

HIGHLIGHTS OF PRESCRIBING INFORMATION

These highlights do not include all the information needed to use Meropenem for injection (I.V.) safely and effectively. See full prescribing information for Meropenem for injection (I.V.).

MEROPEM FOR INJECTION, USP (I.V.)

Initial U.S. Approval: 1996

-----RECENT MAJOR CHANGES

Indications and Usage, Intra-Abdominal Infections, Pediatric Patients (less than 3 months of age) (1.2) 12/2014
Dosage and Administration, Use in Pediatric Patients (less than 3 months of age) (2.3) 12/2014

-----INDICATIONS AND USAGE

Meropenem for injection (I.V.) is a penem antibacterial indicated as single agent therapy for the treatment of:

- Complicated skin and skin structure infections (adult patients and pediatric patients 3 months of age and older only). (1.1)
 - Complicated intra-abdominal infections (adult and pediatric patients). (1.2)
 - Bacterial meningitis (pediatric patients 3 months of age and older only). (1.3)
- To reduce the development of drug-resistant bacteria and maintain the effectiveness of Meropenem for injection (I.V.) and other antibacterial drugs, Meropenem for injection (I.V.) should only be used to treat or prevent infections that are proven or strongly suspected to be caused by susceptible bacteria.

-----DOSAGE AND ADMINISTRATION

- 500 mg every 8 hours by intravenous infusion over 15 to 30 minutes for skin and skin structure infections for adult patients. When treating infections caused by *Pseudomonas aeruginosa*, a dose of 1 gram every 8 hours is recommended. (2.1)
- 1 gram every 8 hours by intravenous infusion over 15 minutes to 30 minutes for intra-abdominal infections for adult patients. (2.1)
- 1 gram every 8 hours by intravenous bolus injection (5 mL to 20 mL) over 3 minutes to 5 minutes for adult patients. (2.1)
- Dosage should be reduced in adult patients with renal impairment. (2.2)

Recommended Meropenem for injection (I.V.) Dosage Schedule for Adult Patients with Renal Impairment		
Creatinine Clearance (mL/min)	Dose (dependent on type of infection)	Dosing Interval
Greater than 50	Recommended dose (500 mg cSSSI and 1 gram Intra-abdominal)	Every 8 hours
26 to 50	Recommended dose	Every 12 hours
10 to 25	One-half recommended dose	Every 12 hours
Less than 10	One-half recommended dose	Every 24 hours

- Pediatric patients 3 months of age and older

Recommended Meropenem for injection (I.V.) Dosage Schedule for Pediatric Patients 3 Months of Age and Older with Normal Renal Function (2.3)			
Type of Infection	Dose (mg/kg)	Up to a Maximum Dose	Dosing Interval
Complicated skin and skin structure*	10	500 mg	Every 8 hours
Intra-abdominal	20	1 gram	Every 8 hours
Meningitis	40	2 gram	Every 8 hours
<p>- Intravenous infusion is to be given over approximately 15 minutes to 30 minutes.</p> <p>- Intravenous bolus injection (5 mL to 20 mL) is to be given over approximately 3 minutes to 5 minutes.</p> <p>- There is no experience in pediatric patients with renal impairment.</p> <p>*20 mg/kg (or 1 gram for pediatric patients weighing over 50 kg) every 8 hours is recommended when treating complicated skin and skin structure infections caused by <i>P. aeruginosa</i> (2.3).</p>			

Pediatric patients less than 3 months of age

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FULL PRESCRIBING INFORMATION: CONTENTS*

- INDICATIONS AND USAGE**
 - Skin and Skin Structure Infections (Adult Patients and Pediatric Patients 3 Months of age and older only)
 - Intra-abdominal Infections (Adult and Pediatric Patients)
 - Bacterial Meningitis (Pediatric Patients 3 Months of age and older only)
- DOSAGE AND ADMINISTRATION**
 - Adult Patients
 - Use in Adult Patients with Renal Impairment
 - Use in Pediatric Patients
 - Preparation of Solution
 - Compatibility
 - Stability and Storage
- DOSAGE FORMS AND STRENGTHS**
- CONTRAINDICATIONS**
- WARNINGS AND PRECAUTIONS**
 - Hypersensitivity Reactions
 - Seizure Potential
 - Interaction with Valproic Acid
 - Clostridium difficile–associated Diarrhea
 - Development of Drug-Resistant Bacteria
 - Overgrowth of Nonsusceptible Organisms
 - Laboratory Tests
 - Patients with Renal Impairment
 - Dialysis
 - Potential for Neuromotor Impairment
- ADVERSE REACTIONS**
 - Adverse Reactions from Clinical Trials
 - Post-Marketing Experience

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FULL PRESCRIBING INFORMATION

1 INDICATIONS AND USAGE

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

Meropenem for injection, USP (I.V.) is useful as presumptive therapy in the indicated condition (e.g. intra-abdominal infections) prior to the identification of the causative organisms because of its broad spectrum of bacterial activity.
For information regarding use in pediatric patients see *Indications and Usage* (1.1), (1.2) or (1.3); *Dosage and Administration* (2.3), *Adverse Reactions* (6.1), and *Clinical Pharmacology* (12.3).

1.1 Skin and Skin Structure Infections (Adult Patients and Pediatric Patients 3 Months of age and older only)

Meropenem for injection, USP (I.V.) is indicated as a single agent therapy for the treatment of complicated skin and skin structure infections due to *Staphylococcus aureus* (methicillin-susceptible isolates only), *Streptococcus pyogenes*, *Streptococcus agalactiae*, viridans group streptococci, *Enterococcus faecalis* (vancomycin-susceptible isolates only), *Pseudomonas aeruginosa*, *Escherichia coli*, *Proteus mirabilis*, *Bacteroides fragilis*, and *Peptostreptococcus* species.

