillin/Tazobactam Dose*	Piperacillin					
	C _{max} (mcg/mL)	AUC ^b (mcg•h/mL)	CL (mL/min)	V (L)	T _{1/2} (h)	CL _R (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	--
Piperacillin/Tazobactam Dose*	Tazobactam					
	C _{max} (mcg/mL)	AUC ^b (mcg•h/mL)	CL (mL/min)	V (L)	T _{1/2} (h)	CL _R (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	--

* Piperacillin and tazobactam were given in combination, infused over 30 minutes.

^a Numbers in [] parentheses are coefficients of variation (CV%).
^b C_{max}=maximum observed concentration, AUC=Area under the curve, CL= clearance, CL_R= Renal clearance V=volume of distribution, T_{1/2}= elimination half-life

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 8).

Table 8: 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 (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 as well 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 volume distribution 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 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 beta-lactamase inhibitor of the Molecular class A enzymes, including Richmond-Sykes class III (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 beta-lactamases at tazobactam concentrations achieved with the recommended dosage regimen.

Antimicrobial 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)]:

Aerobic bacteria

Gram-positive bacteria
Staphylococcus aureus (methicillin susceptible isolates only)

Gram-negative bacteria

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

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