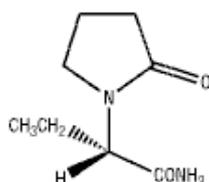


PRODUCT INFORMATION
LEVETIRACETAM SANDOZ® 500mg/5mL
CONCENTRATE SOLUTION FOR IV INFUSION

NAME OF THE MEDICINE

Levetiracetam

Chemical name: (2S)-2-(2-Oxopyrrolidin-1-yl)butanamide



CAS: 102767-28-2

Empirical formula: C₈H₁₄N₂O₂ MW: 170.21

DESCRIPTION

Each 5 mL of Levetiracetam Sandoz Concentrate solution for IV infusion contains 500 mg levetiracetam.

Levetiracetam is a pure enantiomer. It is a white to off white powder with a faint odour and a bitter taste. It is very soluble in water (104 g/100 mL). It is freely soluble in chloroform (65.3 g/100 mL) and in methanol (53.6 g/100 mL), soluble in ethanol (16.5g/100 mL), sparingly soluble in acetonitrile (5.7 g/100 mL) and practically insoluble in n-hexane.

Levetiracetam Sandoz contain the inactive ingredients sodium acetate trihydrate, sodium chloride, acetic acid- glacial and water for injections

PHARMACOLOGY

Pharmacological Action

The precise mechanism of action by which levetiracetam induces seizure protection still remains to be fully elucidated, but appears to be unrelated to the mechanisms of current antiepileptic drugs (AEDs). *In vitro* and *in vivo* experiments suggest that levetiracetam does not alter basic cell characteristics and normal neurotransmission.

In vitro studies show that levetiracetam affects intraneuronal Ca²⁺ levels by partial inhibition of N type Ca²⁺ currents and by reducing the release of Ca²⁺ from intraneuronal stores. In addition, it partially reverses the reductions in γ -amino butyric acid (GABA) and glycine gated currents induced by zinc and β -carbolines. Furthermore, levetiracetam has been shown in *in vitro* studies to bind to a specific site

in rodent brain tissue. This binding site is the synaptic vesicle protein 2A, believed to be involved in vesicle fusion and neurotransmitter exocytosis. Levetiracetam and related analogues show a rank order of affinity for binding to the synaptic vesicle protein 2A which correlates with the potency of their anti-seizure protection in the mouse audiogenic model of epilepsy. This finding suggests that the interaction between levetiracetam and the synaptic vesicle protein 2A seems to contribute to the antiepileptic mechanism of action of the drug.

Pharmacology

In animals

Levetiracetam is not active in the classical screening models for anticonvulsants, however, it induces potent protection in a broad range of animal models of partial and primary generalised seizures, with an unusually high safety margin between therapeutic doses and doses inducing adverse effects.

Levetiracetam also displays potential antiepileptogenic properties by dose dependently inhibiting the development of kindling, even after discontinuation of the active substance.

Withdrawal from chronic treatment did not decrease the seizure threshold. Anxiolytic action and an absence of undesirable effects on cognitive function have also been observed.

The major metabolite, ucb L057, is inactive in seizure models.

In man

Both partial and generalised epilepsy models (epileptiform discharge/ photoparoxysmal response) confirmed the broad spectrum preclinical pharmacological profile.

Pharmacokinetics

Levetiracetam is a highly soluble and permeable compound. The pharmacokinetic profile is linear and time independent with low intra- and inter-subject variability. There is no modification of the clearance after repeated administration. There is no evidence for any relevant gender, race or circadian variability. The pharmacokinetic profile is comparable in healthy volunteers and in patients with epilepsy.

Due to its complete and linear absorption, plasma levels can be predicted from the oral dose of levetiracetam expressed as mg/kg bodyweight. Therefore, there is no need for plasma level monitoring of levetiracetam.

A significant correlation between saliva and plasma concentrations has been shown in adults and children (ratio of saliva/ plasma concentrations ranged from 1 to 1.7 for oral tablet formulation and after four hours post-dose for oral solution formulation).

A single dose of levetiracetam 1,500 mg diluted in 100 mL of a compatible diluent and infused intravenously over 15 minutes is bioequivalent to levetiracetam 1,500 mg oral intake, given as three 500 mg tablets.

The intravenous administration of doses up to 4,000 mg diluted in sodium chloride 0.9% 100 mL infused over 15 minutes and doses up to 2,500 mg diluted in sodium chloride 0.9% 100 mL infused over five minutes was evaluated. The pharmacokinetic and safety profiles did not identify any safety concerns.

Adults and adolescents

Absorption

Levetiracetam is rapidly absorbed after oral administration. Oral absolute bioavailability is close to 100%. Peak plasma concentrations (C_{max}) are achieved at 1.3 hours after dosing. Steady state is achieved after two days of a twice daily administration schedule. Peak concentrations (C_{max}) are typically 31 and 43 mcg/mL following a single 1,000 mg dose and repeated 1,000 mg twice daily (bid) dose, respectively. The extent of absorption is dose independent and is not altered by food but the rate of absorption is slightly reduced.

Distribution

No tissue distribution data are available in humans. Neither levetiracetam nor its major metabolite (ucb L057) are significantly bound to plasma proteins (< 10%). The volume of distribution of levetiracetam is approximately 0.5 to 0.7 L/kg, a value close to the volume of distribution of intracellular and extracellular water.

Metabolism

The major metabolic pathway (24% of the dose) is an enzymatic hydrolysis of the acetamide group. Production of this metabolite, ucb L057, is not supported by liver cytochrome P450 isoforms. Hydrolysis of the acetamide group was measurable in a large number of tissues including whole blood but not plasma. The metabolite ucb L057 is pharmacologically inactive.

Two minor metabolites were also identified. One was obtained by hydroxylation of the pyrrolidone ring (1.6% of the dose) and the other one by opening of the pyrrolidone ring (0.9% of the dose). Other unidentified components accounted for only 0.6% of the dose. No enantiomeric interconversion was evidenced *in vivo* for either levetiracetam or its major metabolite ucb L057.

In vitro, levetiracetam and its primary metabolite have been shown not to inhibit the major human liver cytochrome P450 isoforms (CYP3A4, 2A6, 2C9, 2C19, 2D6, 2E1 and 1A2), glucuronyl transferase (UGT1A1 and UGT1A6) and epoxide hydroxylase activities. In addition, levetiracetam does not affect the *in vitro* glucuronidation of valproic acid.

In human hepatocytes *in vitro*, levetiracetam had no effect on CYP1A/2 or UGT isoform activities (including ethinyloestradiol conjugation). Levetiracetam caused mild induction of CYP2B6 and CYP3A4, but only at high concentrations not considered to be clinically relevant. Therefore, the interaction of levetiracetam with other substances, or *vice versa*, is unlikely.

Excretion

The plasma half-life in adults was 7 ± 1 hours and did not vary either with dose, route of administration or repeated administration. The mean total body clearance was of 0.96 mL/min/kg.

The major route of excretion was via urine, accounting for a mean 95% of the dose, with approximately 93% of the dose excreted within 48 hours. Excretion via faeces accounted for only 0.3% of the dose. The cumulative urinary excretion of levetiracetam and its major metabolite (ucb L057) accounted for 66% and 24% of the dose, respectively, during the first 48 hours.

The renal clearance of levetiracetam is 0.6 mL/minute/kg, indicating that it is excreted by glomerular filtration with subsequent tubular reabsorption. The renal clearance of the major metabolite, ucb L057, is 4.2 mL/minute/kg indicating active tubular secretion in addition to glomerular filtration.

Elderly. In elderly patients, the half-life is increased by about 40% (ten to eleven hours) and is attributed to the decrease in renal function in this population (see DOSAGE AND ADMINISTRATION).

Children (4 to 12 years of age). Following single dose administration (20 mg/kg) to epileptic children (6 to 12 years of age), the half-life of levetiracetam was 6.0 ± 1.1 hours. The apparent body clearance was approximately 30% higher than in epileptic adults.