1.2 Intra-abdominal Infections (Adult and Pediatric Patients)

Meropenem for injection, USP (I.V.) is indicated as a single agent therapy for the treatment of complicated appendicitis and peritonitis caused by viridans group streptococci, *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Bacteroides fragilis*, *B. thetaiotaomicron*, and *Peptostreptococcus* species.

1.3 Bacterial Meningitis (Pediatric Patients 3 Months of age and older only)

Meropenem for injection, USP (I.V.) is indicated as a single agent therapy for the treatment of bacterial meningitis caused by *Streptococcus pneumoniae**, *Haemophilus influenzae*, and *Neisseria meningitidis*.

^[1] The efficacy of meropenem as monotherapy in the treatment of meningitis caused by penicillin nonsusceptible isolates of Streptococcus pneumoniae has not been established.

Recommended Meropenem for injection (I.V.) Dosage Schedule for Pediatric Patients Less than 3 Months of Age with Complicated Intra-Abdominal Infections and Normal Renal Function (2.3)		
Age Group	Dose (mg/kg)	Dose Interval
Infants less than 32 weeks GA and PNA less than 2 weeks	20	Every 12 hours
Infants less than 32 weeks GA and PNA 2 weeks and older	20	Every 8 hours
Infants 32 weeks and older GA and PNA less than 2 weeks	20	Every 8 hours
Infants 32 weeks and older GA and PNA 2 weeks and older	30	Every 8 hours
<p>- Intravenous infusion is to be given over 30 minutes.</p> <p>- There is no experience in pediatric patients with renal impairment.</p> <p>GA: gestational age and PNA: postnatal</p>		

-----DOSAGE FORMS AND STRENGTHS

500 mg Injection Vial (3)

1 g Injection Vial (3)

-----CONTRAINDICATIONS

- Known hypersensitivity to product components or anaphylactic reactions to β-lactams. (4)

-----WARNINGS AND PRECAUTIONS

- Serious and occasionally fatal hypersensitivity (anaphylactic) reactions have been reported in patients receiving β-lactams. (5.1)
- Seizures and other adverse CNS experiences have been reported during treatment. (5.2)
- Co-administration of Meropenem for injection (I.V.) with valproic acid or divalproex sodium reduces the serum concentration of valproic acid potentially increasing the risk of breakthrough seizures. (5.3, 7.2)
- Clostridium difficile*-associated diarrhea (ranging from mild diarrhea to fatal colitis) has been reported. Evaluate if diarrhea occurs. (5.4)
- In patients with renal dysfunction, thrombocytopenia has been observed. (5.8)

-----ADVERSE REACTIONS

Most common adverse reactions (2% or less) are: headache, nausea, constipation, diarrhea, anemia, vomiting, and rash (6.1)

To report SUSPECTED ADVERSE REACTIONS, contact Fresenius Kabi USA, LLC, Vigilance & Medical Affairs or FDA at 1-800-FDA-1088 or www.fda.gov/medwatch for voluntary reporting of adverse reactions.

-----DRUG INTERACTIONS

- Co-administration of Meropenem for injection (I.V.) with probenecid inhibits renal excretion of meropenem (7.1)
- Co-administration of Meropenem for injection (I.V.) with valproic acid or divalproex sodium reduces the serum concentration of valproic acid potentially increasing the risk of breakthrough seizures. (5.3, 7.2)

-----USE IN SPECIFIC POPULATIONS

- Renal Impairment: Dose adjustment is necessary, if creatinine clearance is 50 mL/min or less. (2.2, 8.6)

See 17 for PATIENT COUNSELING INFORMATION

Revised: June 2015

There is inadequate information regarding the use of Meropenem for injection (I.V.) in patients on hemodialysis or peritoneal dialysis.

2.3 Use in Pediatric Patients

Pediatric Patients 3 Months of Age and Older

For pediatric patients from 3 months of age and older, the Meropenem for injection (I.V.) dose is 10 mg/kg, 20 mg/kg or 40 mg/kg every 8 hours (maximum dose is 2 grams every 8 hours), depending on the type of infection (complicated skin and skin structure, intra-abdominal or meningitis). (See dosing table below.) Pediatric patients weighing over 50 kg should be administered Meropenem for injection (I.V.) at a dose of 500 mg every 8 hours for complicated skin and skin structure infections, 1 gram every 8 hours for intra-abdominal infections, and 2 grams every 8 hours for meningitis. Meropenem for injection (I.V.) should be given as intravenous infusion over approximately 15 minutes to 30 minutes or as an intravenous bolus injection (5 mL to 20 mL) over approximately 3 minutes to 5 minutes. There is limited safety data available to support the administration of a 40 mg/kg (up to a maximum of 2 grams) bolus dose.

Recommended Meropenem for injection (I.V.) Dosage Schedule for Pediatric Patients 3 Months of Age and Older With Normal Renal Function

Type of Infection	Dose (mg/kg)	Up to a Maximum Dose	Dosing Interval
Complicated skin and skin structure	10	500 mg	Every 8 hours
Intra-abdominal	20	1 gram	Every 8 hours
Meningitis	40	2 grams	Every 8 hours

There is no experience in pediatric patients with renal impairment.

When treating complicated skin and skin structure infections caused by *P. aeruginosa*, a dose of 20 mg/kg (or 1 gram for pediatric patients weighing over 50 kg) every 8 hours is recommended.

