



XENEM

Imipenem and Cilastatin for Injection USP 500 mg/500 mg

Composition:

Each vial contains:
Imipenem USP Equivalent to anhydrous Imipenem500 mg
Cilastatin Sodium USP Equivalent to Cilastatin.....500 mg
Sodium Bicarbonate USP added as buffer.

Dosage Form:

Powder for solution for infusion.

Pharmacological properties

Pharmacodynamic properties:

Pharmacotherapeutic group: Antibacterial for systemic use, Carbapenems.

Mechanism of action

XENEM consists of two components: imipenem and cilastatin sodium in a 1:1 ratio by weight. Imipenem, also referred to as N-formimidoyl-thienamycin, is a semi-synthetic derivative of thienamycin, the parent compound produced by the filamentous bacterium *Streptomyces cattleya*.

Imipenem exerts its bactericidal activity by inhibiting bacterial cell wall synthesis in Gram-positive and Gram-negative bacteria through binding to penicillin-binding proteins (PBPs). Cilastatin sodium is a competitive, reversible and specific inhibitor of dehydropeptidase-I, the renal enzyme which metabolizes and inactivates imipenem. It is devoid of intrinsic antibacterial activity and does not affect the antibacterial activity of imipenem.

Pharmacokinetic/Pharmacodynamic (PK/PD) relationship
Similar to other beta-lactam antibacterial agents, the time that imipenem concentrations exceed the MIC (T>MIC) has been shown to best correlate with efficacy. Mechanism of resistance
Resistance to imipenem may be due to the following:

•Decreased permeability of the outer membrane of Gram-negative bacteria (due to diminished production of porins)

•Imipenem may be actively removed from the cell with an efflux pump.

•Reduced affinity of PBPs to imipenem

•Imipenem is stable to hydrolysis by most beta-lactamases, including penicillinases and cephalosporinases produced by gram-positive and gram-negative bacteria, with the exception of relatively rare carbapenem hydrolysing beta-lactamases. Species resistant to other carbapenems do generally express co-resistance to imipenem. There is no target-based cross-resistance between imipenem and agents of the quinolone, aminoglycoside, macrolide and tetracycline classes.

Breakpoints

EUCAST MIC breakpoints for imipenem to separate susceptible (S) pathogens from resistant (R) pathogens are as follows (v 1.1 2010-04-27):

•Enterobacteriaceae 1: S ≤2 mg/l, R >8 mg/l

•Pseudomonas spp. 2: S ≤4 mg/l, R >8 mg/l

•Acinetobacter spp.: S ≤2 mg/l, R >8 mg/l

•Staphylococcus spp. 3: Inferred from cefoxitin susceptibility

•Enterococcus spp.: S ≤4 mg/l, R >8 mg/l

•Streptococcus A, B, C, G: The beta-lactam susceptibility of beta-haemolytic streptococcus groups A, B, C and G is inferred from the penicillin susceptibility.

•Streptococcus pneumoniae 4: S ≤2 mg/l, R >2 mg/l

•Other streptococci 4: S ≤2 mg/l, R >2 mg/l

•Haemophilus influenzae 4: S ≤2 mg/l, R >2 mg/l

•Moraxella catarrhalis 4: S ≤2 mg/l, R >2 mg/l

•Neisseria gonorrhoeae: There is insufficient evidence that Neisseria gonorrhoeae is a good target for therapy with imipenem.

•Gram-negative anaerobes: S ≤2 mg/l, R >8 mg/l

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•Non-species related breakpoints 5: S ≤2 mg/l, R >8 mg/l

•Proteus and Morganella species are considered poor targets for imipenem.

•The breakpoints for Pseudomonas relate to high dose frequent therapy (1g every 6 hours).

•Susceptibility of staphylococci to carbapenems is inferred from the cefoxitin susceptibility.