Following repeated oral dose administration (20 to 60 mg/kg/day) to epileptic children (4 to 12 years of age), levetiracetam was rapidly absorbed. Peak plasma concentration was observed 0.5 to 1.0 hour after dosing. Linear and dose proportional increases were observed for peak plasma concentrations and area under the curve. The elimination half-life was approximately five hours. The apparent body clearance was 1.1 mL/minute/kg.

Infants and children (1 month to 4 years of age). Following single dose administration (20 mg/kg) of a 10% oral solution to epileptic children (1 month to 4 years of age), levetiracetam was rapidly absorbed and peak plasma concentrations were observed approximately one hour after dosing. The pharmacokinetic results indicated that half-life was shorter (5.3 hours) than for adults (7.2 hours) and apparent clearance was faster (1.5 mL/minute/kg) than for adults (0.96 mL/minute/kg).

Renal impairment. The apparent body clearance of both levetiracetam and its major metabolite (ucb L057) is correlated to the creatinine clearance. It is, therefore, recommended to adjust the maintenance daily dose of levetiracetam, based on creatinine clearance in patients with moderate and severe renal impairment (see DOSAGE AND ADMINISTRATION).

In anuric endstage renal disease adult subjects the half-life was approximately 25 and 3.1 hours during inter- and intra-dialytic periods, respectively. The fractional removal of levetiracetam was 51% during a typical four hour dialysis session.

Hepatic impairment. In subjects with mild and moderate hepatic impairment, there was no relevant modification of the clearance of levetiracetam. In most subjects with severe hepatic impairment, the clearance of levetiracetam was reduced by more than 50% due to concomitant renal impairment (see DOSAGE AND ADMINISTRATION)

CLINICAL TRIALS

Effectiveness in partial onset seizures in adults and adolescents

Monotherapy

The monotherapy study was designed as a double blind, parallel group, non-inferiority comparison of levetiracetam and carbamazepine controlled release in patients 16 years of age or older with newly diagnosed epilepsy. The seizures were to be either unprovoked partial seizures, type IA (simple partial seizures with unimpaired consciousness), IB (complex partial seizures with impaired consciousness), or IC (partial seizures secondarily generalised (with clear focal origin)) or IIE (generalised tonic clonic seizure (without clear focal origin)), classifiable according to the International Classification of Epileptic Seizures. The study was performed in 85 centers in 13 countries (Europe and South Africa).

At the end of the one week screening period, eligible subjects were stratified by seizure type (IA/IB/IC or IC/IIE without clear focal origin) and randomly assigned to receive carbamazepine (CBZ) controlled release (CR) (n = 291) or levetiracetam (LEV) (n = 285) for up to 121 weeks depending on response. Conservatively, a CR formulation of carbamazepine was used to minimise adverse effects. The maximal duration for an individual subject was 121 weeks.

After a one week screening period (no study drug intake), the subject was randomised and entered a two week up titration period to the first target daily dose (LEV 1,000 mg/CBZ 400 mg), followed by a one week stabilisation period and an evaluation period of 26 weeks in order to achieve a six month seizure freedom (primary efficacy endpoint) and followed by a maintenance period of 26 additional weeks in order to assess safety and maintenance of efficacy.

If a seizure occurred during the evaluation period, dose escalation (made over a two week period) to the second target daily dose (LEV 2,000 mg/CBZ 800 mg) was foreseen. This was followed by a one week stabilisation period, a new evaluation period of 26 weeks and a maintenance period of 26 additional weeks. The same was true if a seizure occurred during the evaluation period at the second dose level: dose escalation (made over a two week period) to the third target daily dose (LEV 3,000 mg/CBZ 1,200 mg), followed by a one week stabilisation period, a new evaluation period of 26 weeks and a maintenance period of 26 additional weeks. Fall back option: in case a subject did not tolerate the second or third study drug target dose, he/she had the opportunity, during the evaluation or the maintenance period, to have one fallback to an intermediate dose (decrease by 200 mg/day for CBZ or by 500 mg/day for LEV) and to continue in the trial on that basis. The subject could not resume the previous dose and could not have further up titration in case a new seizure occurred.

576 subjects were randomised. Approximately one half of the patients in each treatment group completed the study (53.6% of the patients randomised to CBZ and 54.0% of the patients randomised to LEV), similar between the two treatment groups. The distribution by seizure type categories was similar in both treatment groups, with around 86.7% of subjects lastly classified as experiencing partial seizures with clear focus origin. The majority of subjects remained at dose level one (81.7% of subjects randomised to CBZ and 73.4% of subjects randomised to LEV in the per protocol (PP population)).

The prospectively defined primary endpoint was the proportion of subjects from the PP population with six month seizure freedom at the last evaluated dose.

One hundred seventy three (73.0%) of the PP subjects in the LEV arm were seizure free for at least six months at the last evaluated dose, compared to 171 subjects (72.8%) in the CBZ arm. The adjusted absolute difference LEV and CBZ (95% two sided confidence interval) obtained from a logistic regression model including a factor for the seizure type category as last assessed (IA/IB/IC versus IC/IIE) equalled 0.2% (-7.8%; 8.2%). The lower limit of the confidence interval (-7.8%) was above the non-inferiority limit set by protocol (-15%) for this primary efficacy analysis and, therefore, LEV can be considered as non-inferior to CBZ on the proportion of subjects seizure free at least six months at the first evaluated dose in the PP population. Considering the other clinically relevant endpoint, 56.6 and 58.5% of subjects on LEV and CBZ, respectively, were seizure free for one year.

Add on therapy

The effectiveness of levetiracetam tablets as adjunctive therapy (added to other AEDs) in adults was established in three multicentre, randomised, double blind, placebo controlled clinical studies in patients who had refractory partial onset seizures with or without secondary generalisation. In these studies, 904 patients were randomised to placebo, 1,000, 2,000 or 3,000 mg/day. Patients enrolled in study 1 or study 2 had refractory partial onset seizures for at least two years and had taken two or more classical AEDs. Patients enrolled in study 3 had refractory partial onset seizures for at least one year and had taken one classical AED. At the time of the study, patients were taking a stable dose regimen of at least one and could take a maximum of two AEDs. During the baseline period, patients had to have experienced at least two partial onset seizures during each four week period.

Study 1

Study 1 was a double blind, placebo controlled, parallel group study conducted at 41 sites in the United States comparing levetiracetam 1,000 mg/day (n = 97), levetiracetam 3,000 mg/day (n = 101) and placebo (n = 95) given in equally divided doses twice daily. After a prospective baseline period of 12 weeks, patients were randomised to one of the three treatment groups described above. The 18 week treatment period consisted of a six week titration period, followed by a 12 week fixed dose evaluation period, during which concomitant AED regimens were held constant. The primary measure of effectiveness was a between group comparison of the percent reduction in weekly partial seizure frequency relative to placebo over the entire randomised treatment period (titration plus evaluation period). Secondary outcome variables included the responder

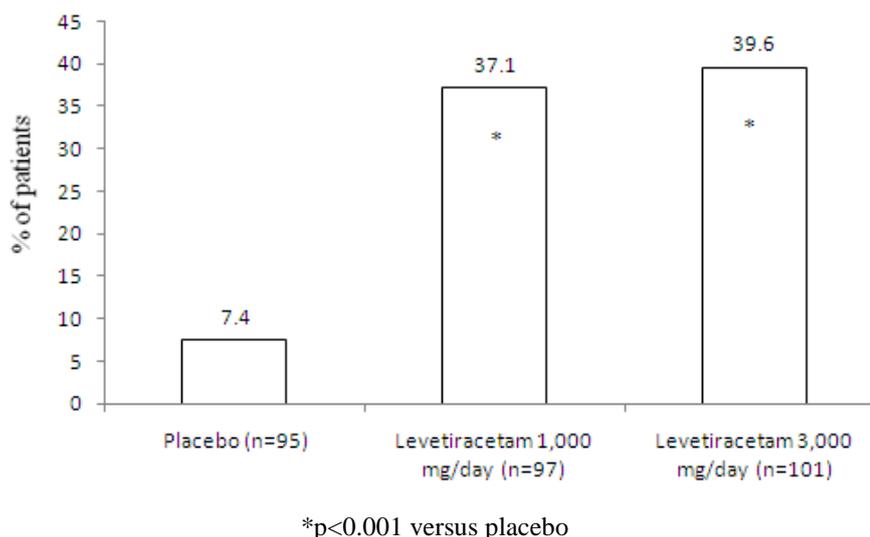
rate (incidence of patients with $\geq 50\%$ reduction from baseline in partial onset seizure frequency). The results of the analysis of study 1 are displayed in Table 1.

