

Summary of Product Characteristics

1 NAME OF THE MEDICINAL PRODUCT

Vancomycin 500 mg powder for concentrate for solution for infusion

2 QUALITATIVE AND QUANTITATIVE COMPOSITION

Vancomycin 500 mg, Powder for concentrate for solution for infusion

Each vial contains 500 mg of vancomycin (as vancomycin hydrochloride), equivalent to 500,000 IU vancomycin.

One ml of reconstituted solution contains 50 mg of vancomycin.

For the full list of excipients, see section 6.1.

3 PHARMACEUTICAL FORM

Powder for concentrate for solution for infusion.

Homogeneous solid, white to slightly brown.

After reconstitution a solution is obtained with a pH between 2.5 – 4.5.

4 CLINICAL PARTICULARS

4.1 Therapeutic Indications

Intravenous administration

Vancomycin is indicated in all age groups for the treatment of the following infections (see sections 4.2, 4.4 and 5.1):

- complicated skin and soft tissue infections (cSSTI)
- bone and joint infections
- community acquired pneumonia (CAP)
- hospital acquired pneumonia (HAP), including ventilator-associated pneumonia (VAP)
- infective endocarditis
- bacteraemia that occurs in association with, or is suspected to be associated with any of the above.

Vancomycin is also indicated in all age groups for the perioperative antibacterial prophylaxis in patients that are at high risk of developing bacterial endocarditis when undergoing major surgical procedures.

Oral administration

Vancomycin is indicated in all age groups for the treatment of *Clostridium difficile* infection (CDI) (see sections 4.2, 4.4 and 5.1). Consideration should be given to official guidance on the appropriate use of antibacterial agents.

4.2 Posology and method of administration

Posology

Where appropriate, vancomycin should be administered in combination with other antibacterial agents.

Intravenous administration

The initial dose should be based on total body weight. Subsequent dose adjustments should be based on serum concentrations to achieve targeted therapeutic concentrations. Renal function must be taken into consideration for subsequent doses and interval of administration.

Patients aged 12 years and older

The recommended dose is 15 to 20 mg/kg of body weight every 8 to 12 h (not to exceed 2 g per dose).

In seriously ill patients, a loading dose of 25–30 mg/kg of body weight can be used to facilitate rapid attainment of target trough serum vancomycin concentration.

Infants and children aged from one month to less than 12 years of age:

The recommended dose is 10 to 15 mg/kg body weight every 6 hours (see section 4.4).

Term neonates (from birth to 27 days of post-natal age) and preterm neonates (from birth to the expected date of delivery plus 27 days)

For establishing the dosing regimen for neonates, the advice of a physician experienced in the management of neonates should be sought. One possible way of dosing vancomycin in neonates is illustrated in the following table: (see section 4.4)

| PMA (weeks) | Dose (mg/kg) | Interval of administration (h) |
|-------------|--------------|--------------------------------|
| < 29 | 15 | 24 |
| 29-35 | 15 | 12 |
| > 35 | 15 | 8 |

PMA: post-menstrual age [(time elapsed between the first day of the last menstrual period and birth (gestational age) plus the time elapsed after birth (post-natal age)].

Peri-operative prophylaxis of bacterial endocarditis in all age groups:

The recommended dose is an initial dose of 15 mg/kg prior to induction of anaesthesia. Depending on the duration of surgery, a second vancomycin dose may be required.

Duration of treatment

Suggested treatment duration is shown in table below. In any case, the duration of treatment should be tailored to the type and severity of infection and the individual clinical response.

| Indication | |
|---|-------------------------------|
| Complicated skin and soft tissue infections - Non necrotizing - Necrotizing | 7 to 14 days 4 to 6 weeks* |
| Bone and joint infections | 4 to 6 weeks** |
| Community-acquired pneumonia | 7 to 14 days |
| Hospital-acquired pneumonia, including ventilator-associated pneumonia | 7 to 14 days |
| Infective endocarditis | 4 to 6 weeks*** |

*Continue until further debridement is not necessary, patient has clinically improved, and patient is afebrile for 48 to 72 hours

**Longer courses of oral suppression treatment with suitable antibiotics should be considered for prosthetic joint infections

***Duration and need for combination therapy is based on valve-type and organism

Special populationsElderly

Lower maintenance doses may be required due to the age-related reduction in renal function.

Renal impairment

In adult and paediatric patients with renal impairment, consideration should be given to an initial starting dose followed by serum vancomycin trough levels rather than to a scheduled dosing regimen, particularly in patients with severe renal impairment or those who undergo renal replacement therapy (RRT) due to the many varying factors that may affect vancomycin levels in them.

In patients with mild or moderate renal failure, the starting dose must not be reduced. In patients with severe renal failure, it is preferable to prolong the interval of administration rather than administer lower daily doses.

