excreted by the kidneys. It may be used as a diagnostic test for lead poisoning but measurement of blood-lead concentrations is generally preferred.

Sodium calcium edetate is also a chelator of other heavy-metal polyvalent ions, including chromium. A cream containing sodium calcium edetate 10% has been used in the treatment of chrome ulcers and skin sensitivity reactions due to contact with heavy metals.

Sodium calcium edetate is also used as a pharmaceutical excipient and as a food additive.

In the treatment of lead poisoning, sodium calcium edetate may be given by intramuscular injection or by intravenous infusion. The intramuscular route may be preferred in patients with lead encephalopathy and increased intracranial pressure in whom excess fluids must be avoided, and also in children, who have an increased risk of incipient encephalopathy. Sodium calcium edetate may initially aggravate the symptoms of lead toxicity due to mobilisation of stored lead and it has often been given with dimercaprol (p.1444) in patients who are symptomatic; the first dose of dimercaprol should preferably be given at least 4 hours before the sodium calcium edetate.

For intravenous infusion, 1 g of sodium calcium edetate should be diluted with 250 to 500 mL of glucose 5% or sodium chloride 0.9%; a concentration of 3% should not be exceeded. The infusion should be given over a period of at least 1 hour. In the UK, the usual dose is 60 to 80 mg/kg daily given in two divided doses. In the USA, a dose of 1000 mg/m^2 daily is suggested for asymptomatic adults and children; a daily dose of 1500 mg/m^2 may be used in patients with symptomatic poisoning. Treatment is given for up to 5 days, repeated if necessary after an interval of at least 2 days. Any further treatment with sodium calcium edetate should then not be given for at least 7 days.

Alternatively, the same daily dose of sodium calcium edetate may be given intramuscularly in 2 to 4 divided doses as a 20% solution. Intramuscular injection of sodium calcium edetate is painful and it is recommended that preservative-free procaine hydrochloride should be added to a concentration of 0.5 to 1.5% to minimise pain; alternatively, lidocaine may be added to a concentration of 0.5%.

As excretion is mainly renal, an adequate urinary flow must be established and maintained during treatment. Doses should be reduced in patients with renal impairment (see below).

Administration in renal impairment. The dose of sodium calcium edetate should be reduced in patients with renal impairment. It has been suggested that the dose is halved and given once daily in moderate impairment, and that smaller and less frequent doses are given if renal impairment is severe.

Preparations

BP 2008: Sodium Calcium Edetate Intravenous Infusion;
USP 31: Edetate Calcium Disodium Injection.

Proprietary Preparations (details are given in Part 3)

Ger.: Calcium Vitis†; ***Gr.:*** Ledclair; ***Irl.:*** Ledclair; ***Switz.:*** Chelintox†; ***Turk.:*** Libenta; ***UK:*** Ledclair.

Multi-ingredient: ***Arg.:*** Calcium C.

Sodium Cellulose Phosphate

Cellulose Sodium Phosphate *(USAN)*; Celulosa, fosfato sódico de.

CAS — 9038-41-9; 68444-58-6.

ATC — V03AG01.

ATC Vet — QV03AG01.

Pharmacopoeias. In *US*.

USP 31 (Cellulose Sodium Phosphate). It is prepared by the phosphorylation of alpha cellulose. A free-flowing, cream-coloured, odourless, powder. Insoluble in water, in dilute acids, and in most organic solvents. The pH of a filtrate of a 5% mixture in water is between 6.0 and 9.0. The inorganic bound phosphate content is not less than 31.0% and not more than 36.0%; the free phosphate content is not more than 3.5%; and the sodium content is not less than 9.5% and not more than 13.0%, all calculated on the dried basis. The calcium binding capacity, calculated on the dried basis, is not less than 1.8 mmol per g.

Adverse Effects and Precautions

Diarrhoea and other gastrointestinal disturbances have been reported.

Sodium cellulose phosphate should not be given to patients with primary or secondary hyperparathyroidism, hypomagnesaemia, hypocalcaemia, bone disease, or enteric hyperoxaluria. It should be used cautiously in pregnant women and children, since they have high calcium requirements.

Patients should be monitored for electrolyte disturbances. Uptake of sodium and phosphate may increase and sodium cellulose phosphate should not be given to patients with renal failure or conditions requiring a restricted sodium intake such as heart failure. Theoretically, long-term treatment could result in calcium deficiency; regular monitoring of calcium and parathyroid hormone has therefore been recommended. Sodium cellulose phosphate is not a totally selective exchange resin and the intestinal absorption of other dietary cations may be reduced; magnesium deficiency has been reported but may be corrected by dosage reduction or oral magnesium supplements. Urinary excretion of oxalate may increase and dietary restriction of oxalate intake may be necessary.