Pediatric Patients Less Than 3 Months of Age

For pediatric patients (with normal renal function) less than 3 months of age, with intra-abdominal infections, the Meropenem for injection (I.V.) dose is based on gestational age (GA) and postnatal age (PNA). (See dosing table below.) Meropenem for injection (I.V.) should be given as intravenous infusion over 30 minutes.

Recommended Meropenem for injection (I.V.) Dosage Schedule for Pediatric Patients Less than 3 Months of Age with Complicated Intra-Abdominal Infections and Normal Renal Function		
Age group	Dose (mg/kg)	Dose Interval
Infants less than 32 weeks GA and PNA less than 2 weeks	20	Every 12 hours
Infants less than 32 weeks GA and PNA 2 weeks and older	20	Every 8 hours
Infants 32 weeks and older GA and PNA less than 2 weeks	20	Every 8 hours
Infants 32 weeks and older GA and PNA 2 weeks and older	30	Every 8 hours

There is no experience in pediatric patients with renal impairment

2.4 Preparation of Solution

For Intravenous Bolus Administration

Constitute injection vials (500 mg and 1 gram) with sterile Water for Injection (see table below). Shake to dissolve and let stand until clear.

Vial size	Amount of Diluent Added (mL)	Approximate Withdrawable Volume (mL)	Approximate Average Concentration (mg/mL)
500 mg	10	10	50
1 gram	20	20	50

For Infusion

Infusion vials (500 mg and 1 gram) may be directly constituted with a compatible infusion fluid. Alternatively, an injection vial may be constituted, then the resulting solution added to an intravenous container and further diluted with an appropriate infusion fluid [see *Dosage and Administration* (2.5) and (2.6)].

WARNING: Do not use flexible container in series connections.

2.5 Compatibility

Compatibility of Meropenem with other drugs has not been established. Meropenem should not be mixed with or physically added to solutions containing other drugs.

2.6 Stability and Storage

Freshly prepared solutions of Meropenem should be used. However, constituted solutions of Meropenem maintain satisfactory potency under the conditions described below. Solutions of intravenous Meropenem should not be frozen.

Intravenous Bolus Administration

Meropenem injection vials constituted with sterile Water for Injection for bolus administration (up to 50 mg/mL of Meropenem) may be stored for up to 3 hours at up to 25°C (77°F) or for 13 hours at up to 5°C (41°F).

Intravenous Infusion Administration

Solutions prepared for infusion (Meropenem concentrations ranging from 1 mg/mL to 20 mg/mL) constituted with Sodium Chloride Injection 0.9% may be stored for 1 hour at up to 25°C (77°F) or 15 hours at up to 5°C (41°F).

Solutions prepared for infusion (Meropenem concentrations ranging from 1 mg/mL to 20 mg/mL) constituted with Dextrose Injection 5% should be used immediately.

NOTE: 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

Single use clear glass vials containing 500 mg or 1 gram (as the trihydrate blend with anhydrous sodium carbonate for constitution) of sterile meropenem powder.

4 CONTRAINDICATIONS

Meropenem for injection (I.V.) is contraindicated in patients with known hypersensitivity to any component of this product or to other drugs in the same class or in patients who have demonstrated anaphylactic reactions to β-lactams.

5 WARNINGS AND PRECAUTIONS

5.1 Hypersensitivity Reactions

Serious and occasionally fatal hypersensitivity (anaphylactic) reactions have been reported in patients receiving therapy with β-lactams. These reactions are more likely to occur in individuals with a history of sensitivity to multiple allergens. There have been reports of individuals with a history of penicillin hypersensitivity who have experienced severe hypersensitivity reactions when treated with another β-lactam. Before initiating therapy with Meropenem for injection (I.V.), it is important to inquire about previous hypersensitivity reactions to penicillins, cephalosporins, other β-lactams, and other allergens. If an allergic reaction to Meropenem for injection (I.V.) occurs, discontinue the drug immediately. Serious anaphylactic reactions require immediate emergency treatment with epinephrine, oxygen, intravenous steroids, and airway management, including intubation. Other therapy may also be administered as indicated.

5.2 Seizure Potential

Seizures and other adverse CNS experiences have been reported during treatment with Meropenem for injection (I.V.). These experiences have occurred most commonly in patients with CNS disorders (e.g., brain lesions or history of seizures) or with bacterial meningitis and/or convulsions [see *Adverse Reactions* (6.1) and *Drug Interactions* (7.2)]. During clinical investigations, 2,904 immunocompetent adult patients were treated for non-CNS infections with the overall seizure rate being 0.7% (based on 20 patients with this adverse event). All meropenem-treated patients with seizures had pre-existing contributing factors. Among these are included prior history of seizures or CNS abnormality and concomitant medications with seizure potential. Dosage adjustment is recommended in patients with advanced age and/or reduced renal function. [see *Dosage and Administration* (2.2)]

Close adherence to the recommended dosage regimens is urged, especially in patients with known factors that predispose to convulsive activity. Continue anti-convulsant therapy in patients with known seizure disorders. If focal tremors, myoclonus, or seizures occur, evaluate neurologically, placed on anti-convulsant therapy if not already instituted, and the dosage of Meropenem for injection (I.V.) re-examined to determine whether it should be decreased or the antibacterial drug discontinued.

5.3 Interaction with Valproic Acid

Case reports in the literature have shown that co-administration of carbapenems, including meropenem, to patients receiving valproic acid or divalproex sodium results in a reduction in valproic acid concentrations. The valproic acid concentrations may drop below the therapeutic range as a result of this interaction, therefore increasing the risk of breakthrough seizures. Increasing the dose of valproic acid or divalproex sodium may not be sufficient to overcome this interaction. The concomitant use of meropenem and valproic acid or divalproex sodium is generally not recommended. Antibacterials other than carbapenems should be considered to treat infections in patients whose seizures are well controlled on valproic acid or divalproex sodium. If administration of Meropenem for injection (I.V.) is necessary, supplemental anti-convulsant therapy should be considered [see *Drug Interactions* (7.2)].