Appropriate consideration should be given to the concomitant administration of medicinal products that may reduce vancomycin clearance and/or potentiate its undesirable effects (see section 4.4).

Vancomycin is poorly dialyzable by intermittent haemodialysis. However, use of high-flux membranes and continuous renal replacement therapy (CRRT) increases vancomycin clearance and generally requires replacement dosing (usually after the haemodialysis session in case of intermittent haemodialysis).

Adults

Dose adjustments in adult patients could be based on glomerular filtration rate estimated (eGFR) by the following formula:

Men: $[\text{Weight (kg)} \times 140 - \text{age (years)}] / 72 \times \text{serum creatinine (mg/dl)}$

Women: 0.85 x value calculated by the above formula.

The usual starting dose for adult patients is 15 to 20 mg/kg that could be administered every 24 hours in patients with creatinine clearance between 20 to 49 ml/min. In patients with severe renal impairment (creatinine clearance below 20 ml/min) or those on renal replacement therapy, the appropriate timing and amount of subsequent doses largely depend on the modality of RRT and should be based on serum vancomycin trough levels and on residual renal function (see section 4.4). Depending on the clinical situation, consideration could be given to withhold the next dose while awaiting the results of vancomycin levels.

In the critically ill patient with renal insufficiency, the initial loading dose (25 to 30 mg/kg) should not be reduced.

Paediatric population

Dose adjustments in paediatric patients aged 1 year and older could be based on glomerular filtration rate estimated (eGFR) by the revised Schwartz formula:

$$\text{eGFR (mL/min/1.73m}^2\text{)} = (\text{height cm} \times 0.413) / \text{serum creatinine (mg/dl)}$$

$$\text{eGFR (mL/min/1.73m}^2\text{)} = (\text{height cm} \times 36.2 / \text{serum creatinine } (\mu\text{mol/L)})$$

For neonates and infants below 1 year of age, expert advice should be sought as the revised Schwartz formula is not applicable to them.

Orientative dosing recommendations for the paediatric population are shown in table below that follow the same principles as in adult patients.

| GFR (mL/min/1.73 m²) | IV dose | Frequency |
|--|----------------|--------------------------|
| 50-30 | 15 mg/kg | 12 hourly |
| 29-10 | 15 mg/kg | 24 hourly |
| < 10 | 10-15 mg/kg | Re-dose based on levels* |
| Intermittent haemodialysis | | |
| Peritoneal dialysis | | |
| Continuous renal replacement therapy | 15 mg/kg | Re-dose based on levels* |

*The appropriate timing and amount of subsequent doses largely depends on the modality of RRT and should be based on serum vancomycin levels obtained prior to dosing and on residual renal function. Depending on the clinical situation, consideration could be given to withhold the next dose while awaiting the results of vancomycin levels.

Hepatic impairment:

No dose adjustment is needed in patients with hepatic insufficiency.

Pregnancy

Significantly increased doses may be required to achieve therapeutic serum concentrations in pregnant women (see Section 4.6).

Obese patients

In obese patients, the initial dose should be individually adapted according to total body weight as in non-obese patients.

Oral administration

Patients aged 12 years and older

Treatment of *Clostridium difficile* infection (CDI):

The recommended vancomycin dose is 125 mg every 6 hours for 10 days for the first episode of non-severe CDI. This dose can be increased to 500 mg every 6 hours for 10 days in case of severe or complicated disease. The maximum daily dose should not exceed 2 g.

In patients with multiple recurrences, consideration may be given to treat the current episode of CDI with vancomycin, 125 mg four times daily for 10 days followed by either tapering the dose, i.e., gradually decreasing it until 125 mg per day or a pulse regimen, i.e., 125–500 mg/day every 2–3 days for at least 3 weeks.

Neonates, infants and children less than 12 years old

The recommended vancomycin dose is 10 mg/kg orally every 6 hours for 10 days. The maximum daily dose should not exceed 2 g.

Treatment duration with vancomycin may need to be tailored to the clinical course of individual patients. Whenever possible the antibacterial suspected to have caused CDI should be discontinued. Adequate replacement of fluid and electrolytes should be ensured.

Monitoring of vancomycin serum concentrations:

The frequency of therapeutic drug monitoring (TDM) needs to be individualized based on the clinical situation and response to treatment, ranging from daily sampling that may be required in some hemodynamically unstable patients to at least once weekly in stable patients showing a treatment response. In patients with normal renal function, the serum concentration of vancomycin should be monitored on the second day of treatment immediately prior to the next dose.

In patients on intermittent haemodialysis, vancomycin levels should be usually obtained before the start of the haemodialysis session.

After oral administration, monitoring vancomycin serum concentrations in patients with inflammatory intestinal disorders should be performed (see section 4.4).

