Administration in children. For the treatment of HIV infection in children, ritonavir is given daily with other antiretroviral drugs. US licensed product information permits the use of oral ritonavir in infants over 1 month of age, whereas in the UK it is recommended from 2 years of age. The dose given should not exceed the maximum adult dose of 600 mg twice daily.

The recommended dose regimen is an initial dose of 250 mg/m^2 twice daily increasing by 50 mg/m^2 twice daily at 2- or 3-day intervals up to 350 to 400 mg/m^2 twice daily.

Molluscum contagiosum. Intractable molluscum contagiosum, a viral skin infection, resolved when a patient was given ritonavir for treatment of HIV infection.[1]

1. Hicks CB, *et al.* Resolution of intractable molluscum contagiosum in a human immunodeficiency virus-infected patient after institution of antiretroviral therapy with ritonavir. *Clin Infect Dis* 1997; **24:** 1023–5.

Preparations

Proprietary Preparations (details are given in Part 3)
Arg.: Rifaxi; ***Austral.:*** Norvir; ***Belg.:*** Norvir; ***Braz.:*** Ritovir†; ***Canad.:*** Norvir; ***Chile:*** Norvir; ***Cz.:*** Norvir; ***Denm.:*** Norvir; ***Fin.:*** Norvir; ***Fr.:*** Norvir; ***Ger.:*** Norvir; ***Gr.:*** Norvir; ***Hong Kong:*** Norvir; ***Hung.:*** Norvir; ***India:*** Ritomune; ***Indon.:*** Norvir; ***Irl.:*** Norvir; ***Israel:*** Norvir; ***Ital.:*** Norvir; ***Jpn:*** Norvir; ***Malaysia:*** Norvir; ***Mex.:*** Norvir; ***Neth.:*** Norvir; ***Norw.:*** Norvir; ***NZ:*** Norvir; ***Pol.:*** Norvir; ***Port.:*** Norvir; ***Rus.:*** Norvir (Норвир)†; ***S.Afr.:*** Norvir; ***Spain:*** Norvir; ***Swed.:*** Norvir; ***Switz.:*** Norvir; ***Thai.:*** Norvir; ***Turk.:*** Norvir; ***UK:*** Norvir; ***USA:*** Norvir; ***Venez.:*** Norvir.

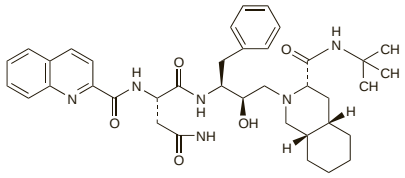
Multi-ingredient: ***Arg.:*** Kaletra; ***Austral.:*** Kaletra; ***Austria:*** Kaletra; ***Belg.:*** Kaletra; ***Braz.:*** Kaletra; ***Canad.:*** Kaletra; ***Chile:*** Kaletra; ***Cz.:*** Kaletra; ***Denm.:*** Kaletra; ***Fin.:*** Kaletra; ***Fr.:*** Kaletra; ***Ger.:*** Kaletra; ***Gr.:*** Kaletra; ***Hong Kong:*** Kaletra; ***Hung.:*** Kaletra; ***India:*** Ritomax-L; ***Israel:*** Kaletra; ***Ital.:*** Kaletra; ***Malaysia:*** Kaletra; ***Mex.:*** Kaletra; ***Neth.:*** Kaletra; ***Norw.:*** Kaletra; ***NZ:*** Kaletra; ***Pol.:*** Kaletra; ***Port.:*** Kaletra; ***Rus.:*** Kaletra (Калетра); ***S.Afr.:*** Kaletra; ***Singapore:*** Kaletra; ***Spain:*** Kaletra; ***Swed.:*** Kaletra; ***Switz.:*** Kaletra; ***Thai.:*** Kaletra; ***Turk.:*** Kaletra; ***UK:*** Kaletra; ***USA:*** Kaletra; ***Venez.:*** Kaletra.