Table 1: Reduction in mean over placebo in weekly frequency of partial onset seizures in study 1

	Placebo (n=95)	Levetiracetam 1000 mg/day (n=97)	Levetiracetam 3000 mg/day (n=101)
Percent reduction in partial seizure frequency over placebo	-	26.1% p<0.001	30.1% p<0.001

The percentage of patients (y-axis) who achieved $\geq 50\%$ reduction in weekly seizure rates from baseline in partial onset seizure frequency over the entire randomised treatment period (titration plus evaluation period) within the three treatment groups (x-axis) is presented in Figure 1.

Figure 1: Responder rate ($\geq 50\%$ reduction from baseline) in study 1



Study 2

Study 2 was a double blind, placebo controlled, crossover study conducted at 62 centres in Europe comparing levetiracetam 1,000 mg/day (n = 106), levetiracetam 2,000 mg/day (n = 105) and placebo (n = 111) given in equally divided doses twice daily.

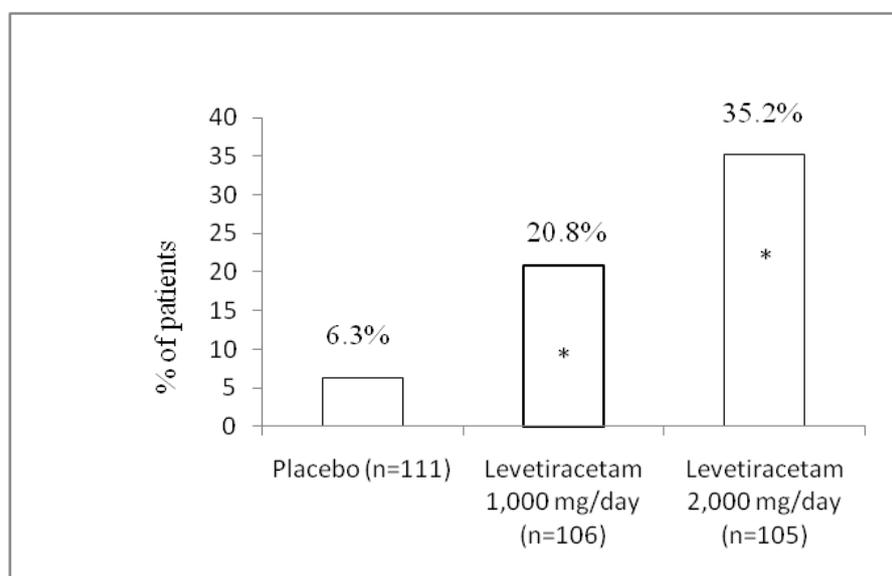
The first period of the study (period A) was designed to be analysed as a parallel group study. After a prospective baseline period of up to 12 weeks, patients were randomised to one of the three treatment groups described above. The 16 week treatment period consisted of the four week titration period followed by a 12 week fixed dose evaluation period, during which concomitant AED regimens were held constant. The primary measure of effectiveness was a between group comparison of the percent reduction in weekly partial seizure frequency relative to placebo over the entire randomised treatment period (titration plus evaluation period). Secondary outcome variables included the responder rate (incidence of patients with $\geq 50\%$ reduction from baseline in partial onset seizure frequency). The results of the analysis of period A are displayed in Table 2.

Table 2: Reduction in mean over placebo in weekly frequency of partial onset seizures in study 2 – period A

	Placebo (n=111)	Levetiracetam 1000 mg/day (n=106)	Levetiracetam 2000 mg/day (n=105)
Percent reduction in partial seizure frequency over placebo	-	17.1% p<0.001	21.4% p<0.001

The percentage of patients (y-axis) who achieved $\geq 50\%$ reduction in weekly seizure rates from baseline in partial onset seizure frequency over the entire randomised treatment period (titration plus evaluation period) within the three treatment groups (x-axis) is presented in Figure 2.

Figure 2: Responder rate ($\geq 50\%$ reduction from baseline) in study 2 – period A



*p<0.001 versus placebo

The comparison of levetiracetam 2,000 mg/day to levetiracetam 1,000 mg/day for responder rate was statistically significant (p = 0.02). Analysis of the trial as a crossover yielded similar results.

Study 3

Study 3 was a double blind, placebo controlled, parallel group study conducted at 47 centres in Europe comparing levetiracetam 3,000 mg/day (n = 180) and placebo (n = 104) in patients with refractory partial onset seizures, with or without secondary generalisation, receiving only one concomitant AED. Study drug was given in two divided doses. After a prospective baseline period of 12 weeks, patients were randomised to one of two treatment groups described above. The 16 week treatment period consisted of a four week titration period, followed by a 12 week fixed dose evaluation period, during which concomitant AED doses were held constant. The primary measure of effectiveness was a between group comparison of the percent reduction in weekly seizure frequency relative to placebo over the entire randomised treatment period (titration plus evaluation period). Secondary outcome variables

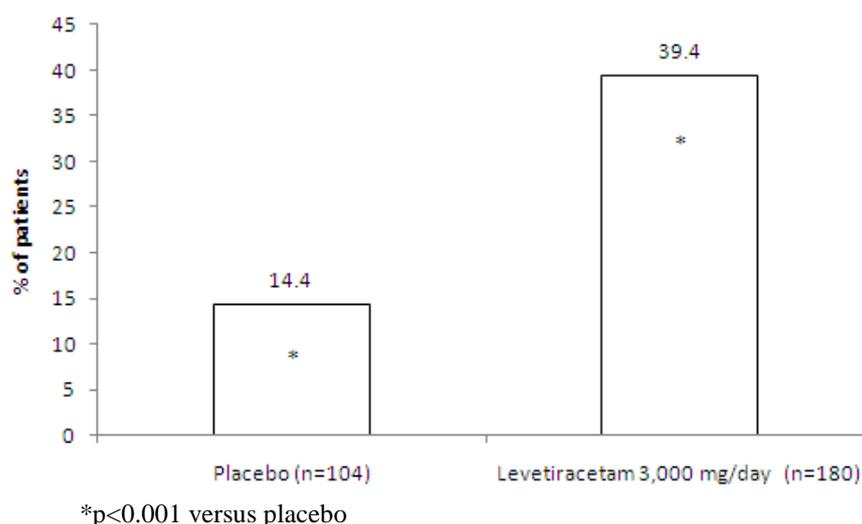
included the responder rate (incidence of patients with $\geq 50\%$ reduction from baseline in partial onset seizure frequency). Table 3 displays the results of the analysis of study 3.

Table 3: Reduction in mean over placebo in weekly frequency of partial onset seizures in study 3

	Placebo (n=104)	Levetiracetam 3000 mg/day (n=180)
Percent reduction in partial seizure frequency over placebo	-	23.0% p<0.001

The percentage of patients (y-axis) who achieved $\geq 50\%$ reduction in weekly seizure rates from baseline in partial onset seizure frequency over the entire randomised treatment period (titration plus evaluation period) within the two treatment groups (x-axis) is presented in Figure 3.

Figure 3: Responder rate ($\geq 50\%$ reduction from baseline) in study 3



Effectiveness in partial onset seizures in paediatric patients with epilepsy

The effectiveness of levetiracetam as adjunctive therapy (added to other AEDs) in paediatric patients was established in a multicentre, randomised double blind, placebo controlled study, conducted at 60 sites in North America, in children 4 to 16 years of age with partial seizures uncontrolled by standard AEDs. Eligible patients on a steady dose of one to two AEDs, who still experienced at least four partial onset seizures during the four weeks prior to screening, as well as at least four partial onset seizures in each of the two four week baseline periods, were randomised to receive either levetiracetam or placebo. The population included 198 patients (levetiracetam, n = 101; placebo, n = 97) with uncontrolled partial onset seizures, whether or not secondarily generalised. The study consisted of an eight week baseline period and four week titration period followed by a ten week evaluation period. Dosing was initiated at a target dose of 20 mg/kg/day in two divided doses. During the treatment period, levetiracetam doses were adjusted in 20 mg/kg/day increments, at two week intervals to the target dose of 60 mg/kg/day (or 40 mg/kg/day as a maximum tolerated dose).