Therapeutic trough (minimum) vancomycin blood levels should normally be 10-20 mg/l, depending on the site of infection and susceptibility of the pathogen. Trough values of 15-20 mg/l are usually recommended by clinical laboratories to better cover susceptible-classified pathogens with MIC \geq 1 mg/L (see sections 4.4 and 5.1).

Model-based methods may be useful in the prediction of individual dose requirements to reach an adequate AUC. The model-based approach can be used both in calculating the personalized starting dose and for dose adjustments based on TDM results (see section 5.1).

Method of administration:

Intravenous administration

Intravenous vancomycin is usually administered as an intermittent infusion and the dosing recommendations presented in this section for the intravenous route correspond to this type of administration.

Vancomycin shall only be administered as slow intravenous infusion of at least one hour duration or at a maximum rate of 10 mg/min (whichever is longer) which is sufficiently diluted (at least 100 ml per 500 mg or at least 200 ml per 1000 mg) (see section 4.4).

Patients whose fluid intake must be limited can also receive a solution of 500 mg/50 ml or 1000 mg/100 ml, although the risk of infusion-related undesirable effects can be increased with these higher concentrations.

For information about the preparation of the solution, please see section 6.6.

Continuous vancomycin infusion may be considered, e.g., in patients with unstable vancomycin clearance.

Oral administration

The dose of vancomycin administered orally can be diluted in 30 ml of water and given to the patient, or administered by nasogastric tube.

For instructions on reconstitution and dilution of the medicinal product before administration, see section 6.6.

4.3 Contraindications

Hypersensitivity to the active substance or to any of the excipients listed in section 6.1 (see section 4.4).

Vancomycin should not be administered intramuscularly due to the risk of necrosis at the site of administration..

4.4 Special warnings and precautions for use

Hypersensitivity reactions

Serious and occasionally fatal hypersensitivity reactions are possible (see sections 4.3 and 4.8). In case of hypersensitivity reactions, treatment with vancomycin must be discontinued immediately and the adequate emergency measures must be initiated.

In patients receiving vancomycin over a longer-term period or concurrently with other medications which may cause neutropenia or agranulocytosis, the leukocyte count should be monitored at regular intervals. All patients receiving vancomycin should have periodic haematologic studies, urine analysis, liver and renal function tests.

Vancomycin should be used with caution in patients with allergic reactions to teicoplanin, since cross hypersensitivity, including fatal anaphylactic shock, may occur.

Spectrum of antibacterial activity

Vancomycin has a spectrum of antibacterial activity limited to Gram-positive organisms. It is not suitable for use as a single agent for the treatment of some types of infections unless the pathogen is already documented and known to be susceptible or there is a high suspicion that the most likely pathogen(s) would be suitable for treatment with vancomycin.

The rational use of vancomycin should take into account the bacterial spectrum of activity, the safety profile and the suitability of standard antibacterial therapy to treat the individual patient.

Ototoxicity

Ototoxicity, which may be transitory or permanent (see section 4.8) has been reported in patients with prior deafness, who have received excessive intravenous doses, or who receive concomitant treatment with another ototoxic active substance such as an aminoglycoside. Vancomycin should also be avoided in patients with previous hearing loss. Deafness may be preceded by tinnitus. Experience with other antibiotics suggests that deafness may be progressive despite cessation of treatment. To reduce the risk of ototoxicity, blood levels should be determined periodically and periodic testing of auditory function is recommended.

The elderly are particularly susceptible to auditory damage. Monitoring of vestibular and auditory function in the elderly should be carried out during and after treatment. Concurrent or sequential use of other ototoxic substances should be avoided.

Infusion-related reactions

Rapid bolus administration (i.e. over several minutes) may be associated with exaggerated hypotension (including shock and, rarely, cardiac arrest), histamine like responses and maculopapular or erythematous rash ("red man's syndrome" or "red neck syndrome"). Vancomycin should be infused slowly in a dilute solution (2.5 to 5.0 mg/ml) at a rate no greater than 10 mg/min and over a period not less than 60 minutes to avoid rapid infusion-related reactions. Stopping the infusion usually results in a prompt cessation of these reactions.

The frequency of infusion-related reactions (hypotension, flushing, erythema, urticaria and pruritus) increases with the concomitant administration of anaesthetic agents (see section 4.5). This may be reduced by administering vancomycin by infusion over at least 60 minutes, before anaesthetic induction.

Severe cutaneous adverse reactions (SCARs)

Severe cutaneous adverse reactions (SCARs) including Stevens-Johnson syndrome (SJS), toxic epidermal necrolysis (TEN), drug reaction with eosinophilia and systemic symptoms (DRESS) and acute generalized exanthematous pustulosis (AGEP), which can be life-threatening or fatal, have been reported in association with vancomycin treatment (see section 4.8). Most of these reactions occurred within a few days and up to eight weeks after commencing treatment with vancomycin.