•Strains with MIC values above the susceptible breakpoint are very rare or not yet reported. The identification and antimicrobial susceptibility tests on any such isolate must be repeated and if the result is confirmed the isolate must be sent to a reference laboratory. Until there is evidence regarding clinical response for confirmed isolates with MIC above the current resistant breakpoint they should be reported resistant.

•Non-species related breakpoint have been determined mainly on the basis of PK/PD data and are independent of MIC distributions of specific species. They are for use only for species not mentioned in the overview of species-related breakpoints or footnotes.

Susceptibility

The prevalence of acquired resistance may vary geographically and with time for selected species and local information on resistance is desirable, particularly when treating severe infections. As necessary, expert advice should be sought when the local prevalence of resistance is such that the utility of the agent in at least some types of infections is questionable.

Commonly susceptible species:

Gram-positive aerobes:

Enterococcus faecalis

Staphylococcus aureus (Methicillin-susceptible)*

Staphylococcus coagulase negative (Methicillin-susceptible)

Streptococcus agalactiae

Streptococcus pneumoniae

Streptococcus pyogenes

Streptococcus viridans group

Gram-negative aerobes:

Citrobacter freundii

Enterobacter aerogenes

Enterobacter cloacae

Escherichia coli

Haemophilus influenzae

Klebsiella oxytoca

Klebsiella pneumoniae

Moraxella catarrhalis

Serratia marcescens

Gram-positive anaerobes:

Clostridium parviformans**

Peptostreptococcus spp.**

Gram-negative anaerobes:

Bacteroides fragilis

Bacteroides fragilis group

Fusobacterium spp.

Porphyromonas asaccharolytica

Prevotella spp.

Veillonella spp.

Species for which acquired resistance may be a problem:

Gram-negative aerobes:

Acinetobacter baumannii

Pseudomonas aeruginosa

Inherently resistant species:

Gram positive aerobes:

Enterococcus faecium

Gram negative aerobes:

Some strains of Burkholderia cepacia (formerly Pseudomonas cepacia)

Legionella spp.

Stenotrophomonas maltophilia (formerly Xanthomonas maltophilia, formerly Pseudomonas maltophilia)

Others:

Chlamydia spp.

Chlamydia spp.

Mycoplasma spp.

Ureoplasma urealyticum

* All methicillin-resistant staphylococci are resistant to imipenem/cilastatin.

** EUCAST non-species related breakpoint is used.

Pharmacokinetic properties:

Imipenem

Absorption

In normal volunteers, intravenous infusion of XENEM over 20 minutes resulted in peak plasma levels of imipenem ranging from 12 to 20 µg/ml for the 250 mg/250 mg dose, from 21 to 58 µg/ml for the 500 mg/500 mg dose, and from 41 to 83 µg/ml for the 1000 mg/1000 mg dose. The mean peak plasma levels of imipenem following the 250 mg/250 mg, 500 mg/500 mg, and 1000 mg/1000 mg doses were 17, 39, and 66 µg/ml, respectively. At these doses, plasma levels of imipenem decline to below 1 µg/ml or less in four to six hours.

Distribution

The binding of imipenem to human serum proteins is approximately 20%.

Biotransformation

When administered alone, imipenem is metabolised in the kidneys by dehydropeptidase-I. Individual urinary recoveries ranged from 5 to 40%, with an average recovery of 15-20% in several studies.

Cilastatin is a specific inhibitor of dehydropeptidase-I enzyme and effectively inhibits metabolism of imipenem so that concomitant administration of imipenem and Cilastatin allows therapeutic antibacterial levels of imipenem to be attained in both urine and plasma.

Elimination

The plasma half-life of imipenem was one hour. Approximately 70% of the administered antibiotic was recovered intact in the urine within ten hours, and no further urinary excretion of imipenem was detectable. Urine concentrations of imipenem exceeded 10 µg/ml for up to eight hours after a 500 mg/500 mg dose of XENEM. The remainder of the administered dose was recovered in the urine as antibacterially inactive metabolites, and faecal elimination of Imipenem was essentially nil.