The primary measure of effectiveness was a between group comparison of the percent reduction in weekly partial seizure frequency relative to placebo over the entire randomised treatment period (titration plus evaluation period). Secondary outcome variables included the responder rate (incidence of patients with $\geq 50\%$ reduction from baseline in partial onset seizure frequency per week). Table 4 displays the results of this study.

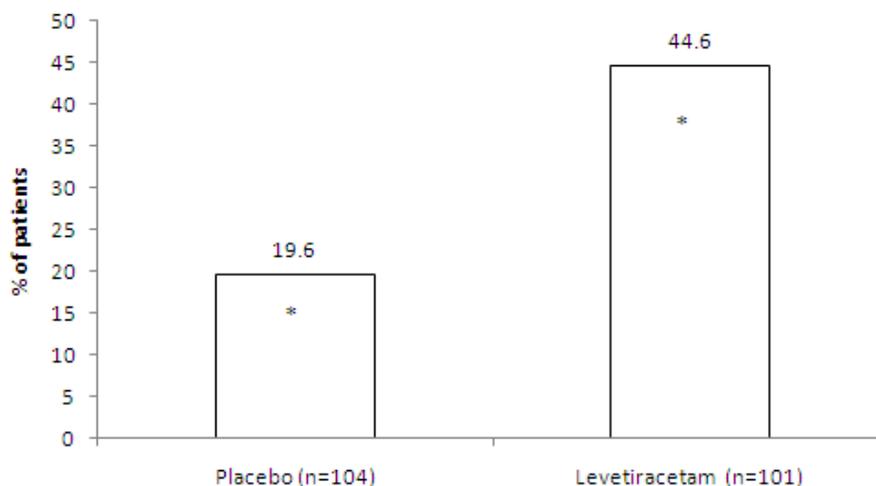
Table 4: Reduction in mean over placebo in weekly frequency of partial onset seizures

	Placebo (n=97)	Levetiracetam (n=101)
Percent reduction in partial seizure frequency over placebo	-	26.8%*

*P=0.0002

The percentage of patients (y-axis) who achieved $\geq 50\%$ reduction in weekly seizure rates from baseline in partial onset seizure frequency over the entire randomised treatment period (titration plus evaluation period) within the two treatment groups (x-axis) is presented in Figure 4.

Figure 4: Responder rate ($\geq 50\%$ reduction from baseline)



*p<0.0002 versus placebo

Effectiveness in myoclonic seizures in patients ≥ 12 years of age with juvenile myoclonic epilepsy

The effectiveness of levetiracetam as adjunctive therapy in patients 12 years of age and older with Juvenile Myoclonic Epilepsy (JME) experiencing myoclonic seizures was established in one multicentre, randomised, double blind, placebo controlled study conducted at 37 sites in 14 countries. Eligible patients on a stable dose of one AED experiencing one or more myoclonic seizures per day for at least eight days during the prospective eight week baseline period were randomised to either levetiracetam or placebo. The population included 120 patients (levetiracetam, n = 60; placebo, n = 60) with idiopathic generalised epilepsy (IGE) which included JME, juvenile absence epilepsy or epilepsy with generalised tonic clonic seizures on awakening. The majority were patients with JME. Patients were titrated over four weeks to a target dose of 3,000

mg/day and treated at a stable dose of 3,000 mg/day over 12 weeks (evaluation period). Study drug was given in two divided doses.

The primary measure of effectiveness was the proportion of patients with at least 50% reduction in the number of days per week with one or more myoclonic seizures during the treatment period (titration + evaluation periods) as compared to baseline. Secondary outcome variables included seizure frequency per week over the treatment period. Table 5 displays the results of this study.

Table 5: Responder rate ($\geq 50\%$ reduction from baseline) in myoclonic seizure days per week for patients with JME

	Placebo (n=60)	Levetiracetam (n=60)
Percentage of responders	23.3%	58.3%

*p=0.0002

Effectiveness in primary generalised tonic clonic seizures in patients ≥ 4 years of age with idiopathic generalised epilepsy

The effectiveness of levetiracetam as adjunctive therapy (added to other AEDs) in patients 4 years of age and older with IGE experiencing primary generalised tonic clonic (PGTC) seizures was established in one multicentre, randomised, double blind, placebo controlled study, conducted at 50 sites in eight countries. Eligible patients on a stable dose of one or two AEDs experiencing at least three PGTC seizures during the eight week combined baseline period (at least one PGTC seizure during the four weeks prior to the prospective baseline period and at least one PGTC seizure during the four week prospective baseline period) were randomised to either levetiracetam or placebo. The eight week combined baseline period is referred to as ‘baseline’ in the remainder of this section. The population included 164 patients (levetiracetam, n = 80; placebo, n = 84) with IGE (predominately JME, juvenile absence epilepsy, childhood absence epilepsy or epilepsy with grand mal seizures on awakening) experiencing PGTC seizures. Each of these syndromes of IGE was well represented in this patient population. Patients were titrated over four weeks to a target dose of 3,000 mg/day for adults or a pediatric target dose of 60 mg/kg/day and treated at a stable dose of 3,000 mg/day (or 60 mg/kg/day for children) over 20 weeks (evaluation period). Study drug was given in two equally divided doses per day.

The primary measure of effectiveness was the percent reduction from baseline in weekly PGTC seizure frequency for levetiracetam and placebo treatment groups over the treatment period (titration + evaluation periods). There was a statistically significant decrease from baseline in PGTC frequency in the levetiracetam treated patients compared to the placebo treated patients (see Table 6).

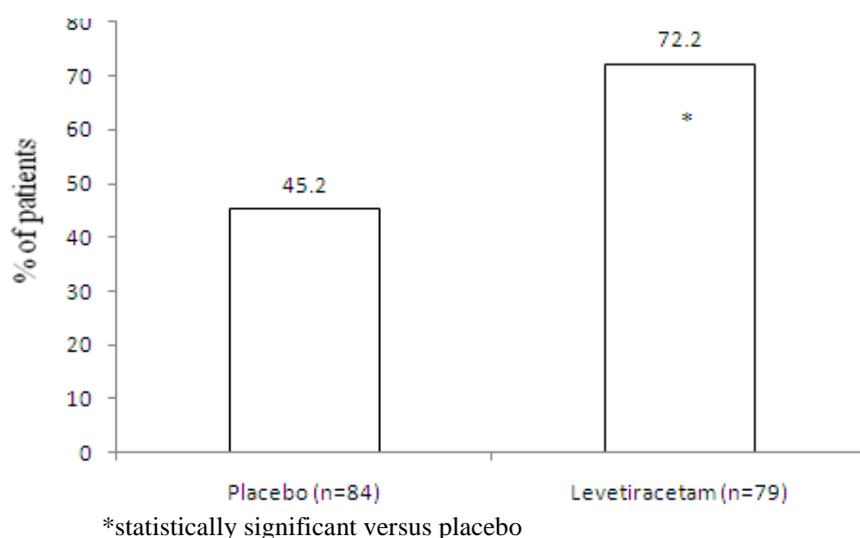
Table 6: Median percent reduction from baseline in PGTC seizure frequency per week

	Placebo (n=84)	Levetiracetam (n=78)
Percentage reduction in PGTC seizure frequency	44.6%	77.6%

*statistically significant versus placebo

The percentage of patients (y-axis) who achieved $\geq 50\%$ reduction in weekly seizure rates from baseline in PGTC seizure frequency over the entire randomised treatment period (titration + evaluation period) within the two treatment groups (x-axis) is presented in Figure 5.