At the time of prescription patients should be advised of the signs and symptoms and monitored closely for skin reactions. If signs and symptoms suggestive of these reactions appear, vancomycin should be withdrawn immediately and an alternative treatment considered. If the patient has developed a SCAR with the use of vancomycin, treatment with vancomycin must not be restarted at any time.

Administration site related reactions

Pain and thrombophlebitis may occur in many patients receiving intravenous vancomycin and are occasionally severe. The frequency and severity of thrombophlebitis can be minimized by administering the medicinal product slowly as a dilute solution (see section 4.2) and by changing the sites of infusion regularly.

The efficacy and safety of vancomycin has not been established for the intrathecal, intralumbar and intraventricular routes of administration.

Parental administration

Nephrotoxicity

Vancomycin should be used with care in patients with renal insufficiency, including anuria, as the possibility of developing toxic effects is much higher in the presence of prolonged high blood concentrations. The risk of toxicity is increased by high blood concentrations or prolonged therapy.

Regular monitoring of the blood levels of vancomycin is indicated in high dose therapy and longer-term use, particularly in patients with renal dysfunction or impaired faculty of hearing as well as in concurrent administration of nephrotoxic or ototoxic substances, respectively (see sections 4.2 and 4.5)

Eye disorders

Vancomycin is not authorized for intracameral or intravitreal use, including prophylaxis of endophthalmitis. Hemorrhagic occlusive retinal vasculitis (HORV), including permanent loss of vision, have been observed in individual cases following intracameral or intravitreal use of vancomycin during or after cataract surgery.

Oral administration

Intravenous administration of vancomycin is not effective for the treatment of *Clostridium difficile* infection. Vancomycin should be administered orally for this indication.

Testing for *Clostridium difficile* colonization or toxin is not recommended in children younger than 1 year due to high rate of asymptomatic colonisation unless severe diarrhoea is present in infants with risk factors for stasis such as Hirschsprung disease, operated anal atresia or other severe motility disorders. Alternative aetiologies should always be sought and *Clostridium difficile* enterocolitis be proven.

Potential for Systemic Absorption

Absorption may be enhanced in patients with inflammatory disorders of the intestinal mucosa or with *Clostridium difficile*-induced pseudomembranous colitis. These patients may be at risk for the development of adverse reactions, especially if there is a concomitant renal impairment. The greater the renal impairment, the greater the risk of developing the adverse reactions associated with the parenteral administration of vancomycin. Monitoring of serum vancomycin concentrations of patients with inflammatory disorders of the intestinal mucosa should be performed.

Nephrotoxicity

Serial monitoring of renal function should be performed when treating patients with underlying renal dysfunction or patients receiving concomitant therapy with an aminoglycoside or other nephrotoxic drugs.

Ototoxicity

Serial tests of auditory function may be helpful in order to minimise the risk of ototoxicity in patients with an underlying hearing loss, or who are receiving concomitant therapy with an ototoxic agent such as an aminoglycoside.

Drug interactions with anti-motility agents and proton pump inhibitors

Anti-motility agents should be avoided and proton pump inhibitor use should be reconsidered.

Development of Drug-Resistant Bacteria

Oral vancomycin use increases the chance of vancomycin-resistant *Enterococci* populations in the gastrointestinal tract. As a consequence, prudent use of oral vancomycin is advised.

4.5 Interaction with other medicinal products and other forms of interactions

Other potentially nephrotoxic or ototoxic medications

Concurrent or sequential administration of vancomycin with other potentially neurotoxic or/and nephrotoxic active substances particularly gentamycin, amphotericin B, streptomycin, neomycin, kanamycin, amikacin, tobramycin, viomycin, bacitracin, polymyxin B, colistin, cisplatin and piperacillin/tazobactam may potentiate the nephrotoxicity and/or ototoxicity of vancomycin and consequently requires careful monitoring of the patient (see section 4.4).

Anaesthetics

Concurrent administration of vancomycin and anaesthetic agents has been associated with erythema, histamine like flushing and anaphylactoid reactions. This may be reduced if the vancomycin is administered over 60 minutes before anaesthetic induction.

Muscle relaxants

If vancomycin is administered during or directly after surgery, the effect (neuromuscular blockade) of muscle relaxants (such as succinylcholine) concurrently used can be enhanced and prolonged.

4.6 Fertility, pregnancy and lactation

Pregnancy

No sufficient safety experience is available regarding vancomycin during human pregnancy. Reproduction toxicological studies on animals do not suggest any effects on the development of the embryo, foetus or gestation period (see section 5.3).

However, vancomycin penetrates the placenta and a potential risk of embryonal and neonatal ototoxicity and nephrotoxicity cannot be excluded. Therefore vancomycin should be given in pregnancy only if clearly needed and after a careful risk/benefit evaluation.