Saquinavir *(BAN, USAN, rINN)*

Ro-31-8959; Sakinavir; Saquinavirum. N^1-{(1*S*,2*R*)-1-Benzyl-3-[(3*S*,4a*S*,8a*S*)-3-(*tert*-butylcarbamoyl)perhydroisoquinolin-2-yl]-2-hydroxypropyl}-N^2-(2-quinolylcarbonyl)-L-aspartamide; (*S*)-*N*-[(α*S*)-α-{(1*R*)-2-[(3*S*,4a*S*,8a*S*)-3-(*tert*-Butylcarbamoyl)octahydro-2(1*H*)-isoquinolyl]-1-hydroxyethyl}phenethyl]-2-quinaldamidosuccinamide.

Саквинавир

$C_{38}H_{50}N_6O_5$ = 670.8.
CAS — 127779-20-8.
ATC — J05AE01.
ATC Vet — QJ05AE01.



Pharmacopoeias. In *Int.*

Saquinavir Mesilate *(BANM, rINNM)*

Mesilato de saquinavir; Ro-31-8959/003; Sakinaviirimesilaatti; Sakinavirmesilat; Saquinavir, mésilate de; Saquinavir Mesylate *(USAN)*; Saquinaviri mesilas. Saquinavir methanesulfonate.

Саквинавира Мезилат

$C_{38}H_{50}N_6O_5,CH_4O_3S$ = 766.9.
CAS — 149845-06-7.
ATC — J05AE01.
ATC Vet — QJ05AE01.

Pharmacopoeias. In *Int.* and *US.*
USP 31 (Saquinavir Mesylate). Store in airtight containers.

Adverse Effects

The most common adverse effects associated with antiretroviral regimens containing saquinavir are gastrointestinal disorders (abdominal pain, diarrhoea, flatulence, nausea, vomiting) and fatigue. Other commonly reported adverse effects include alopecia, anaemia, anorexia, increased appetite, asthenia, constipation, dizziness, dry lips, mouth and skin, dyspepsia, dyspnoea, eczema, headache, hypersensitivity, decreased libido, malaise, muscle spasm, paraesthesia, peripheral neuropathy, pruritus, rash, sleep disturbances, and taste disorders. Commonly reported laboratory abnormalities include raised liver enzyme values, increased blood amylase, bilirubin, and creatinine, and lowered haemoglobin and platelet, lymphocyte, and white blood cell count. Rare but serious adverse effects that may be associated with saquinavir include acute myeloid leukaemia, haemolytic anaemia, allergic reactions, ascites, bullous skin eruptions, intestinal obstruction, jaundice, nephrolithiasis, pancreatitis, polyarthritis, portal hypertension, seizures, Stevens-Johnson syndrome, attempted suicide, and thrombocytopenia (occasionally fatal).

Immune reconstitution syndrome (an inflammatory immune response resulting in clinical deterioration) has been reported during the initial phase of treatment with combination antiretroviral therapy, including saquinavir, in HIV-infected patients with severe immune deficiency. Accumulation or redistribution of body fat (lipodystrophy) including central obesity, dorsocervical fat enlargement (buffalo hump), peripheral wasting, facial wasting, breast enlargement, and cushingoid appearance have been seen in patients receiving antiretroviral therapy, including saquinavir. Metabolic abnormalities such as hypertriglyceridaemia, hypercholesterolaemia, insulin resistance, hyperglycaemia, and hyperlactataemia have also been reported. Elevated creatine phosphokinase, myalgia, myositis, and rarely rhabdomyolysis have been reported with HIV-protease inhibitors, particularly when given with nucleoside analogues. Osteonecrosis has been reported, particularly in patients with advanced HIV disease or long-term exposure to combination antiretroviral therapy.

For further information on adverse effects associated with HIV-protease inhibitors see under Indinavir Sulfate, p.882.

Precautions

Ritonavir-boosted saquinavir should not be used in patients with decompensated liver disease and should be used with caution in patients with moderate hepatic or severe renal impairment. Patients with pre-existing liver disease or co-infected with chronic hepatitis B or C and treated with combination antiretroviral therapy are at increased risk for severe and potentially fatal hepatic adverse events. Caution is advised in treating patients with haemophilia A and B as reports of spontaneous bleeding have been associated with the use of HIV-protease inhibitors.

Interactions

Saquinavir is reported to be metabolised by the cytochrome P450 system, with the specific isoenzyme CYP3A4 responsible for more than 90% of the hepatic metabolism. Saquinavir is also a substrate and an inhibitor of P-glycoprotein. Drugs that affect this isoenzyme and/or P-glycoprotein may modify saquinavir plasma concentrations. Saquinavir may alter the pharmacokinetics of other drugs that are metabolised by this enzyme system or that are substrates for P-glycoprotein.