5.4 Clostridium difficile–associated Diarrhea

Clostridium difficile-associated diarrhea (CDAD) has been reported with use of nearly all antibacterial agents, including Meropenem for injection (I.V.), 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 isolates 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 not directed against *C. difficile* may need to be discontinued. Appropriate fluid and electrolyte management, protein supplementation, antibacterial drug treatment of *C. difficile*, and surgical evaluation should be instituted as clinically indicated.

5.5 Development of Drug-Resistant Bacteria

Prescribing Meropenem for injection (I.V.) in the absence of a proven or strongly suspected bacterial infection or a prophylactic indication is unlikely to provide benefit to the patient and increases the risk of the development of drug-resistant bacteria.

5.6 Overgrowth of Nonsusceptible Organisms

As with other broad-spectrum antibacterial drugs, prolonged use of meropenem may result in overgrowth of nonsusceptible organisms. Repeated evaluation of the patient is essential. If superinfection does occur during therapy, appropriate measures should be taken.

5.7 Laboratory Tests

While Meropenem for injection (I.V.) possesses the characteristic low toxicity of the beta-lactam group of antibacterial drugs, periodic assessment of organ system functions, including renal, hepatic, and hematopoietic, is advisable during prolonged therapy.

5.8 Patients with Renal Impairment

In patients with renal impairment, thrombocytopenia has been observed but no clinical bleeding reported [see *Dosage and Administration* (2.2), *Adverse Reactions* (6.1), *Use In Specific Populations* (8.5) and (8.6), and *Clinical Pharmacology* (12.3)].

5.9 Dialysis

There is inadequate information regarding the use of Meropenem for injection (I.V.) in patients on hemodialysis or peritoneal dialysis.

5.10 Potential for Neuromotor Impairment

Patients receiving Meropenem for injection (I.V.) on an outpatient basis may develop adverse events such as seizures, headaches and/or paresthesias that could interfere with mental alertness and/or cause motor impairment. Until it is reasonably well established that Meropenem for injection (I.V.) is well tolerated, patients should not operate machinery or motorized vehicles [see *Adverse Reactions* (6.1)].

6 ADVERSE REACTIONS

The following are discussed in greater detail in other sections of labeling:

- Hypersensitivity Reactions [see *Warnings and Precautions* (5.1)]
- Seizure Potential [see *Warnings and Precautions* (5.2)]
- Interaction with Valproic Acid [see *Warnings and Precautions* (5.3)]
- Clostridium difficile* – associated Diarrhea [see *Warnings and Precautions* (5.4)]
- Development of Drug-Resistant Bacteria [see *Warnings and Precautions* (5.5)]
- Overgrowth of Nonsusceptible Organisms [see *Warnings and Precautions* (5.6)]
- Laboratory Tests [see *Warnings and Precautions* (5.7)]
- Patients with Renal Impairment [see *Warnings and Precautions* (5.8)]
- Dialysis [see *Warnings and Precautions* (5.9)]
- Potential for Neuromotor Impairment [see *Warnings and Precautions* (5.10)]

6.1 Adverse Reactions from Clinical Trials

Because clinical trials are conducted under widely varying conditions, adverse reactions 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.

Adult Patients:

During clinical investigations, 2,904 immunocompetent adult patients were treated for non-CNS infections with Meropenem for injection (I.V.) (500 mg or 1 gram every 8 hours). Deaths in 5 patients were assessed as possibly related to meropenem; 36 (1.2%) patients had meropenem discontinued because of adverse events. Many patients in these trials were severely ill and had multiple background diseases, physiological impairments and were receiving multiple other drug therapies. In the seriously ill patient population, it was not possible to determine the relationship between observed adverse events and therapy with Meropenem for injection (I.V.). The following adverse reaction frequencies were derived from the clinical trials in the 2904 patients treated with Meropenem for injection (I.V.)

Local Adverse Reactions

Local adverse reactions that were reported irrespective of the relationship to therapy with Meropenem for injection (I.V.) were as follows:

Inflammation at the injection site	2.4%
Injection site reaction	0.9%
Phlebitis/thrombophlebitis	0.8%
Pain at the injection site	0.4%
Edema at the injection site	0.2%

Systemic Adverse Reactions

Systemic adverse reactions that were reported irrespective of the relationship to Meropenem for injection (I.V.) occurring in greater than 1% of the patients were diarrhea (4.8%), nausea/vomiting (3.6%), headache (2.3%), rash (1.9%), sepsis (1.6%), constipation (1.4%), apnea (1.3%), shock (1.2%), and pruritus (1.2%).

Additional systemic adverse reactions that were reported irrespective of relationship to therapy with Meropenem for injection (I.V.) and occurring in less than or equal to 1% but greater than 0.1% of the patients are listed below within each body system in order of decreasing frequency:

Bleeding events were seen as follows: gastrointestinal hemorrhage (0.5%), melena (0.3%), epistaxis (0.2%), hemoperitoneum (0.2%), summing to 1.2%.