Lactation

Vancomycin is excreted in human milk and should be therefore used in lactation period only if clearly necessary. Vancomycin should be cautiously given to breast-feeding mothers because of potential adverse reactions in the infant (disturbances in the intestinal flora with diarrhoea, colonisation with yeast-like fungi and possibly sensibilisation).

Considering the importance of this medicine for nursing mother, the decision to stop breastfeeding should be considered.

4.7 Effects on ability to drive and use machines

Vancomycin has no or negligible influence on the ability to drive and use machines.

4.8 Undesirable effects

Summary of the Safety profile

The most common adverse reactions are phlebitis, pseudo-allergic reactions and flushing of the upper body ("red-neck syndrome") in connection with too rapid intravenous infusion of vancomycin.

The absorption of vancomycin from the gastrointestinal tract is negligible. However, in severe inflammation of the intestinal mucosa, especially in combination with renal insufficiency, adverse reactions that occur when vancomycin is administered parenterally may appear.

Severe cutaneous adverse reactions (SCARs), including Stevens-Johnson syndrome (SJS), toxic epidermal necrolysis (TEN), drug reaction with eosinophilia and systemic symptoms (DRESS) and acute generalized exanthematous pustulosis (AGEP) have been reported in association with vancomycin treatment (see section 4.4).

Tabulated List of Adverse reactions

Within each frequency grouping, undesirable effects are presented in order of decreasing seriousness.

The adverse reactions listed below are defined using the following MedDRA convention and system organ class database:

Very common ($\geq 1/10$)

Common ($\geq 1/100$ to $< 1/10$)

Uncommon ($\geq 1/1,000$ to $< 1/100$)

Rare ($\geq 1/10,000$ to $< 1/1,000$)

Very rare ($< 1/10,000$)

Not known (cannot be estimated from the available data)

| System organ class | |
|--|--|
| Frequency | Adverse reaction |
| Blood and the lymphatic system disorders: | |
| Rare | Reversible neutropenia ¹ , agranulocytosis, eosinophilia, thrombocytopenia, pancytopenia. |

| | |
|--|---|
| Immune system disorders: | |
| Rare | Hypersensitivity reactions, anaphylactic reactions ² |
| Ear and labyrinth disorders: | |
| Uncommon | Transient or permanent loss of hearing ⁴ |
| Rare | Vertigo, tinnitus ³ , dizziness, |
| Cardiac disorders | |
| Very rare | Cardiac arrest |
| Vascular disorders: | |
| Common | Decrease in blood pressure |
| Rare | Vasculitis |
| Respiratory, thoracic and mediastinal disorders: | |
| Common | Dyspnoea, stridor |
| Gastrointestinal disorders: | |
| Rare | Nausea |
| Very rare | Pseudomembranous enterocolitis |
| Not known | Vomiting, diarrhoea |
| Skin and subcutaneous tissue disorders: | |
| Common | Flushing of the upper body ("red man syndrome"), exanthema and mucosal inflammation, pruritus, urticaria |
| Very rare | Exfoliative dermatitis, Stevens-Johnson syndrome, Lyell's syndrome, Linear IgA bullous dermatosis ⁵ , Toxic epidermal necrolysis (TEN) |
| Not known | Eosinophilia and systemic symptoms (DRESS syndrome), AGEP (Acute Generalized Exanthematous Pustulosis) |
| Renal and urinary disorders: | |
| Common | Renal insufficiency manifested primarily by increased serum creatinine and serum urea |
| Rare | Interstitial nephritis, acute renal failure. |
| Not known | Acute tubular necrosis |
| General disorders and administration site conditions: | |
| Common | Phlebitis, redness of the upper body and face. |
| Rare | Drug fever, shivering, pain and muscle spasm of the chest and back muscles |

Description of selected adverse drug reactions

Reversible neutropenia usually starting one week or more after onset of intravenous therapy or after total dose of more than 25 g.

During or shortly after rapid infusion anaphylactic/ anaphylactoid reactions including wheezing may occur. The reactions abate when administration is stopped, generally between 20 minutes and 2 hours. Vancomycin should be infused slowly (see sections 4.2 and 4.4). Necrosis may occur after intramuscular injection.

Tinnitus, possibly preceding onset of deafness, should be regarded as an indication to discontinue treatment.


Ototoxicity has primarily been reported in patients given high doses, or in those on concomitant treatment with other ototoxic medicinal products like aminoglycosides, or in those who had a pre-existing reduction in kidney function or hearing.

Paediatric population

The safety profile is generally consistent among children and adult patients. Nephrotoxicity has been described in children, usually in association with other nephrotoxic agents such as aminoglycosides.