No accumulation of imipenem in plasma or urine has been observed with regimens of XENEM, administered as frequently as every six hours, in patients with normal renal function.

Cilastatin

Absorption

Peak plasma levels of cilastatin, following a 20 minute intravenous infusion of XENEM, ranged from 21 to 26 µg/ml for the 250 mg/250 mg dose, from 21 to 55 µg/ml for the 500 mg/500 mg dose and from 56 to 88 µg/ml for the 1000 mg/1000 mg dose. The mean peak plasma levels of cilastatin following the 250 mg/250 mg, 500 mg/500 mg, and 1000 mg/1000 mg doses were 22, 42, and 72 µg/ml respectively.

Distribution

The binding of cilastatin to human serum proteins is approximately 40%.

Biotransformation and elimination

The plasma half-life of cilastatin is approximately one hour. Approximately 70-80% of the dose of cilastatin was recovered unchanged in the urine as cilastatin within 10 hours of administration of XENEM. No further cilastatin appeared in the urine thereafter. Approximately 10% was found as the N-acetyl metabolite, which has inhibitory activity against dehydropeptidase comparable to that of cilastatin. Activity of dehydropeptidase-I in the kidney returned to normal levels shortly after the elimination of cilastatin from the blood stream.

Pharmacokinetics in special populations

Renal insufficiency

Following a single 250 mg/250 mg intravenous dose of XENEM, the area under the curve (AUCs) for imipenem increased 1.1-fold, 1.9-fold, and 2.7-fold in subjects with mild (Creatinine Clearance (CrCL) 50-80 ml/min/1.73 m²), moderate (CrCL 30-50 ml/min/1.73 m²), and severe (CrCL <30 ml/min/1.73 m²) renal impairment, respectively, compared to subjects with normal renal function (CrCL >80 ml/min/1.73 m²), and AUCs for cilastatin increased 1.6-fold, 2.0-fold, and 6.2-fold in subjects with mild, moderate, and severe renal impairment, respectively, compared to subjects with normal renal function. Following a single 250 mg/250 mg intravenous dose of XENEM given 24 hours after haemodialysis, AUCs for imipenem and cilastatin were 3.7-fold and 16.4-fold higher, respectively, as compared to subjects with normal renal function. Urinary recovery, renal clearance and plasma clearance of imipenem and cilastatin decrease with decreasing renal function following intravenous administration of XENEM. Dose adjustment is necessary for patients with impaired renal function.

Hepatic insufficiency

The pharmacokinetics of imipenem in patients with hepatic insufficiency have not been established. Due to the limited extent of hepatic metabolism of imipenem, its pharmacokinetics are not expected to be affected by hepatic impairment. Therefore, no dose adjustment is recommended in patients with hepatic impairment.

Paediatric population

The average clearance (CL) and volume of distribution (V_{dss}) for imipenem were approximately 45% higher in paediatric patients (3 months to 14 years) as compared to adults. The AUC for imipenem following administration of 15/15 mg/kg per body weight of imipenem/cilastatin to paediatric patients was approximately 30% higher than the exposure in adults receiving a 500 mg/500 mg dose. At the higher dose, the exposure following administration of 25/25 mg/kg imipenem/cilastatin to children was 9% higher as compared to the exposure in adults receiving a 1000 mg/1000 mg dose.

Elderly

In healthy elderly volunteers (65 to 75 years of age with normal renal function for their age), the pharmacokinetics of a single dose of XENEM 500 mg/500 mg administered intravenously over 20 minutes were consistent with those expected in subjects with slight renal impairment for which no dose alteration is considered necessary. The mean plasma half-lives of imipenem and cilastatin were 91 ± 7.0 minutes and 69 ± 15 minutes, respectively. Multiple dosing has no effect on the pharmacokinetics of either imipenem or cilastatin, and no accumulation of imipenem/cilastatin was observed.