Figure 5: Responder rate ($\geq 50\%$ reduction from baseline) in PGTC seizure frequency per week



When levetiracetam was used to treat PGTC seizures in adults and adolescents with IGE, there was no effect on the frequency of absences.

INDICATIONS

Levetiracetam Sandoz concentrate solution for IV infusion after dilution is an alternative for patients when oral administration is temporarily not feasible.

Levetiracetam Sandoz concentrate solution for IV infusion is indicated for:

- Use in epileptic patients aged 4 years and older, initially as add-on therapy, in the treatment of partial onset seizures with or without secondary generalisation.
- Monotherapy in the treatment of partial onset seizures, with or without secondary generalisation, in patients from 16 years of age with newly diagnosed epilepsy.
- Add on therapy in the treatment of myoclonic seizures in adults and adolescents from 12 years of age with Juvenile Myoclonic Epilepsy (JME).
- Add on therapy in the treatment of PGTC seizures in adults and children from 4 years of age with idiopathic generalized epilepsy (IGE).

CONTRAINDICATIONS

Hypersensitivity to levetiracetam or other pyrrolidone derivatives or any other excipients (see DESCRIPTION).

PRECAUTIONS

In accordance with current clinical practice, if levetiracetam has to be discontinued it is recommended to withdraw it gradually.

Levetiracetam Sandoz concentrate solution for IV infusion should not be administered by rapid infusion or direct IV injection.

To date, there is no data to support the use of levetiracetam concentrate solution for IV infusion for status epilepticus.

Due to its complete and linear absorption, plasma levels can be predicted from the oral dose of levetiracetam expressed as mg/kg bodyweight. There is no need, therefore, for plasma level monitoring of levetiracetam.

No data on the interaction of levetiracetam with alcohol are available.

Suicidal behaviour and ideation

Antiepileptic drugs, including levetiracetam, increase the risk of suicidal thoughts or behaviour in patients taking these drugs for any indication. Patients treated with any AED for any indication should be monitored for the emergence or worsening of depression, suicidal thoughts or behaviour, and/or any unusual changes in mood or behaviour.

Pooled analyses of 199 placebo controlled clinical trials (mono and adjunctive therapy) of 11 different AEDs showed that patients randomised to one of the AEDs had approximately twice the risk (adjusted relative risk 1.8, 95% CI: 1.2, 2.7) of suicidal thinking or behaviour compared to patients randomised to placebo. In these trials, which had a median treatment duration of 12 weeks, the estimated incidence rate of suicidal behaviour or ideation among 27,863 AED treated patients was 0.43%, compared to 0.24% among 16,029 placebo treated patients, representing an increase of approximately one case of suicidal thinking or behaviour for every 530 patients treated. There were four suicides in drug treated patients in the trials and none in placebo treated patients, but the number is too small to allow any conclusion about drug effect on suicide.

The increased risk of suicidal thoughts or behaviour with AEDs was observed as early as one week after starting drug treatment with AEDs and persisted for the duration of treatment assessed. Because most trials included in the analysis did not extend beyond 24 weeks, the risk of suicidal thoughts or behaviour beyond 24 weeks could not be assessed.

The risk of suicidal thoughts or behaviour was generally consistent among drugs in the data analysed. The finding of increased risk with AEDs of varying mechanisms of

action and across a range of indications suggests that the risk applies to all AEDs used for any indication. The risk did not vary substantially by age (5-100 years) in the clinical trials analysed. Table 7 shows absolute and relative risk by indication for all evaluated AEDs.

Table 7: Risk by indication for antiepileptic drugs in the pooled analysis

Indication	Placebo patients with events/1000 patients	Drug patients with events/1000 patients	Relative risk: incidence of events in drug patients/incidence in placebo patients	Risk difference additional drug patients with events/1000 patients
Epilepsy	1.0	3.4	3.5	2.4
Psychiatric	5.7	8.5	1.5	2.9
Other	1.0	1.8	1.9	0.9
Total	2.4	4.3	1.8	1.9

The relative risk for suicidal thoughts or behaviour was higher in clinical trials for epilepsy than in clinical trials for psychiatric or other conditions, but the absolute risk differences were similar for the epilepsy and psychiatric indications.

Anyone considering prescribing levetiracetam or any other AED must balance this risk with the risk of untreated illness. Epilepsy and many other illnesses for which AEDs are prescribed are themselves associated with morbidity and mortality and an increased risk of suicidal thoughts and behaviour. Should suicidal thoughts and behaviour emerge during treatment, the prescriber needs to consider whether the emergence of these symptoms in any given patient may be related to the illness being treated.

Patients, their caregivers, and families should be informed that AEDs increase the risk of suicidal thoughts and behaviour and should be advised of the need to be alert for the emergence of worsening of the signs and symptoms of depression, any unusual changes in mood or behaviour, or the emergence of suicidal thoughts, behaviour, or thoughts about self-harm. Behaviours of concern should be reported immediately to the treating doctor.

Impaired renal and hepatic function

The administration of levetiracetam to patients with renal impairment may require dose adaptation. Monitoring of renal function in patients with severe hepatic impairment is recommended before dose selection (see DOSAGE AND ADMINISTRATION).

Acute kidney injury

The use of levetiracetam has been associated with acute kidney injury.

Blood cell counts

Decreased blood cell counts (neutropenia, agranulocytosis, leukopenia, thrombocytopenia and pancytopenia) have been reported in association with levetiracetam administration. Complete blood cell counts are advised in patients experiencing important weakness, pyrexia, recurrent infections or coagulation disorders.

Effects on fertility

There are no human data on the effects of levetiracetam on male or female fertility. No adverse effects on male or female fertility or reproductive performance were observed in rats at oral doses of levetiracetam up to 1,800 mg/kg/day (corresponding to approximately six times the maximal recommended clinical dose on a mg/m² basis) administered for at least two weeks prior to, and throughout, mating.

Use in pregnancy (Category B3)

Category B3: Drugs which have been taken by only a limited number of pregnant women and women of childbearing age, without an increase in the frequency of malformation or other direct or indirect harmful effects on the human foetus having been observed.

Studies in animals have shown evidence of an increased occurrence of fetal damage, the significance of which is considered uncertain in humans.

In rats and rabbits, levetiracetam and/or its metabolites cross the placenta and the fetal levels approximate maternal plasma levels. In these species, levetiracetam produced evidence of developmental toxicity at doses similar to or greater than human therapeutic doses.

Oral administration to female rats from two weeks prior to mating and throughout pregnancy and lactation was associated with increased incidences of minor fetal skeletal abnormalities and retarded offspring growth prenatally and/or postnatally at doses \geq 350 mg/kg/day (approximately equivalent to the maximal recommended clinical dose of 3,000 mg/day on a mg/m² basis) and with increased pup mortality and offspring behavioural alterations at a dose of 1,800 mg/kg/day (six times the maximal human dose on a mg/m² basis). The developmental no effect dose was 70 mg/kg/day (equivalent to 0.2 times the maximal human dose on a mg/m² basis). There was no overt maternal toxicity at the doses used in this study.

Oral administration to pregnant rabbits during the period of organogenesis resulted in increased embryofetal mortality and increased incidences of minor fetal skeletal abnormalities at doses \geq 600 mg/kg/day (about four times the maximal human dose on a mg/m² basis) and in decreased fetal weights and increased incidences of minor fetal skeletal anomalies at a dose of 1,800 mg/kg/day (12 times the maximal human dose on a mg/m² basis). The developmental no effect dose was 200 mg/kg/day (1.3 times the maximal human dose on a mg/m² basis). Maternal toxicity was also observed at 1,800 mg/kg/day.

Oral administration to pregnant rats during the period of organogenesis resulted in reduced fetal weight and increased incidence of embryo fetal mortality and increased incidence of fetal skeletal variations at a dose of 3,600 mg/kg/day (12 times the maximal human dose on a mg/m² basis). The developmental no effect dose was 1,200 mg/kg/day (four times the maximal human dose on a mg/m² basis). There was no overt maternal toxicity.

Oral administration to rats during the late gestation and throughout lactation produced no adverse developmental or maternal effects at doses of up to 1,800 mg/kg/day (six times the maximal human dose on a mg/m² basis).