Reporting of suspected adverse reactions

Reporting suspected adverse reactions after authorisation of the medicinal product is important. It allows continued monitoring of the benefit/risk balance of the medicinal product. Healthcare professionals are asked to report any suspected adverse reactions via:

HPRA Pharmacovigilance
 Earlsfort Terrace
 IRL - Dublin 2
 Tel: +353 1 6764971 

4.9 Overdose

Toxicity due to overdose has been reported. 500 mg iv to a child, 2 year of age, resulted in lethal intoxication. Administration of a total of 56 g during 10 days to an adult resulted in renal insufficiency. In certain high-risk conditions (e. g. in case of severe renal impairment) high serum levels and oto- and nephrotoxic effects can occur.

Measures in case of overdose:

- A specific antidote is not known.
- Symptomatic treatment while maintaining renal function is required
- Vancomycin is poorly removed from the blood by haemodialysis or peritoneal dialysis. Haemofiltration or haemoperfusion with polysulfone resins have been used to reduce serum concentrations of vancomycin.

5 PHARMACOLOGICAL PROPERTIES

5.1 Pharmacodynamic properties

Pharmacotherapeutic group: 1.1.11 Anti-infectives. Antibacterials. Other antibacterials.

ATC Code: J01XA01 – Anti-infectives for systemic use – Antibacterials for systemic use – Other antibacterials – Glycopeptide antibacterials.

Mechanism of action

Vancomycin is a tricyclic glycopeptide antibiotic that inhibits the synthesis of the cell wall in sensitive bacteria by binding with high affinity to the D-alanyl-D-alanine terminus of cell wall precursor units. The drug is slowly bactericidal for dividing microorganisms. In addition, it impairs the permeability of the bacterial cell membrane and RNA synthesis.

Pharmacokinetic/ Pharmacodynamic relationship

Vancomycin displays concentration-independent activity with the area under the concentration curve (AUC) divided by the minimum inhibitory concentration (MIC) of the target organism as the primary predictive parameter for efficacy. On basis of in vitro, animal and limited human data, an AUC/MIC ratio of 400 has been established as a PK/PD target to achieve clinical effectiveness with vancomycin. To achieve this target when MICs are ≥ 1.0 mg/l, dosing in the upper range and high trough serum concentrations (15-20 mg/l) are required (see section 4.2).

Mechanism of resistance

Acquired resistance to glycopeptides is most common in enterococci and is based on acquisition of various van gene complexes which modifies the D-alanyl-D-alanine target to D-alanyl-D-lactate or D-alanyl-D-serine which bind vancomycin poorly. In some countries, increasing cases of resistance are observed particularly in enterococci; multi-resistant strains of *Enterococcus faecium* are especially alarming.

Van genes have rarely been found in *Staphylococcus aureus*, where changes in cell wall structure result in "intermediate" susceptibility, which is most commonly heterogeneous. Also, methicillin-resistant *staphylococcus* strains (MRSA) with reduced susceptibility for vancomycin were reported. The reduced susceptibility or resistance to vancomycin in *Staphylococcus* is not well understood. Several genetic elements and multiple mutations are required.

There is no cross-resistance between vancomycin and other classes of antibiotics. Cross-resistance with other glycopeptide antibiotics, such as teicoplanin, does occur. Secondary development of resistance during therapy is rare.

Synergism

The combination of vancomycin with an aminoglycoside antibiotic has a synergistic effect against many strains of *Staphylococcus aureus*, non-enterococcal group D-streptococci, enterococci and streptococci of the *Viridans* group. The combination of vancomycin with a cephalosporin has a synergistic effect against some oxacillin-resistant *Staphylococcus epidermidis* strains, and the combination of vancomycin with rifampicin has a synergistic effect against *Staphylococcus epidermidis* and a partial synergistic effect against some *Staphylococcus aureus* strains. As vancomycin in combination with a cephalosporin may also have an antagonistic effect against some *Staphylococcus epidermidis* strains and in combination with rifampicin against some *Staphylococcus aureus* strains, preceding synergism testing is useful.

Specimens for bacterial cultures should be obtained in order to isolate and identify the causative organisms and to determine their susceptibility to vancomycin.

Susceptibility testing breakpoints

Vancomycin is active against gram-positive bacteria, such as staphylococci, streptococci, enterococci, pneumococci, and clostridia. Gram-negative bacteria are resistant.

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. This information only provides approximate guidance on the chance whether micro-organisms are susceptible to vancomycin.

Minimum inhibitory concentration (MIC) breakpoints established by the European Committee on Antimicrobial Susceptibility Testing (EUCAST) are as follows:

| | Susceptible | Resistant |
|---|-------------|-----------|
| <i>Staphylococcus aureus</i> ¹ . | ≤ 2 mg/L | > 2 mg/L |
| Coagulase-negative staphylococci ¹ | ≤ 4 mg/L | > 4 mg/L |
| <i>Enterococcus</i> spp. | ≤ 4 mg/L | > 4 mg/L |
| <i>Streptococcus</i> groups A, B, C and G.. | ≤ 2 mg/L | > 2 mg/L |
| <i>Streptococcus pneumoniae</i> | ≤ 2 mg/L | > 2 mg/L |
| Gram positive anaerobes | ≤ 2 mg/L | > 2 mg/L |

¹S. aureus with vancomycin MIC values of 2 mg/L are on the border of the wild type distribution and there may be an impaired clinical response.