Saquinavir is contra-indicated with drugs that are highly dependent on CYP3A4 for clearance and for which elevated plasma concentrations are associated with serious or life-threatening events. These drugs include antiarrhythmics (amiodarone, bepridil, flecainide, propafenone, and quinidine), antihistamines (astemizole and terfenadine), antimycobacterial (rifampicin), ergot derivatives (dihydroergotamine, ergometrine, ergotamine, methylergometrine), gastrointestinal prokinetics (cisapride), antipsychotics (pimozide), sedatives and hypnotics (midazolam and triazolam), and statins (simvastatin and lovastatin). St John's wort decreases the concentration of saquinavir; use with the antiretroviral is not recommended due to the possible loss of its activity and development of resistance.

For further information on drug interactions of HIV-protease inhibitors see under Indinavir Sulfate, p.883 and Table 1, p.917.

Antiviral Action

Saquinavir is a selective, competitive, reversible inhibitor of HIV-1 and HIV-2 protease. It interferes with the formation of essential viral proteins making them incapable of infecting other cells. Viral resistance develops rapidly when HIV-protease inhibitors are given alone and therefore they are used with other antiretrovirals. HIV isolates resistant to saquinavir have been reported and variable cross-resistance with other HIV-protease inhibitors has been seen. Cross-resistance between saquinavir and NRTIs or NNRTIs is unlikely because these drugs have different target enzymes.

Pharmacokinetics

Saquinavir is absorbed to a limited extent (about 30%) after oral doses of the mesilate and undergoes extensive first-pass hepatic metabolism, resulting in a bioavailability of 4% when taken with food. Bioavailability was found to be greater from a soft gelatin capsule formulation of saquinavir base in a suitable vehicle (*Fortovase, Roche*) than from a hard capsule formulation (*Invirase, Roche*). Bioavailability is substantially less when saquinavir is taken in the fasting state. Plasma concentrations are reported to be higher in HIV-infected patients than in healthy subjects. Saquinavir is about 98% bound to plasma proteins and extensively distributed into the tissues, although CSF concentrations are reported to be negligible. It is rapidly metabolised by the cytochrome P450 system (specifically the isoenzyme CYP3A4) to a number of inactive monohydroxylated and dihydroxylated compounds. It is excreted mainly in the faeces with a reported terminal elimination half-life of 13.2 hours.

◊ References.

1. Regazzi MB, *et al.* Pharmacokinetic variability and strategy for therapeutic drug monitoring of saquinavir (SQV) in HIV-1 infected individuals. *Br J Clin Pharmacol* 1999; **47:** 379–82.
2. Grub S, *et al.* Pharmacokinetics and pharmacodynamics of saquinavir in pediatric patients with human immunodeficiency virus infection. *Clin Pharmacol Ther* 2002; **71:** 122–30.
3. Acosta EP, *et al.* Pharmacokinetics of saquinavir plus low-dose ritonavir in human immunodeficiency virus-infected pregnant women. *Antimicrob Agents Chemother* 2004; **48:** 430–6.

Uses and Administration

Saquinavir is an HIV-protease inhibitor with antiviral activity against HIV. It is used in the treatment of HIV infection and AIDS (p.856). Viral resistance emerges rapidly when saquinavir is used alone, and it is therefore used with other antiretrovirals, including low-dose ritonavir which is given as a pharmacokinetic enhancer (ritonavir-boosted saquinavir).

Saquinavir is given orally as the mesilate but doses are expressed in terms of the base; 229 mg of saquinavir mesilate is equivalent to about 200 mg of saquinavir. The dose is 1 g twice daily given with ritonavir 100 mg twice daily with or after food.

◊ Reviews.

1. Vella S, Floridia M. Saquinavir: clinical pharmacology and efficacy. *Clin Pharmacokinet* 1998; **34:** 189–201.
2. Figgitt DP, Plosker GL. Saquinavir soft-gel capsule: an updated review of its use in the management of HIV infection. *Drugs* 2000; **60:** 481–516.
3. Plosker GL, Scott LJ. Saquinavir: a review of its use in boosted regimens for treating HIV infection. *Drugs* 2003; **63:** 1299–1324.