Neonatal and juvenile animal studies in rats and dogs demonstrated that there were no adverse effects seen in any of the standard developmental or maturation endpoints at doses of up to 1,800 mg/kg/day corresponding to 30 times the maximum recommended human dose.

The risk of having an abnormal child as a result of antiepileptic medication is far outweighed by the dangers to the mother and foetus of uncontrolled epilepsy.

It is recommended that:

- women on AEDs receive pre-pregnancy counselling with regard to the risk of fetal abnormalities;
- AEDs should be continued during pregnancy and monotherapy should be used if possible at the lowest effective dose as risk of abnormality is greater in women taking combined medication;
- folic acid supplementation (5 mg) should be commenced four weeks prior to and continue for 12 weeks after conception;
- specialist prenatal diagnosis including detailed mid-trimester ultrasound should be offered.

Post-marketing data from several prospective pregnancy registries have documented outcomes in over 1000 women exposed to levetiracetam monotherapy during the first trimester of pregnancy. Overall, these data do not suggest a substantial increase in the risk for major congenital malformations, although a teratogenic risk cannot be completely excluded. Therapy with multiple antiepileptic drugs is associated with a higher risk of congenital malformations than monotherapy and therefore monotherapy should be considered.

Levetiracetam should be used during pregnancy only if the potential benefit justifies the potential risk to the foetus. As with other AEDs, physiological changes during pregnancy may affect levetiracetam concentration. There have been reports of decreased levetiracetam concentrations during pregnancy. This decrease is more pronounced during the third trimester (up to 60 % of baseline concentration before pregnancy).

Use in lactation

Levetiracetam and/or its metabolites are excreted in milk in lactating rats; peak milk concentrations occurred three hours after oral administration (milk: plasma ratio 0.9). Levetiracetam is excreted in human breast milk. Because of the potential for serious adverse reactions in breastfeeding infants from levetiracetam, a decision should be made whether to discontinue breastfeeding or discontinue the drug, taking into account the importance of the drug to the mother.

Paediatric use

To date, there are no data to support the use of levetiracetam in patients less than 4 years of age.

Use in the elderly

See DOSAGE AND ADMINISTRATION.

Genotoxicity

Levetiracetam was negative in gene mutation assays (bacterial, Chinese hamster ovary/ Hypoxanthine-guanine phosphoribosyl transferase (HGPRT) locus) and in assays for chromosomal damage *in vitro* and *in vivo* (Chinese hamster ovary cells, mouse micronucleus assay). The hydrolysis product and major human metabolite (ucb L057) was not mutagenic in bacterial reverse mutation assays or the *in vitro* mouse lymphoma assay.

Carcinogenicity

There was no evidence of carcinogenicity following administration of levetiracetam in the diet to rats or orally to mice for 104 weeks, associated with respective systemic exposures (plasma AUC) up to fourfold and eightfold that in humans at the maximal recommended clinical dose of 3,000 mg/day.

Effect on ability to drive or operate machinery.

No studies on the effects on the ability to drive and use machines have been performed.

Due to possible different individual sensitivity, some patients might experience, at the beginning of treatment or following a dosage increase, somnolence or other central nervous system (CNS) related symptoms. Therefore, caution is recommended in those patients when performing skilled tasks, e.g. driving vehicles or operating machinery.

INTERACTIONS WITH OTHER MEDICINES

In vitro, levetiracetam and its major metabolite (ucb L057) have been shown not to inhibit the major human liver cytochrome P450 isoforms, glucuronyl transferase, (valproic acid) and epoxide hydroxylase activities. In human hepatocytes in culture, levetiracetam did not cause enzyme induction.

Probenecid (500 mg four times daily) has been shown to inhibit the renal clearance of the major metabolite (ucb L057) but not levetiracetam. Nevertheless, the concentration of ucb L057 remains low. It is expected that other drugs excreted by active tubular secretion could also reduce the renal clearance of the metabolite. The effect of levetiracetam on probenecid was not studied and the effect of levetiracetam on other actively secreted drugs, e.g. nonsteroidal anti-inflammatory drugs (NSAIDs), sulfonamides and methotrexate is unknown.

Premarketing data from clinical studies conducted in adults indicate that levetiracetam did not influence the serum concentrations of existing antiepileptic medicinal products (phenytoin, carbamazepine, valproic acid, phenobarbital, lamotrigine, gabapentin and primidone) and that these antiepileptic medicinal products did not influence the pharmacokinetics of levetiracetam.

Consistent with formal pharmacokinetic studies in adults, there has been no clear evidence of clinically significant drug interactions in paediatric patients receiving up to 60 mg/kg/day.

A retrospective assessment of pharmacokinetic interactions in children and adolescents with epilepsy (4 to 17 years) confirmed that adjunctive therapy with levetiracetam did not influence the steady-state serum concentrations of concomitantly administered carbamazepine, valproate, topiramate and lamotrigine. However, data suggested that enzyme inducing antiepileptic medicinal products increase levetiracetam clearance by 22%. Dosage adjustment is not required.

Pharmacokinetic studies demonstrated a lack of interaction with digoxin, oral contraceptives (ethinylloestradiol and levonorgestrel) and warfarin. Endocrine parameters (luteinising hormone (LH) and progesterone) and prothrombin times were not modified.

No data on the influence of antacids on the absorption of levetiracetam are available.

ADVERSE EFFECTS

The prescriber should be aware that the following data were obtained from studies where levetiracetam was added to concomitant antiepileptic therapy. Therefore, it was not possible in all cases to determine which agent(s), if any, was associated with the adverse events. It is also difficult to predict the frequency of adverse events in the course of usual medical practice where patient characteristics and other factors may differ from those prevailing during clinical studies.

Adult patients

Levetiracetam has been administered to more than 3,000 subjects and patients. Of these, 780 patients were treated for more than six months, 592 for more than one year, 366 for more than two years and 185 for more than three years.

1,023 adult patients with epilepsy participated in controlled clinical trials (672 patients were treated with levetiracetam and 351 patients with placebo).

From placebo controlled studies conducted in adults, 46.4 and 42.2% of patients experienced drug related, treatment emergent adverse events in the levetiracetam group and placebo group, respectively. 2.4 and 2.0% of patients experienced serious drug related, treatment emergent adverse events in the levetiracetam group and placebo group, respectively.

During monotherapy treatment with levetiracetam, 79.6% of subjects experienced at least one adverse event and 49.8% experienced at least one drug related undesirable effect. The most frequently reported adverse effects were fatigue and somnolence.

Very common adverse events ($\geq 10\%$)

The very common adverse events ($\geq 10\%$) were somnolence, asthenia, infection, headache and accidental injury. Of these, somnolence, asthenia and infection appeared to occur more frequently in levetiracetam treated patients than in placebo treated patients, whereas accidental injury was more common in the placebo group and headache was similarly reported in the two groups.

Table 8: Incidence (%) of very common treatment-emergent adverse events in adult placebo-controlled studies, by body system

Body System/Adverse Event	Levetiracetam group (n=672) %	Placebo group (n=351) %
Body as a whole		
Accidental Injury	10.3	16.5
Asthenia	14.1	9.7
Headache	13.1	13.7
Infection	13.2	7.4
Nervous system		
Somnolence	14.9	9.7

In the pooled safety analysis, there was no clear dose response relationship but incidence and severity of CNS related undesirable effects decreased over time.

More than 93% of events categorised under the Coding Symbols for Thesaurus of Adverse Reaction Terms (COSTART) preferred term ‘infection’ are symptoms of community acquired infections (common cold and upper respiratory tract infections). There was no increase in incidence of other infections (e.g. lower respiratory tract infections, urinary tract infections, etc.). Minor, but statistically significant, decreases compared to placebo in total mean red blood cell count ($0.03 \times 10^6/\text{mm}^2$), mean haemoglobin (0.9 g/L) and mean haematocrit (0.38%) were seen in levetiracetam treated patients in controlled trials. A total of 3.2% of treated and 1.8% of placebo patients had at least one possibly significant ($\leq 2.8 \times 10^9/\text{L}$) decreased white blood cell, and 2.4% for treated and 1.4% of placebo patients had at least one possible significant ($\leq 1.0 \times 10^9/\text{L}$) decreased neutrophil count. Of the treated patients with a low neutrophil count, all but one rose towards or to baseline with continued treatment. No patient was discontinued secondary to low neutrophil counts.