Commonly susceptible species

Gram positive

Enterococcus faecalis

Staphylococcus aureus

Methicillin-resistant *Staphylococcus aureus*

coagulase-negative Staphylococci

Streptococcus spp.

Streptococcus pneumoniae

Enterococcus spp.

Staphylococcus spp.

Anaerobic species

Clostridium spp. except *Clostridium innocuum*

Eubacterium spp.

Peptostreptococcus spp.

Species for which acquired resistance may be a problem

Enterococcus faecium

Inherently resistant

All Gram negative bacteria

Gram positive aerobic species

Erysipelothrix rhusiopathiae,

Heterofermentative Lactobacillus,

Leuconostoc spp

Pediococcus spp.

Anaerobic species

Clostridium innocuum

The emergence of resistance towards vancomycin differs from one hospital to another and a local microbiological laboratory should therefore be contacted for relevant local information.

5.2 Pharmacokinetic properties

Absorption

Vancomycin is administered intravenously for the treatment of systemic infections.

In the case of patients with normal renal function, intravenous infusion of multiple doses of 1g vancomycin (15 mg/kg) for 60 minutes produces approximate average plasma concentrations of 50-60 mg/L, 20-25 mg/L and 5-10 mg/L, immediately, 2 hours and 11 hours after completing the infusion, respectively. The plasma levels obtained after multiple doses are similar to those achieved after a single dose.

Vancomycin is not usually absorbed into the blood after oral administration. However, absorption may occur after oral administration in patients with (pseudomembranous) colitis. This may lead to vancomycin accumulation in patients with co-existing renal impairment.

Distribution

The volume of distribution is about 60 L/1.73 m²body surface. At serum concentrations of vancomycin of 10 mg/l to 100 mg/l, the binding of the drug to plasma proteins is approximately 30-55%, measured by ultra-filtration.

Vancomycin diffuses readily across the placenta and is distributed into cord blood. In non-inflamed meninges, vancomycin passes the blood-brain barrier only to a low extent.

Biotransformation

There is very little metabolism of the drug. After parenteral administration it is excreted almost completely as microbiologically active substance (approx. 75-90% within 24 hours) through glomerular filtration via the kidneys.

Elimination

The elimination half-life of vancomycin is 4 to 6 hours in patients with normal renal function and 2.2-3 hours in children. Plasma clearance is about 0.058 L/kg/h and kidney clearance about 0.048 L/kg/h. In the first 24 hours, approximately 80 % of an administered dose of vancomycin is excreted in the urine through glomerular filtration. Renal dysfunction delays the excretion of vancomycin. In anephric patients, the mean half-life is 7.5 days. Due to ototoxicity of vancomycin therapy-adjuvant monitoring of the plasma concentrations is indicated in such cases.

Biliary excretion is insignificant (less than 5% of a dose).

Although the vancomycin is not eliminated efficiently by haemodialysis or peritoneal dialysis, there have been reports of an increase in vancomycin clearance with haemoperfusion and haemofiltration.

After oral administration, only a fraction of the administered dose is recovered in the urine. In contrast, high concentrations of vancomycin are found in the faeces (>3100 mg/kg with doses of 2 g/day).

Linearity/non-linearity

Vancomycin concentration generally increases proportionally with increasing dose. Plasma concentrations during multiple dose administration are similar to those after the administration of a single dose.

Characteristics in specific groups

Renal impairment

Vancomycin is primarily cleared by glomerular filtration. In patients with impaired renal function the terminal elimination half-life of vancomycin is prolonged and the total body clearance is reduced. Subsequently, optimal dose should be calculated in line with dosing recommendations provided in section 4.2. Posology and method of administration.

Hepatic impairment

Vancomycin pharmacokinetics is not altered in patients with hepatic impairment.

Pregnant Women:

Significantly increased doses may be required to achieve therapeutic serum concentrations in pregnant women (see Section 4.6).

Overweight patients

Vancomycin distribution may be altered in overweight patients due to increases in volume of distribution, in renal clearance and possible changes in plasma protein binding. In these subpopulations vancomycin serum concentrations were found higher than expected in male healthy adults (see section 4.2).

Paediatric population

Vancomycin PK has shown wide inter-individual variability in preterm and term neonates. In neonates, after intravenous administration, vancomycin volume of distribution varies between 0.38 and 0.97 L/kg, similar to adult values, while clearance varies between 0.63 and 1.4 ml/kg/min. Half-life varies between 3.5 and 10 h and is longer than in adults, reflecting the usual lower values for clearance in the neonate.