Preparations

USP 31: Saquinavir Capsules.

Proprietary Preparations (details are given in Part 3)
Arg.: Fortovase; Proteovir; ***Austral.:*** Fortovase; Invirase; ***Austria:*** Fortovase; Invirase; ***Belg.:*** Fortovase†; Invirase; ***Braz.:*** Fortovase; Invirase; Svir†; ***Canad.:*** Fortovase; Invirase; ***Chile:*** Fortovase†; Invirase; ***Cz.:*** Fortovase†; Invirase; ***Denm.:*** Fortovase; Invirase; ***Fin.:*** Fortovase†; Invirase; ***Fr.:*** Fortovase; Invirase; ***Ger.:*** Fortovase†; Invirase; ***Gr.:*** Fortovase; Invirase; ***Hong Kong:*** Fortovase†; Invirase; ***Hung.:*** Invirase; ***Irl.:*** Fortovase†; Invirase; ***Israel:*** Fortovase; Invirase; ***Ital.:*** Fortovase; Invirase; ***Jpn:*** Fortovase; Invirase; ***Mex.:*** Fortovase; Invirase; ***Neth.:*** Fortovase; Invirase; ***Norw.:*** Fortovase; Invirase; ***NZ:*** Fortovase; Invirase; ***Philipp.:*** Invirase; ***Pol.:*** Invirase; ***Port.:*** Fortovase†; Invirase; ***S.Afr.:*** Fortovase†; Invirase; ***Spain:*** Fortovase; Invirase; ***Swed.:*** Fortovase†; Invirase; ***Switz.:*** Fortovase†; Invirase; ***Thai.:*** Fortovase; ***UK:*** Fortovase†; Invirase; ***USA:*** Fortovase†; Invirase; ***Venez.:*** Fortovase.

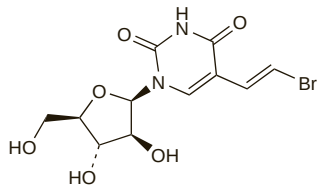
Sorivudine *(BAN, USAN, rINN)*

Bravavir; Bromovinylarauracil; Brovavir; BV-araU; BVAU; Sorivudina; Sorivudinum; SQ-32756; YN-72. (*E*)-1-β-D-Arabinofuranosyl-5-(2-bromovinyl)uracil.

Соривудин

$C_{11}H_{13}BrN_2O_6$ = 349.1.

CAS — 77181-69-2.



Profile

Sorivudine is a synthetic thymidine derivative with antiviral activity against varicella-zoster virus. It has been investigated for the treatment of herpes zoster but was withdrawn from the market in Japan after deaths in patients also given fluorouracil.

◊ References.

1. Yawata M. Deaths due to drug interaction. *Lancet* 1993; **342:** 1166.
2. Diasio RB. Sorivudine and 5-fluorouracil: a clinically significant drug-drug interaction due to inhibition of dihydropyrimidine dehydrogenase. *Br J Clin Pharmacol* 1998; **46:** 1–4.

Stavudine *(BAN, USAN, pINN)*

BMY-27857; d4T; Estavudina; Stavudiini; Stavudin; Stavudinas; Stavudinum. 1-(2,3-Dideoxy-β-D-*glycero*-pent-2-enofuranosyl)-thymine.

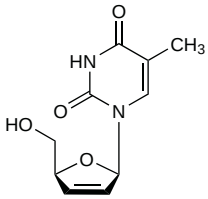
Ставудин

$C_{10}H_{12}N_2O_4$ = 224.2.

CAS — 3056-17-5.

ATC — J05AF04.

ATC Vet — QJ05AF04.



Pharmacopoeias. In *Eur.* (see p.vii) and *US.*

Ph. Eur. 6.2 (Stavudine). A white or almost white powder. It exhibits polymorphism. Soluble in water; sparingly soluble in alcohol; slightly soluble in dichloromethane. Protect from light and humidity.

USP 31 (Stavudine). A white to off-white, crystalline powder. Soluble in water, in dimethylacetamide, and in dimethyl sulfoxide; sparingly soluble in alcohol, in acetonitrile, and in methyl alcohol; slightly soluble in dichloromethane; insoluble in petroleum spirit. Store in airtight containers at a temperature of 25°, excursions permitted between 15° and 30°. Protect from light.