Body as a Whole: pain, abdominal pain, chest pain, fever, back pain, abdominal enlargement, chills, pelvic pain

Cardiovascular: heart failure, heart arrest, tachycardia, hypertension, myocardial infarction, pulmonary embolus, bradycardia, hypotension, syncope

Digestive System: oral moniliasis, anorexia, cholestatic jaundice/jaundice, flatulence, ileus, hepatic failure, dyspepsia, intestinal obstruction

Hemic/Lymphatic: anemia, hypochromic anemia, hypervolemia

Metabolic/Nutritional: peripheral edema, hypoxia

Nervous System: insomnia, agitation/delirium, confusion, dizziness, seizure, nervousness, paresthesia, hallucinations, somnolence, anxiety, depression, asthenia [see *Warnings and Precautions* (5.2) and (5.10)]

Respiratory: respiratory disorder, dyspnea, pleural effusion, asthma, cough increased, lung edema

Skin and Appendages: urticaria, sweating, skin ulcer

Urogenital System: dysuria, kidney failure, vaginal moniliasis, urinary incontinence

Adverse Laboratory Changes

Adverse laboratory changes that were reported irrespective of relationship to Meropenem for injection (I.V.) and occurring in greater than 0.2% of the patients were as follows:

Hepatic: increased SGPT (ALT), SGOT (AST), alkaline phosphatase, LDH, and bilirubin

Hematology: increased platelets, increased eosinophils, decreased platelets, decreased hemoglobin, decreased hematocrit, decreased WBC, shortened prothrombin time and shortened partial thromboplastin time, leukocytosis, hypokalemia

Indications and Usage (1.3), *Dosage and Administration* (2.3), *Adverse Reactions* (6.1), *Clinical Pharmacology* (12.3) and *Clinical Studies* (14.1)].

Intra-abdominal Infections

Use of Meropenem for injection (I.V.) in pediatric patients 3 months of age and older with intra-abdominal infections is supported by evidence from adequate and well-controlled studies in adults with additional data from pediatric pharmacokinetics studies and controlled clinical trials in pediatric patients. Use of Meropenem for injection (I.V.) in pediatric patients less than 3 months of age with intra-abdominal infections is supported by evidence from adequate and well-controlled studies in adults with additional data from a pediatric pharmacokinetic and safety study [see *Indications and Usage* (1.2), *Dosage and Administration* (2.3), *Adverse Reactions* (6.1), *Clinical Pharmacology* (12.3) and *Clinical Studies* (14.2)].

Bacterial Meningitis

Use of Meropenem for injection (I.V.) in pediatric patients 3 months of age and older with bacterial meningitis is supported by evidence from adequate and well-controlled studies in the pediatric population [see *Indications and Usage* (1.3), *Dosage and Administration* (2.3), *Adverse Reactions* (6.1), *Clinical Pharmacology* (12.3) and *Clinical Studies* (14.3)].

8.5 Geriatric Use

Of the total number of subjects in clinical studies of Meropenem for injection (I.V.), approximately 1,100 (30%) were 65 years of age and older, while 400 (11%) were 75 years and older. Additionally, in a study of 511 patients with complicated skin and skin structure infections, 93 (18%) were 65 years of age and older, while 36 (7%) were 75 years and older. No overall differences in safety or effectiveness were observed between these subjects and younger subjects; spontaneous reports and other reported clinical experience have not identified differences in responses between the elderly and younger patients, but greater sensitivity of some older individuals cannot be ruled out.

Meropenem is known to be substantially excreted by the kidney, and the risk of adverse reactions to this drug may be greater in patients with renal impairment. 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.

A pharmacokinetic study with Meropenem for injection (I.V) in elderly patients has shown a reduction in the plasma clearance of meropenem that correlates with age-associated reduction in creatinine clearance [see *Clinical Pharmacology* (12.3)].

8.6 Patients with Renal Impairment

Dosage adjustment is necessary in patients with creatinine clearance 50 mL/min or less [see *Dosage and Administration* (2.2), *Warnings and Precautions* (5.8), and *Clinical Pharmacology* (12.3)].

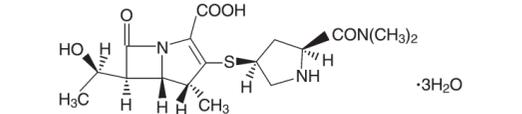
10 OVERDOSAGE

In mice and rats, large intravenous doses of meropenem (2,200 mg/kg to 4,000 mg/kg) have been associated with ataxia, dyspnea, convulsions, and mortalities. Intentional overdosing of Meropenem for injection (I.V.) is unlikely, although accidental overdosing might occur if large doses are given to patients with reduced renal function. The largest dose of meropenem administered in clinical trials has been 2 grams given intravenously every 8 hours. At this dosage, no adverse pharmacological effects or increased safety risks have been observed.

Limited post-marketing experience indicates that if adverse events occur following overdosage, they are consistent with the adverse event profile described in the Adverse Reactions section and are generally mild in severity and resolve on withdrawal or dose reduction. Consider symptomatic treatments. In individuals with normal renal function, rapid renal elimination takes place. Meropenem and its metabolite are readily dialyzable and effectively removed by hemodialysis; however, no information is available on the use of hemodialysis to treat overdosage.

11 DESCRIPTION

Meropenem for injection, USP (I.V.) is a sterile, pyrogen-free, synthetic, broad-spectrum, carbapenem antibacterial for intravenous administration. It is (4R,5S,6S)-2-[[[(3S,5S)-5-(Dimethylcarbamoyl)-3-pyrrolidinyl]thio]-6-[[[(1R)-1-hydroxyethyl]-4-methyl-7-oxo-1-azabicyclo[3.2.0]hept-2-ene-2-carboxylic acid trihydrate. Its empirical formula is C₁₇H₂₀N₂O₅S•3H₂O with a molecular weight of 437.52. Its structural formula is:



Meropenem for injection, USP (I.V.) is a white to pale yellow crystalline powder. The solution varies from colorless to yellow depending on the concentration. The pH of freshly constituted solutions is between 7.3 and 8.3. Meropenem is soluble in 5% monobasic potassium phosphate solution, sparingly soluble in water, very slightly soluble in hydrated ethanol, and practically insoluble in acetone or ether.