Therapeutic indications:

Xenem is indicated for the treatment of the following infections in adults and children 1 year of age and above:

Complicated intra-abdominal infections

Severe pneumonia including hospital and ventilator-associated pneumonia

Intra- and post-partum infections

Complicated urinary tract infections

complicated skin and soft-tissue infections may be used in the management of neutropenic patients with fever that is suspected to be due to a bacterial infection. Treatment of patients with bacteraemia that occurs in association with, or is suspected to be associated with, any of the infections listed above.

Posology and method of administration:

Posology

The dose recommendations for represent the quantity of Imipenem/Cilastatin to be administered.

The daily dose of should be based on the type of infection and given in equally divided doses based on consideration of degree of susceptibility of the pathogen(s) and the patient's renal function

Adults and adolescents

For patients with normal renal function (creatinine clearance of ≥90 ml/min), the recommended dose regimens are:

500 mg/500 mg every 6 hours OR

1000 mg/1000 mg every 8 hours OR every 6 hours

It is recommended that infections suspected or proven to be due to less susceptible bacterial species (such as *Pseudomonas aeruginosa*) and very severe infections (e.g. in neutropenic patients with a fever) should be treated with 1000 mg/1000 mg administered every 6 hours.

A reduction in dose is necessary when creatinine clearance is < 90 ml/min.

The maximum total daily dose should not exceed 4000 mg/4000 mg per day.

To determine the reduced dose for adults with impaired renal function:

1. The total daily dose (i. e. 2000/2000, 3000/3000 or 4000/4000 mg) that would usually be applicable to patients with normal renal function should be selected.

2. From table 1 the appropriate reduced dose regimen is selected according to the patient's creatinine clearance.

Creatinine clearance (mL/min) is:	IF TOTAL DAILY DOSE is: 2000 mg/day	IF TOTAL DAILY DOSE is: 3000 mg/day	IF TOTAL DAILY DOSE is: 4000 mg/day
≥90 (normal)	500 q6h	1000 q6h	1000 q6h
reduced dosage (mg) for patients with renal impairment:			
<90 - ≥60	400 q6h	500 q6h	750 q6h
<60 - ≥30	300 q6h	500 q6h	500 q6h
<30 - ≥15	200 q6h	500 q12h	500 q12h

Patients with a creatinine clearance of <15 ml/min

These patients should not receive unless haemodialysis is instituted within 48 hours.

Patients on haemodialysis

When treating patients with creatinine clearances of <15 ml/min who are undergoing dialysis use the dose recommendation for patients with creatinine clearances of 15 to 29 ml/min.

Both imipenem and cilastatin are cleared from the circulation during haemodialysis. The patient should receive after haemodialysis and at 12 hour intervals timed from the end of that haemodialysis session. Dialysis patients, especially those with background central nervous system (CNS) disease, should be carefully monitored; for patients on haemodialysis, is recommended only when the benefit outweighs the potential risk of seizures.

Hepatic impairment

No dose adjustment is recommended in patients with impaired hepatic function

Elderly population:

No dose adjustment is required for the elderly patients with normal renal function.

(Paediatric population ≥1 year of age:

For paediatric patients ≥1 year of age, the recommended dose is 15/15 or 25/25 mg/kg/dose administered every 6 hours.

It is recommended that infections suspected or proven to be due to less susceptible bacterial species (such as *Pseudomonas aeruginosa*) and very severe infections (e.g. in neutropenic patients with a fever) should be treated with 25/25 mg/kg administered every 6 hours.

Paediatric population <1 year of age:

Clinical data are insufficient to recommend dosing for children less than 1 year of age. Patients on haemodialysis

When treating patients with creatinine clearances of <15 ml/min who are undergoing dialysis use the dose recommendation for patients with creatinine clearances of 15 to 29 ml/min.

Both imipenem and cilastatin are cleared from the circulation during haemodialysis. The patient should receive after haemodialysis and at 12 hour intervals timed from the end of that haemodialysis session. Dialysis patients, especially those with background central nervous system (CNS) disease, should be carefully monitored; for patients on haemodialysis, is recommended only when the benefit outweighs the potential risk of seizures.