Common adverse events ($\geq 1\%$ and $< 10\%$) (See Table 9)

Table 9: Incidence (%) of common treatment-emergent adverse events in adult placebo-controlled studies by body system

Body System/Adverse Event	Levetiracetam group (n=672) %	Placebo group (n=351) %
Body as a whole		
Abdominal pain	3.7	5.1
Back pain	4.0	4.6
Chest pain	1.3	1.1
Drug level increased	1.3	0.9
Fever	1.3	1.7
Flu syndrome	4.2	6.0
Hostility	2.1	0.6
Pain	6.5	6.6
Digestive system		
Anorexia	2.4	2.0
Diarrhoea	4.2	5.1
Dyspepsia	2.8	3.4
Gastroenteritis	1.2	0.9
Gingivitis	1.2	0.6
Nausea	4.2	4.6
Tooth disorder	1.5	0.6
Vomiting	2.2	2.0

Haemic and lymph system		
Ecchymosis	1.5	1.1
Metabolic/nutritional disorders		
Weight gain	1.2	1.1
Nervous system		
Amnesia	1.6	0.3
Anxiety	1.6	1.1
Ataxia	2.5	1.4
Convulsion	6.0	6.8
Depression	4.0	2.3
Dizziness	9.2	4.3
Emotional lability	1.6	0.3
Insomnia	3.0	2.8
Nervousness	3.9	1.7
Paraesthesia	1.9	1.7
Thinking abnormal	1.5	1.4
Tremor	1.5	1.7
Vertigo	2.5	1.4
Respiratory system		
Bronchitis	1.3	1.4
Cough increased	2.1	1.7
Pharyngitis	5.7	3.7
Rhinitis	4.3	2.6
Sinusitis	2.1	0.9
Skin and appendages		
Rash	2.8	4.0
Special senses		
Amblyopia	1.2	1.4
Diplopia	2.4	1.7
Otitis media	1.2	0.9
Urogenital system		
Urinary tract infection	1.9	3.4

The incidence of serious adverse events in placebo controlled studies was 9.9% in the levetiracetam group versus 8.9% in the placebo group. Many of the serious adverse events are typical for a population of patients with epilepsy.

The serious adverse events which occurred in more than 1% of patients were convulsion (1.8% in levetiracetam group versus 1.4% in placebo group) and accidental injury (1.6% in both levetiracetam and placebo group).

Paediatric patients

A study conducted in paediatric patients (4 to 16 years of age) showed that 55.4 and 40.2% of the paediatric patients experienced undesirable effects in the levetiracetam and placebo groups, respectively, and that 0.0 and 1.0% of the paediatric patients experienced serious undesirable effects in the levetiracetam and placebo groups, respectively. In the paediatric clinical study, 16.8% of patients receiving levetiracetam and 20.6% receiving placebo either discontinued or had a dose reduction as a result of an adverse event. The most commonly reported undesirable effects in the paediatric population were somnolence, hostility, nervousness, emotional lability, agitation, anorexia, asthenia and headache. Safety results in paediatric patients were consistent with the safety profile of levetiracetam in adults, except for behavioural and psychiatric undesirable effects which were more common in children than in adults (38.6 versus 18.6%). However, the relative risk was similar in children as compared to adults as

there was also a higher incidence of behavioural psychiatric adverse events in the placebo group in children as compared to adults (27.8% versus 10.5%).

Table 10: Incidence (%) of common treatment-emergent adverse events in a placebo-controlled, add-on study in paediatric patients aged 4-16 years by body system (adverse events occurred in at least 2% of levetiracetam-treated patients and occurred more frequently than placebo-treated patients)

Body System/Adverse Event	Levetiracetam group (n=101) %	Placebo group (n=97) %
Body as a whole		
Accidental injury	17	10
Asthenia	9	3
Pain	6	3
Flu syndrome	3	2
Face oedema	2	1
Neck pain	2	1
Viral infection	2	1
Digestive system		
Vomiting	15	13
Anorexia	13	8
Diarrhoea	8	7
Gastroenteritis	4	2
Constipation	3	1
Haemic and lymph system		
Ecchymosis	4	1
Metabolic/nutrition disorders		
Dehydration	2	1
Nervous system		
Somnolence	23	11
Hostility	12	6
Nervousness	10	2
Personality disorder	8	7
Dizziness	7	2
Emotional lability	6	4
Agitation	6	1
Depression	3	1
Vertigo	3	1
Reflexes increased	2	1
Confusion	2	0
Respiratory system		
Rhinitis	13	8
Cough increased	11	7
Pharyngitis	10	8
Asthma	2	1
Skin and appendages		
Pruritus	2	0
Skin discoloration	2	0
Vesiculobullous rash	2	0
Special senses		
Conjunctivitis	3	2
Amblyopia	2	0
Ear pain	2	0
Urogenital system		
Albuminuria	4	0
Urine abnormality	2	1

Other events occurring in 2% or more of paediatric patients treated with levetiracetam but as or more frequent in the placebo group were the following: abdominal pain, allergic reaction, ataxia, convulsion, epistaxis, fever, headache, hyperkinesia, infection, insomnia, nausea, otitis media, rash, sinusitis, status epilepticus (not otherwise specified), thinking abnormal, tremor and urinary incontinence.

Other controlled clinical trials

The following adverse effects, listed by body system, have been observed in additional controlled clinical trials.

General disorders

Very common: fatigue.

Respiratory system

Common: nasopharyngitis.

Nervous system

Common: balance disorder, disturbance in attention, memory impairment.

Skin and subcutaneous tissue disorders

Common: eczema, pruritus.

Eye disorders

Common: vision blurred.

Blood and lymphatic system disorders

Common: thrombocytopenia.

Musculoskeletal and connective tissue disorders

Common: myalgia.

Psychiatric disorders

Common: irritability, mood swings, personality disorder.

Postmarketing experience

In post-marketing experience, nervous system and psychiatric disorders have been most frequently reported.

In addition to the adverse reactions reported during clinical studies and listed above, the following adverse reactions have been reported in post-marketing experience. Data are insufficient to support an estimate of their incidence in the population to be treated.

- Blood and lymphatic system disorders: Pancytopenia with bone marrow suppression identified in some of these cases, agranulocytosis, leucopenia and neutropenia.
- Immune system disorders: drug reaction with eosinophilia and systemic symptoms (DRESS)

- Psychiatric disorders: Abnormal behaviour, aggression, anger, panic attack, confusion, hallucination, psychotic disorder, suicide, suicide attempt and suicidal ideation.
- Nervous system disorders: choreoathetosis, dyskinesia, lethargy
- Skin and subcutaneous tissue disorders: toxic epidermal necrolysis, Stevens-Johnson syndrome, erythema multiforme and alopecia; in several alopecia cases, recovery was observed when levetiracetam was discontinued.
- Musculoskeletal and connective tissue disorders: muscular weakness, rhabdomyolysis, blood creatine phosphokinase increased.
- Liver and biliary system disorders: Hepatitis, hepatic failure and abnormal liver function test.
- Renal and urinary disorders: acute kidney injury
- Metabolic and nutritional disorders: Weight loss, pancreatitis, hyponatremia.

Cases of encephalopathy have been rarely observed after levetiracetam administration.

DOSAGE AND ADMINISTRATION

Levetiracetam therapy can be initiated with either intravenous or oral administration. Conversion to or from oral to intravenous can be done directly without titration. The total daily dose and frequency of administration should be maintained.

Levetiracetam Sandoz concentrate solution for IV infusion is for intravenous use only and must be diluted in at least 100 mL of a compatible diluent and administered as a 15 minute intravenous infusion (see PRESENTATION AND STORAGE CONDITIONS).