When constituted as instructed, each 500 mg Meropenem for injection, USP (I.V.) vial will deliver 500 mg meropenem and 45.1 mg of sodium as sodium carbonate (1.96 mEq). Each 1 gram Meropenem for injection, USP (I.V.) vial will deliver 1 gram of meropenem and 90.2 mg of sodium as sodium carbonate (3.92 mEq). [see *Dosage and Administration* (2.4)].

12 CLINICAL PHARMACOLOGY

12.1 Mechanism of Action

Meropenem is an antibacterial drug [see *Clinical Pharmacology* (12.4)].

12.3 Pharmacokinetics

Plasma Concentrations

At the end of a 30-minute intravenous infusion of a single dose of Meropenem for injection (I.V.) in healthy volunteers, mean peak plasma concentrations of meropenem are approximately 23 mcg/mL (range 14 to 26) for the 500 mg dose and 49 mcg/mL (range 39 to 58) for the 1 gram dose. A 5-minute intravenous bolus injection of Meropenem for injection (I.V.) in healthy volunteers results in mean peak plasma concentrations of approximately 45 mcg/mL (range 18 to 65) for the 500 mg dose and 112 mcg/mL (range 83 to 140) for the 1 gram dose.

Following intravenous doses of 500 mg, mean plasma concentrations of meropenem usually decline to approximately 1 mcg/mL at 6 hours after administration.

No accumulation of meropenem in plasma was observed with regimens using 500 mg administered every 8 hours or 1 gram administered every 6 hours in healthy volunteers with normal renal function.

Distribution

The plasma protein binding of meropenem is approximately 2%.

Meropenem penetrates well into most body fluids and tissues including cerebrospinal fluid, achieving concentrations matching or exceeding those required to inhibit most susceptible bacteria. After a single intravenous dose of meropenem for injection (I.V.), the highest mean concentrations of meropenem were found in tissues and fluids at 1 hour (0.5 hours to 1.5 hours) after the start of infusion, except where indicated in the tissues and fluids listed in the table below.

Table 1. Meropenem Concentrations in Selected Tissues (Highest Concentrations Reported)

Tissue	Intravenous Dose (gram)	Number of Samples	Mean [mcg/mL or mcg/(gram)] ^a	Range [mcg/mL or mcg/(gram)]
Endometrium	0.5	7	4.2	1.7 to 10.2
Myometrium	0.5	15	3.8	0.4 to 8.1
Ovary	0.5	8	2.8	0.8 to 4.8
Cervix	0.5	2	7	5.4 to 8.5
Fallopian tube	0.5	9	1.7	0.3 to 3.4
Skin	0.5	22	3.3	0.5 to 12.6
Interstitial fluid ^b	0.5	9	5.5	3.2 to 8.6
Skin	1	10	5.3	1.3 to 16.7
Interstitial fluid ^b	1	5	26.3	20.9 to 37.4
Colon	1	2	2.6	2.5 to 2.7
Bile	1	7	14.6 (3 hours)	4 to 25.7
Gall bladder	1	1	-	3.9
Peritoneal fluid	1	9	30.2	7.4 to 54.6
Lung	1	2	4.8 (2 hours)	1.4 to 8.2
Bronchial mucosa	1	7	4.5	1.3 to 11.1
Muscle	1	2	6.1 (2 hours)	5.3 to 6.9
Fascia	1	9	8.8	1.5 to 20
Heart valves	1	7	9.7	6.4 to 12.1
Myocardium	1	10	15.5	5.2 to 25.5
CSF (inflamed)	20 mg/kg ^d or 40 mg/kg ^d	8	1.1 (2 hours) or 3.3 (3 hours)	0.2 to 2.8 or 0.9 to 6.5
CSF (uninflamed)	1	4	0.2 (2 hours)	0.1 to 0.3

^a at 1 hour unless otherwise noted

^b obtained from blister fluid

^c in pediatric patients of age 5 months to 8 years

^d in pediatric patients of age 1 month to 15 years

Metabolism

There is one metabolite of meropenem that is microbiologically inactive.

Excretion

In subjects with normal renal function, the elimination half-life of meropenem is approximately 1 hour.

Meropenem is primarily excreted unchanged by the kidneys. Approximately 70% (50% to 75%) of the dose is excreted unchanged within 12 hours. A further 28% is recovered as the microbiologically inactive metabolite. Fecal elimination represents only approximately 2% of the dose. The measured renal clearance and the effect of probenecid show that meropenem undergoes both filtration and tubular secretion.

Urinary concentrations of meropenem in excess of 10 mcg/mL are maintained for up to 5 hours after a 500 mg dose.

Specific Populations

Renal Impairment

Pharmacokinetic studies with Meropenem for injection (I.V.) in patients with renal impairment have shown that the plasma clearance of meropenem correlates with creatinine clearance. Dosage adjustments are necessary in subjects with renal impairment (creatinine clearance 50 mL/min or less) [see *Dosage and Administration* (2.2) and *Use In Specific Populations* (8.6)]. Meropenem I.V. is hemodialyzable. However, there is no information on the usefulness of hemodialysis to treat overdosage [see *Overdosage* (10)].

Hepatic Impairment

A pharmacologic study with Meropenem for injection (I.V.) in patients with hepatic impairment has shown no effects of liver disease on the pharmacokinetics of meropenem.

Geriatric Patients

A pharmacokinetic study with Meropenem for injection (I.V.) in elderly patients with renal impairment showed a reduction in plasma clearance of meropenem that correlates with age-associated reduction in creatinine clearance.