Adverse Effects

The most common adverse effect reported with stavudine either as monotherapy or with other antiretrovirals is peripheral neuropathy; it occurs more frequently in patients taking stavudine with didanosine and hydroxycarbamide. Other common adverse effects include abdominal pain, nausea, diarrhoea, dyspepsia, fatigue, dizziness, depression, headache, insomnia, sleep disturbances, pruritus, and rash. Abnormal liver function tests may occur and hepatitis, hepatic failure, and pancreatitis have been reported rarely; fatalities have occurred and were reported most often in patients taking stavudine with didanosine and hydroxycarbamide. Lactic acidosis, usually associated with severe hepatomegaly and steatosis, has been associated with treatment with NRTIs. There have been reports of motor weakness associated with stavudine, occurring particularly in association with lactic acidosis.

Immune reconstitution syndrome (an inflammatory immune response resulting in clinical deterioration) has been reported during the initial phase of treatment with combination antiretroviral therapy, including stavudine, in HIV-infected patients with severe immune deficiency. Accumulation or redistribution of body fat (lipodystrophy) including central obesity, dorsocervical fat enlargement (buffalo hump), peripheral wasting, facial wasting, breast enlargement, and cushingoid appearance have been seen in patients receiving antiretroviral therapy, including stavudine. Metabolic abnormalities such as hypertriglyceridaemia, hypercholesterolaemia, insulin resistance, hyperglycaemia, and hyperlactataemia have also been reported. NRTIs have also been associated with mitochondrial dysfunction manifesting as abnormal behaviour, anaemia, convulsions, hyperlipasaemia, hypertonia, and neutropenia. Elevated creatine phosphokinase, myalgia, myositis, and rarely rhabdomyolysis have been reported, particularly when nucleoside analogues have been given with HIV-protease inhibitors. Osteonecrosis has been reported, particularly in patients with advanced HIV disease or long-term exposure to combination antiretroviral therapy. For further information on adverse effects associated with NRTIs see Zidovudine, p.914.

Effects on the nervous system. Peripheral neuropathy is a well recognised adverse effect of stavudine and has been the subject of a review.[1]

1. Moyle GJ, Sadler M. Peripheral neuropathy with nucleoside antiretrovirals: risk factors, incidence and management. *Drug Safety* 1998; **19:** 481–94.

Gynaecomastia. Bilateral gynaecomastia was associated with stavudine use in a patient with HIV infection who was also receiving lamivudine and co-trimoxazole.[1] Symptoms resolved when stavudine was stopped. Four other cases of gynaecomastia were reported in HIV-infected patients given HAART regimens containing stavudine.[2]

1. Melbourne KM, *et al.* Gynecomastia with stavudine treatment in an HIV-positive patient. *Ann Pharmacother* 1998; **32:** 1108.
2. Manfredi R, *et al.* Gynecomastia associated with highly active antiretroviral therapy. *Ann Pharmacother* 2001; **35:** 438–9.

Precautions

Stavudine should be used with caution in patients with a history of peripheral neuropathy and treatment suspended if peripheral neuropathy develops; if symptoms resolve on withdrawal, stavudine may be resumed at half the previous dose. Treatment with stavudine may be associated with lactic acidosis and should be stopped if there is a rapid increase in aminotransferase concentrations, progressive hepatomegaly or steatosis, or metabolic or lactic acidosis of unknown aetiology. Stavudine should be given with caution to patients with hepatomegaly or other risk factors for liver disease. If liver enzymes increase to 5 times the upper limit of normal during treatment then stavudine should be stopped. Patients co-infected with chronic hepatitis B or C who are being treated with combination antiretroviral therapy are at an increased risk of severe and potentially fatal hepatic adverse events. Patients with a history of pancreatitis should also be observed carefully for signs of pancreatitis during stavudine treatment. Use with other drugs likely to cause peripheral neuropathy or pancreatitis should be avoided if possible. Stavudine should be used with caution and doses reduced in patients with renal impairment.

Interactions

The intracellular activation of stavudine and hence its antiviral effect may be inhibited by zidovudine, doxorubicin, and ribavirin.

Use of stavudine with other drugs known to cause pancreatitis or peripheral neuropathy should be avoided if possible. The combination of hydroxycarbamide and didanosine if given with stavudine, may carry a higher risk of adverse effects including hepatotoxicity, peripheral neuropathy, and pancreatitis (fatal and non-fatal).