Monotherapy

The recommended starting dose is 250 mg twice daily which should be increased to an initial therapeutic dose of 500 mg twice daily after two weeks. The dose can be further increased by 250 mg twice daily every two weeks depending upon the clinical response. The maximum dose is 1,500 mg twice daily.

Add-on therapy

Adults (> 18 years of age) and adolescents (aged 12 to 17 years of age) weighing 50 kg or more

As adjunctive therapy, the therapeutic dose is 500 mg twice daily. This dose can be started on the first day of treatment.

Depending upon the clinical response and tolerance, the daily dose can be increased up to 1,500 mg twice daily. Dose changes can be made in 500 mg twice daily increments or decrements every two to four weeks.

When satisfactory control of seizures has been attained, monotherapy with Levetiracetam Sandoz concentrate solution for IV infusion may be envisaged by progressively decreasing and withdrawing the concomitant antiepileptic medication.

Use in Elderly (65 years and older)

Adjustment of the dose is recommended in the elderly with compromised renal function (see *Patients with renal impairment*)

Children (aged 4 to 11 years of age) and adolescents (aged 12 to 17 years of age) weighing less than 50 kg

The initial therapeutic dose is 10 mg/kg twice daily (see Table 11).

Depending on the clinical response and tolerance, the daily dose can be increased up to 60 mg/kg daily (in two 30 mg/kg doses). Dose changes can be made in 10 mg/kg twice daily dose increments or decrements every two weeks. The lowest effective dose should be used.

The dosage in children 50 kg or greater is the same as in adults.

The physician should prescribe the most appropriate pharmaceutical form and strength according to weight and dose.

Table 11: Recommended dosing in children aged 4 years and older

Weight	Starting dose:	Maximum dose:
	10 mg/kg twice daily	30 mg/kg twice daily
15 kg ¹	150 mg twice daily	450 mg twice daily
20 kg ¹	200 mg twice daily	600 mg twice daily
25 kg	250 mg twice daily	750 mg twice daily
From 50 kg ²	500 mg twice daily	1500 mg twice daily

¹ Children 20 kg or less should preferably start the treatment with levetiracetam 100 mg/mL oral solution

² Dosage in children and adolescents 50 kg or more is the same as in adults

Infants and children less than 4 years of age

There are insufficient data to recommend the use of levetiracetam in children under 4 years of age.

Patients with renal impairment

Levetiracetam Sandoz concentrate solution for IV infusion daily dose must be individualised according to renal function. For adult patients, see Table 12 and adjust the dose as indicated.

To use this dosing table an estimate of the patient's creatinine clearance (CL_{Cr}) in mL/minute is needed. The CL_{Cr} in mL/minute may be estimated from serum creatinine (micromol/L) determination using the following formula.

$$\text{CL}_{\text{Cr}} = \frac{[140 - \text{age}(\text{years})] \times \text{weight}(\text{kg})}{0.8136 \times \text{serum creatinine}(\mu\text{mol/L})} \quad (\times 0.85 \text{ for women})$$

Then CL_{Cr} is adjusted for body surface area (BSA) as follows:

$$\text{CL}_{\text{Cr}}(\text{mL}/\text{min}/1.73\text{m}^2) = \frac{\text{CL}_{\text{Cr}}(\text{mL}/\text{min}) \times 1.73}{\text{BSA Subject}(\text{m}^2)}$$

Table 12: Adult dosage schedule based on renal function

Group	Creatinine clearance (mL/min/1.73 m ²)	Dosage (mg)	Frequency (daily)
Normal	> 80	500 to 1500	Twice
Mild	50-79	500 to 1000	Twice
Moderate	30-49	250 to 750	Twice
Severe	< 30	250 to 500	Twice
End-stage renal disease patients undergoing dialysis ⁽¹⁾	-	500 to 1000	Once ⁽²⁾

¹ A 750 mg loading dose is recommended on the first day of treatment with levetiracetam.

² Following dialysis, a 250 to 500 mg supplemental dose is recommended

For children with renal impairment, levetiracetam dose needs to be adjusted based on the renal function as levetiracetam clearance is related to renal function. This recommendation is based on a study in adult renally impaired patients.

Patients with hepatic impairment

No dose adjustment is needed in patients with mild and moderate hepatic impairment. In patients with severe hepatic impairment, the CL_{Cr} may underestimate the renal insufficiency. Therefore, a 50% reduction of the daily maintenance dose is recommended when the CL_{Cr} is < 60 mL/min/1.73m².

OVERDOSAGE

Contact the Poisons Information Centre on (telephone Australia 13 11 26 or New Zealand 0800 POISON or 0800 764766) for advice on management of overdose.

Symptoms

The highest known dose of levetiracetam received in the clinical development program was 6,000 mg/day.

Other than drowsiness, there were no adverse events in the few known cases of overdose in clinical trials. Cases of somnolence, agitation, aggression, depressed level of consciousness, respiratory depression and coma were observed with levetiracetam overdoses in postmarketing use.

Treatment

There is no specific antidote for levetiracetam. Treatment for an overdose will be symptomatic and may include haemodialysis. The dialyser extraction efficiency is 60% for levetiracetam and 74% for the major metabolite (ucb L057).

PRESENTATION AND STORAGE CONDITIONS

Concentrate solution for IV infusion Incompatibilities

The formation of precipitate has been observed when mixing Levetiracetam concentrate solution for IV infusion and phenytoin sodium in a polyvinyl chloride (PVC) bag.

This medicinal product must not be mixed with other medicinal products except those mentioned below.

Instructions for use and handling of the concentrate solution for IV infusion

Table 13 provides a summary for the recommended preparation and administration of Levetiracetam Sandoz concentrate solution for IV infusion to achieve a total daily dose of 500 mg, 1,000 mg, 2,000 mg or 3,000 mg in two divided doses.

Table 13: Preparation and administration of Levetiracetam Sandoz concentrate solution for IV infusion

Dose	Withdrawal volume	Volume of diluent	Infusion time	Frequency of Administration	Total daily dose
250 mg	2.5 mL (half 5 mL vial)	100 mL	15 min	Twice daily	500 mg/day
500 mg	5 mL (5 mL vial)	100 mL	15 min	Twice daily	1000 mg/day
1000 mg	10 mL (two 5 mL vials)	100 mL	15 min	Twice daily	2000 mg/day
1500 mg	15 mL (three 5 mL vials)	100 mL	15 min	Twice daily	3000 mg/day

Levetiracetam Sandoz concentrate solution for IV infusion is for single use in one patient only.

Levetiracetam Sandoz concentrate solution for IV infusion was found to be physically compatible and chemically stable when mixed with the following diluents and antiepileptic drugs for up to 24 hours and stored in PVC infusion bags at temperature (25°C). From a microbiological point of view, the product should be used immediately. If not used immediately, in-use storage times and conditions prior to use are the responsibility of the user.

To reduce microbiological hazard, use as soon as practicable after dilution. If storage is necessary, hold at 2-8°C for not more than 24 hours, or at room temperature 25°C for not more than 6 hours.

Diluents

Sodium chloride (0.9%) injection, Lactated Ringer's injection and Dextrose 5% injection

Other antiepileptic medicinal products:

- Lorazepam
- Diazepam
- Sodium valproate

Levetiracetam Sandoz concentrate solution for IV infusion is a colourless glass vial sealed with bromobutyl grey rubber stopper and aluminium flip-off cap, each containing levetiracetam 500 mg in 5ml as a clear colourless solution.

Pack size of 1 and 10 vials.

Levetiracetam Sandoz concentrate solution for IV infusion is stable for 2 years when store below 25°C.

NAME AND ADDRESS OF THE SPONSOR

Sandoz Pty Ltd
ABN 60 075 449 553
54 Waterloo Road

Macquarie Park, NSW 2113
Australia
Tel: 1800 634 500

POISON SCHEDULE OF THE MEDICINE

Schedule 4 – Prescription Only Medicine

DATE OF FIRST INCLUSION IN THE AUSTRALIAN REGISTER OF THERAPEUTIC GOODS (THE ARTG): 05/02/2013

DATE OF MOST RECENT AMENDMENT: 19/06/2017