In infants and older children, the volume of distribution ranges between 0.26-1.05 L/kg while clearance varies between 0.33-1.87 ml/kg/min.

5.3 Preclinical safety data

No reproduction tests were performed with the drug, so its effect on reproduction is not known. A conventional teratology study performed in female rats revealed no teratogenic effects and the same occurred in a similar study in female rabbits. In these species, the target organ of toxicity was the kidney.

Vancomycin has been studied in a number of standard studies *in vitro* and *in vivo* to determine the mutagenic potential, involving scanning of non-specific DNA damage, incidental mutations, chromosomal damage and loss of chromosomes.

The medicinal product was not genotoxic.

6 PHARMACEUTICAL PARTICULARS

6.1 List of excipients

Sodium hydroxide and hydrochloric acid (for pH adjustment).

6.2 Incompatibilities

Vancomycin solutions have a low pH that may cause chemical or physical instability if mixed with other compounds. Mixing with alkaline solutions should be avoided. Therefore, each parental solution should be checked visually for precipitation and discolouration prior to use.

This medicinal product must not be mixed with other solutions for infusion except those mentioned in section 6.6.

6.3 Shelf life

Powder:

2 years

Reconstituted Solution:

For intravenous use, the reconstituted solution should be diluted immediately after preparation.

For oral use, the reconstituted solution with purified water for oral administration is stable when stored at 2-8 °C for 48 hours.

Diluted solution:

Chemical and physical in- use stability has been demonstrated:

- for a period of 24 hours at 25 °C, after reconstitution and further dilution with sodium chloride 9 mg/ml (0.9%) or glucose solution 50 mg/ml (5%);
- for a period of 96 hours when stored at 2-8 °C, after reconstitution and further dilution with sodium chloride 9 mg/ml (0.9%) or glucose solution 50 mg/ml (5%), or Ringer's lactate solution or with sodium chloride 9 mg/ml (0.9%) + glucose 50 mg/ml (5%).

From a microbiological point of view the medicinal product should be used immediately.

6.4 Special precautions for storage

Powder as packed for sale

Store below 25 °C.

Keep the vial in the outer carton in order to protect from light.

For storage conditions of the reconstituted medicinal product and diluted medicinal product, see section 6.3.

6.5 Nature and contents of container

Immediate packaging: colourless type I glass vial, with a rubber stopper and an orange aluminium flip-off cap.

Secondary packaging: cartons containing 1, 5, 10 or 20 vials.

Not all pack sizes may be marketed.

6.6 Special precautions for disposal and other handling

Reconstituted solutions containing 50 mg/ml of vancomycin should be further diluted depending on the method of administration.

Preparation of the reconstituted solution

Dissolve the powder in 10 ml of sterile Water for injection

One ml of reconstituted solution contains 50 mg of vancomycin.

Appearance of reconstituted solution

After reconstitution the solution is clear and colorless to slightly yellowish brown without visible particles.

For storage conditions of the reconstituted medicinal product, see section 6.3.

Preparation of final diluted Solution for infusion

Reconstituted solutions containing 50 mg/ml of vancomycin should be further diluted.

Suitable diluents are:

- 5% Glucose Injection
- 0.9% Sodium Chloride Injection
- 5% Glucose Injection with 0.9% Sodium Chloride Injection
- Ringer's Lactate Injection

Intermittent infusion:

Reconstituted solution containing 500 mg vancomycin (50 mg/ml) must be diluted further with at least 100 ml diluent (to 5 mg/ml)

The concentration of vancomycin in Solution for infusion should not exceed 5 mg/ml.

The desired dose should be administered slowly by intravenous use at a rate of no more than 10 mg/minute, for at least 60 minutes or even longer.

Continuous infusion:

This should be used only if treatment with an intermittent infusion is not possible. Dilute 1000 mg to 2000 mg of dissolved vancomycin in a sufficient amount of the above suitable diluent and administer it in the form of a drip infusion, so that the patient will receive the prescribed daily dose in 24 hours.

Oral Administration

The contents of vials for parenteral administration may be used.

The reconstituted solutions containing 500 mg and 1000 mg of vancomycin can be diluted in 30 ml of water and given to the patient or administered through a nasogastric tube.

Appearance of diluted solution

After dilution the solution is clear and colorless without visible particles.

For storage conditions of the diluted medicinal product, see section 6.3.

Before administration, the reconstituted and diluted solutions should be inspected visually for particulate matter and discoloration. Only clear, and colorless solution free from particles should be used.

Disposal

Vials are for single use only. Unused medicinal products must be discarded.

Any unused medicinal product or waste material should be disposed of in accordance with local requirements.

7 MARKETING AUTHORISATION HOLDER

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