Antidiabetics. Fatal lactic acidosis has been reported[1] in a patient given *metformin* with didanosine, stavudine, and tenofovir.

1. Worth L, *et al.* A cautionary tale: fatal lactic acidosis complicating nucleoside analogue and metformin therapy. *Clin Infect Dis* 2003; **37:** 315–16.

Antivirals. Reference to *in-vivo* antagonism of the antiretroviral effect of stavudine when used with *zidovudine*.[1]

1. Havlir DV, *et al.* In vivo antagonism with zidovudine plus stavudine combination therapy. *J Infect Dis* 2000; **182:** 321–5.

Phenylpropanolamine. Hypertensive crisis associated with use of phenylpropanolamine and clemastine occurred in a patient receiving HIV prophylaxis with indinavir, lamivudine, and stavudine.[1] The most likely cause was an interaction between phenylpropanolamine and stavudine, although interactions with the other antiretrovirals could not be ruled out.

1. Khurana V, *et al.* Hypertensive crisis secondary to phenylpropanolamine interacting with triple-drug therapy for HIV prophylaxis. *Am J Med* 1999; **106:** 118–19.

Antiviral Action

Stavudine is converted intracellularly in stages to the triphosphate. This triphosphate halts the DNA synthesis of retroviruses, including HIV, through competitive inhibition of reverse transcriptase and incorporation into viral DNA. Stavudine-resistant strains of HIV have been identified and cross-resistance to other nucleoside reverse transcriptase inhibitors may occur.

Pharmacokinetics

Stavudine is absorbed rapidly after oral doses producing peak plasma concentrations within 1 hour and with a reported bioavailability of about 86%. Giving it with food delays but does not reduce absorption. Stavudine crosses the blood-brain barrier producing a CSF to plasma ratio of about 0.4 after 4 hours. Binding to plasma proteins is negligible. Stavudine is metabolised intracellularly to the active antiviral triphosphate. The elimination half-life is reported to be about 1 to 1.5 hours after single or multiple doses. The intracellular half-life of stavudine triphosphate has been estimated to be 3.5 hours *in vitro*. About 40% of a dose is excreted in the urine by active tubular secretion and glomerular filtration. Stavudine is removed by haemodialysis.

◊ References.

1. Rana KZ, Dudley MN. Clinical pharmacokinetics of stavudine. *Clin Pharmacokinet* 1997; **33:** 276–84.
2. Kaul S, *et al.* Effect of food on bioavailability of stavudine in subjects with human immunodeficiency virus infection. *Antimicrob Agents Chemother* 1998; **42:** 2295–8.
3. Grasela DM, *et al.* Pharmacokinetics of single-dose oral stavudine in subjects with renal impairment and in subjects requiring hemodialysis. *Antimicrob Agents Chemother* 2000; **44:** 2149–53.

Uses and Administration

Stavudine is a nucleoside reverse transcriptase inhibitor related to thymidine with antiviral activity against HIV-1. It is used in the treatment of HIV infection and AIDS (p.856). Viral resistance emerges rapidly when stavudine is used alone, and it is therefore used with other antiretrovirals. Stavudine is given orally, usually as a capsule or solution. Usual adult doses of stavudine are 40 mg every 12 hours for patients weighing 60 kg or more or 30 mg every 12 hours for patients weighing less than 60 kg.

For details of doses in infants, children, and adolescents, see below.

For details of reduced doses of stavudine to be used in patients with renal impairment, see below.

◊ Reviews.

1. Hurst M, Noble S. Stavudine: an update of its use in the treatment of HIV infection. *Drugs* 1999; **58:** 919–49.
2. Cheer SM, Goa KL. Stavudine once daily. *Drugs* 2002; **62:** 2667–74.

Administration in children. For the treatment of HIV infection in infants, children, and adolescents stavudine is given orally with other antiretroviral drugs. Doses are based on body-weight:

- in neonates from birth to 13 days old a dose of 500 micrograms/kg every 12 hours may be given
- in infants at least 14 days old and those weighing less than 30 kg the dose is 1 mg/kg every 12 hours
- in children and adolescents weighing 30 kg or more, the adult dose is given (see above)