Hepatic impairment

No dose adjustment is recommended in patients with impaired hepatic function

Elderly population:

No dose adjustment is required for the elderly patients with normal renal function.

(Paediatric population ≥1 year of age:

For paediatric patients ≥1 year of age, the recommended dose is 15/15 or 25/25 mg/kg/dose administered every 6 hours.

It is recommended that infections suspected or proven to be due to less susceptible bacterial species (such as *Pseudomonas aeruginosa*) and very severe infections (e.g. in neutropenic patients with a fever) should be treated with 25/25 mg/kg administered every 6 hours.

Paediatric population <1 year of age:

Clinical data are insufficient to recommend dosing for children less than 1 year of age.

Paediatric population with renal impairment:

Clinical data are insufficient to recommend dosing for paediatric patients with renal impairment (serum creatinine > 2 mg/dl).

Method of administration

Xenem is to be reconstituted and further diluted prior to administration. Each dose of ≤500 mg/500 mg should be given by intravenous infusion over 20 to 30 minutes. Each dose >500 mg/500 mg should be infused over 40 to 60 minutes. In patients who develop nausea during the infusion, the rate of infusion may be slowed.

Contraindications:

Hypersensitivity to the active substances or to any of the excipients (e.g. Sodium bicarbonate).

Hypersensitivity to any other carbapenem antibacterial agent.

Severe hypersensitivity (e.g. anaphylactic reaction, severe skin reaction) to any other type of beta-lactam antibacterial agent (e.g. penicillins or cephalosporins).

Special warnings and precautions:

General

The selection of imipenem/cilastatin to treat an individual patient should take into account the appropriateness of using a carbapenem antibacterial agent based on factors such as severity of the infection, the prevalence of resistance to other suitable antibacterial agents and the risk of selecting for carbapenem-resistant bacteria.

Hypersensitivity

Serious and occasionally fatal hypersensitivity (anaphylactic) reactions have been reported in patients receiving therapy with beta-lactams. These reactions are more likely to occur in individuals with a history of sensitivity to multiple allergens. Before initiating therapy with a beta-lactam, careful inquiry should be made concerning previous hypersensitivity reactions to carbapenems, penicillins, cephalosporins, other beta-lactams and other allergens. If an allergic reaction to XENEM occurs, discontinue the therapy immediately.

Interaction:

Generalized seizures have been reported in patients who received ganciclovir and XENEM. These medicinal products should not be used concomitantly unless the potential benefit outweighs the risks.

Decreases in valproic acid levels that may fall below the therapeutic range have been reported when valproic acid was co-administered with carbapenem agents. The lowered valproic acid levels can lead to inadequate seizure control; therefore, concomitant use of imipenem and valproic acid/sodium valproate is not recommended and alternative antibacterial or anti-convulsant therapies should be considered.

Breast-feeding

Oral anti-coagulants

Simultaneous administration of antibiotics with warfarin may augment its anti-coagulant effects.

There have been many reports of increases in the anti-coagulant effects of orally administered anti-coagulant agents, including warfarin in patients who are concomitantly receiving antibacterial agents. The risk may vary with the underlying infection, age and general status of the patient so that the contribution of the antibiotic to the increase in INR (International normalised ratio) is difficult to assess. It is recommended that the INR should be monitored frequently during and shortly after co-administration of antibiotics with an oral anti-coagulant agent.

Concomitant administration of XENEM and probenecid resulted in minimal increases in the plasma levels and plasma half-life of imipenem. The urinary recovery of active (non-metabolised) imipenem decreased to approximately 60% of the dose when XENEM was administered with probenecid. Concomitant administration of XENEM and probenecid doubled the plasma level and half-life of cilastatin, but had no effect on urine recovery of cilastatin.

Paediatric population
Interaction studies have only been performed in adults.

Fertility, pregnancy and lactation:

Pregnancy

There are no adequate and well-controlled studies for the use of imipenem/cilastatin in pregnant women.

Studies in