Pediatric Patients

The pharmacokinetics of meropenem for injection I.V., in pediatric patients 2 years of age or older, are similar to those in adults. The elimination half-life for meropenem was approximately 1.5 hours in pediatric patients of age 3 months to 2 years.

The pharmacokinetics of meropenem in patients less than 3 months of age receiving combination antibacterial drug therapy are given below.

Table 2 Meropenem Pharmacokinetic Parameters in Patients Less Than 3 Months of Age^a

	GA less than 32 weeks PNA less than 2 weeks (20 mg/kg every 12 hours)	GA less than 32 weeks or older (20 mg/kg every 8 hours)	GA 32 weeks or older PNA less than 2 weeks (20 mg/kg every 8 hours)	GA 32 weeks or older PNA 2 weeks or older (30 mg/kg every 8 hours)	Overall
CL (L/h/kg)	0.089	0.122	0.135	0.202	0.119
V (L/kg)	0.489	0.467	0.463	0.451	0.468
AUC₀₋₂₄ (mcg·h/mL)	448	491	445	444	467
C_{min} (mcg/mL)	44.3	46.5	44.9	61	46.9
C_{min} (mcg/mL)	5.36	6.65	4.84	2.1	5.65
T_{1/2} (h)	3.82	2.68	2.33	1.58	2.68

^a Values are derived from a population pharmacokinetic analysis of sparse data

Drug Interactions

Probenecid competes with meropenem for active tubular secretion and thus inhibits the renal excretion of meropenem. Following administration of probenecid with meropenem, the mean systemic exposure increased 56% and the mean elimination half-life increased 38%. Co-administration of probenecid with meropenem is not recommended.

12.4 Microbiology

Mechanism of Action

The bactericidal activity of meropenem results from the inhibition of cell wall synthesis. Meropenem readily penetrates the cell wall of most Gram-positive and Gram-negative bacteria to reach penicillin-binding-protein (PBP) targets. Its strongest affinities are toward PBPs 2, 3 and 4 of *Escherichia coli* and *Pseudomonas aeruginosa*, and PBPs 1, 2 and 4 of *Staphylococcus aureus*. Bactericidal concentrations (defined as a 3 log₁₀ reduction in cell counts within 12 hours to 24 hours) are typically 1-2 times the bacteriostatic concentrations of meropenem, with the exception of *Listeria monocytogenes*, against which lethal activity is not observed. Meropenem has significant stability to hydrolysis by β-lactamases, both penicillinases and cephalosporinases produced by Gram-positive and Gram-negative bacteria. Meropenem should not be used to treat methicillin-resistant *Staphylococcus aureus* (MRSA) or methicillin-resistant *Staphylococcus epidermidis* (MRSE).

Mechanism of Resistance

There are several mechanisms of resistance to carbapenems: 1) decreased permeability of the outer membrane of Gram-negative bacteria (due to diminished production of porins) causing reduced bacterial uptake, 2) reduced affinity of the target PBPs, 3) increased expression of efflux pump components, and 4) production of antibacterial drug-destroying enzymes (carbapenemases, metallo-β-lactamases). Localized clusters of infections due to carbapenem-resistant bacteria have been reported in some regions.

Cross-Resistance

Cross-resistance is sometimes observed with isolates resistant to other carbapenems.

Interactions with Other Antibacterial Drugs

In vitro tests show meropenem to act synergistically with aminoglycoside antibacterials against some isolates of *Pseudomonas aeruginosa*.

Spectrum of Activity

Meropenem has been shown to be active against most isolates of the following bacteria, both *in vitro* and in clinical infections as described in the INDICATIONS AND USAGE section (1).

Gram-positive bacteria

Enterococcus faecalis (vancomycin-susceptible isolates only)
Staphylococcus aureus (methicillin-susceptible isolates only)
Streptococcus agalactiae
Streptococcus pneumoniae (penicillin-susceptible isolates only)
Streptococcus pyogenes
Viridans group streptococci

Gram-negative bacteria

Escherichia coli
Haemophilus influenzae
Klebsiella pneumoniae
Neisseria meningitidis
Pseudomonas aeruginosa
Proteus mirabilis

Anaerobic bacteria

Bacteroides fragilis
Bacteroides thetaiotaomicron
Peptostreptococcus species

The following *in vitro* data are available, but their clinical significance is unknown. At least 90% of the following bacteria have exhibited *in vitro* minimum inhibitory concentrations (MICs) less than or equal to the susceptible breakpoints for meropenem. However, the safety and effectiveness of meropenem in treating clinical infections due to these bacteria have not been established in adequate and well-controlled trials.

Gram-positive bacteria

Staphylococcus epidermidis (methicillin-susceptible isolates only)

Gram-negative bacteria

Aeromonas hydrophila
Campylobacter jejuni
Citrobacter koseri (formerly *diversus*)
Citrobacter freundii
Enterobacter cloacae
Hafnia alvei
Klebsiella oxytoca
Moraxella catarrhalis
Morganella morganii
Pasteurella multocida
Proteus vulgaris
Serratia marcescens

Anaerobic bacteria

Bacteroides distasonis
Bacteroides ovatus
Bacteroides uniformis
Bacteroides ureolyticus
Bacteroides vulgatus
Clostridium difficile
Clostridium perfringens
Eubacterium lentum
Fusobacterium species
Prevotella bivia
Prevotella intermedia
Prevotella melanogenica
Porphyromonas asaccharolytica
Propionibacterium acnes

Susceptibility Test Methods

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

Dilution Techniques:

Quantitative methods are used to determine antimicrobial minimum inhibitory concentrations (MICs). These MICs provide estimates of the susceptibility of bacteria to antimicrobial compounds. The MICs should be determined using a standardized test method. Standardized procedures are based on a dilution method¹³ (broth or agar) or equivalent using standardized inoculum concentrations and standardized concentrations of meropenem powder. The MIC values should be interpreted according to the criteria provided in Table 3.

Diffusion Techniques:

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 method¹⁴ and requires the use of standardized inoculum concentrations. This procedure uses paper disks impregnated with 10-mcg of meropenem to test the susceptibility of microorganisms to meropenem. The disk diffusion interpretive criteria are provided in Table 3.

Anaerobic Techniques:

For anaerobic bacteria, the susceptibility to meropenem as MICs can be determined by a standardized test method.²⁴ The MIC values obtained should be interpreted according to the criteria provided in Table 3.

Pathogen	Minimum Inhibitory Concentrations (mcg/mL)			Disk Diffusion (zone diameters in mm)		
	S	I	R	S	I	R
<i>Enterobacteriaceae</i>	≤ 1	2	≥ 4	≥ 23	20 to 22	≤ 19
<i>Pseudomonas aeruginosa</i> ^a	≤ 2	4	≥ 8	≥ 19	16 to 18	≤ 15
<i>Haemophilus influenzae</i> ^a	≤ 0.5	--	--	≥ 20	--	--
<i>Neisseria meningitidis</i> ^b	≤ 0.25	--	--	≥ 30	--	--
<i>Streptococcus pneumoniae</i> ^{c,d}	≤ 0.25	0.5	≥ 1	--	--	--
<i>Streptococcus agalactiae</i> and <i>Streptococcus pyogenes</i> ^{d,e,f}	≤ 0.5	--	--	--	--	--
Anaerobes ^{g,h}	≤ 4	8	≥ 16	--	--	--

S = Susceptible, I = Intermediate, R = Resistant

No interpretative criteria have been established for testing enterococci.

Susceptibility of staphylococci to meropenem may be deduced from testing penicillin and either cefotaxim or oxacillin.

- The interpretive criteria for *Paeruginosa* are based upon the dosing of 1 g every 8 hours.
- The current absence of data on resistant isolates precludes defining any category other than "Susceptible". If isolates yield MIC results other than susceptible, they should be submitted to a reference laboratory for additional testing.
- For nonmeningitis isolates of *S. pneumoniae* a penicillin MIC of ≤ 0.06 mcg/mL or oxacillin zone ≥ 20 mm can predict susceptibility to meropenem. MIC testing should be performed on isolates that do not test as susceptible by either of these methods, and on all meningitis *S. pneumoniae* isolates.
- Viridans group streptococci should be tested for meropenem susceptibility using a MIC method and results should be reported using the interpretive criteria listed for *S. agalactiae* and *S. pyogenes*.
- Reliable disk diffusion tests for meropenem do not yet exist for testing streptococci
- MIC values using either Brucella blood or Wilkins Chalgren agar (former reference medium) are considered equivalent, based upon published *in vitro* literature and a multicenter reduced bacterial uptake. This category implies possible clinical applicability in body sites where the drug is physiologically concentrated or in situations where a high dosage of drug can be used. This category also provides a buffer zone that prevents small uncontrolled technical factors from causing major discrepancies in interpretation. A report of *Resistant* indicates that the antimicrobial is not likely to inhibit growth of the pathogen if the antimicrobial compound in the blood reaches the concentrations usually achievable; other therapy should be selected.

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

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. Standard meropenem powder should provide the following range of values noted in Table 4.

QC Strain	Minimum Inhibitory Concentrations (MICs = mcg/mL)	Disk Diffusion (Zone diameters in mm)
<i>Staphylococcus aureus</i> ATCC 29213	0.03 to 0.12	—
<i>Staphylococcus aureus</i> ATCC 25923	—	29 to 37
<i>Streptococcus pneumoniae</i> ATCC 49619	0.06 to 0.25	28 to 35
<i>Enterococcus faecalis</i> ATCC 29212	2 to 8	—
<i>Escherichia coli</i> ATCC 25922	0.008 to 0.06	28 to 34
<i>Haemophilus influenzae</i> ATCC 49766	0.03 to 0.12	—
<i>Haemophilus influenzae</i> ATCC 49247	—	20 to 28
<i>Pseudomonas aeruginosa</i> ATCC 27853	0.25 to 1	27 to 33
<i>Bacteroides fragilis</i> ^a ATCC 25285	0.03 to 0.25	—
<i>Bacteroides thetaiotaomicron</i> ^a ATCC 29741	0.125 to 0.5	—
<i>Eubacterium lentum</i> ^a ATCC 43055	0.125 to 1	—
<i>Clostridium difficile</i> ^a ATCC 700057	0.5 to 4	—

^a Using the Reference Agar Dilution procedure.

13 NONCLINICAL TOXICOLOGY

13.1 Carcinogenesis, Mutagenesis, Impairment of Fertility

Carcinogenesis:

Carcinogenesis studies have not been performed.

Mutagenesis:

Genetic toxicity studies were performed with meropenem using the bacterial reverse mutation test, the Chinese hamster ovary HGPRT assay, cultured human lymphocytes cytogenic assay, and the mouse micronucleus test. There was no evidence of mutagenic potential found in any of these tests.

Impairment of Fertility:

Reproductive studies were performed with meropenem in rats at doses up to 1,000 mg/kg/day, and cynomolgus monkeys at doses up to 360 mg/kg/day (on the basis of AUC comparisons, approximately 1.8 times and 3.7 times, respectively, to the human exposure at the usual dose of 1 gram every 8 hours). There was no reproductive toxicity seen.

14 CLINICAL STUDIES

14.1 Complicated Skin and Skin Structure Infections