◊ Potential complications of long-term sodium cellulose phosphate therapy include secondary hyperparathyroidism and bone disease; deficiency of magnesium, copper, zinc, and iron; and hyperoxaluria. A study in 18 patients[1] with absorptive hypercalciuria and recurrent renal stones indicated that these complications could largely be avoided if use was confined to those with absorptive hypercalciuria (hypercalciuria, intestinal hyperabsorption of calcium, and normal or suppressed parathyroid function), if the dose was adjusted so as not to reduce intestinal calcium absorption or urinary calcium subnormally (the optimal maintenance dose in most patients was 10 g daily), if oral magnesium supplements were provided, and if a moderate dietary restriction of calcium and oxalate was imposed. There was no evidence of zinc, copper, or iron deficiency.

1. Pak CYC. Clinical pharmacology of sodium cellulose phosphate. *J Clin Pharmacol* 1979; **19:** 451–7.

Interactions

Sodium cellulose phosphate binds with calcium and other cations. Use with calcium or magnesium salts, including cation-donating antacids or laxatives, may reduce its efficacy. Magnesium supplements are often required in patients receiving sodium cellulose phosphate but should be given at least one hour before or after any dose of the resin since the absorption of the magnesium may otherwise be impaired.

Uses and Administration

Sodium cellulose phosphate, the sodium salt of the phosphate ester of cellulose, is a cation-exchange resin that exchanges sodium ions for calcium and other divalent cations. When given orally, it binds calcium ions within the stomach and intestine to form a non-absorbable complex which is excreted in the faeces. Theoretically a 5-g dose will bind about 350 mg calcium. It is used in the treatment of absorptive hypercalciuria type I with recurrent formation of calcium-containing renal calculi (p.2181), usually with a moderate dietary calcium restriction. Sodium cellulose phosphate is also used in the treatment of hypercalcaemia associated with osteopetrosis, sarcoidosis, and vitamin D intoxication, and in idiopathic hypercalcaemia of infancy, although other more effective agents are usually used (see Vitamin D-mediated Hypercalcaemia, p.1668).

The usual initial dose is 15 g daily by mouth in 3 divided doses with meals reducing to 10 g daily for maintenance. A suggested dose for children is 10 g daily (but see Adverse Effects and Precautions, above). The powder may be taken dispersed in water or sprinkled onto food. Oral magnesium supplements equivalent to about 60 or 90 mg (about 2.4 or 3.6 mmol) of elemental magnesium twice daily have been recommended for patients taking daily doses of sodium cellulose phosphate 10 or 15 g respectively. The magnesium supplement should not be given simultaneously with sodium cellulose phosphate.

Sodium cellulose phosphate has also been used for the investigation of calcium absorption.

Preparations

USP 31: Cellulose Sodium Phosphate for Oral Suspension.

Proprietary Preparations (details are given in Part 3)
Spain: Anacalcit; ***USA:*** Calcibind.

Sodium Edetate

Sodu edetynian.

Эдетат Натрия

CAS — 17421-79-3 (monosodium edetate).

ATC — S01XA05.

ATC Vet — QS01XA05.

NOTE. The name sodium edetate has been used in the literature for various sodium salts of edetic acid. Do not confuse with sodium calcium edetate (p.1462) or etomidate (p.1783); see also Inappropriate Administration, below.

Disodium Edetate *(BAN)*

Dinatrii edetas; Dinatrii Edetas Dihydricus; Dinatrio edetatas; Dinatriumedetaatti; Dinatriumedetat; Disodium Edathamil; Disodium EDTA; Disodium Tetracemate; Disodu edetynian; Edetan disodný dihydrát; Édétate disodique; Edetate Disodium; Edetato disódico; Edetynian disodu; Natrii Edetas; Nátrium-edetát; Sodium Versenate. Disodium dihydrogen ethylenediaminetetra-acetate dihydrate .

$C_{10}H_{14}N_2Na_2O_8,2H_2O$ = 372.2.

CAS — 139-33-3 (anhydrous disodium edetate); 6381-92-6 (disodium edetate dihydrate).

ATC — S01XA05.

ATC Vet — QS01XA05.

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

Ph. Eur. 6.2 (Disodium Edetate). A white or almost white, crystalline powder. Soluble in water; practically insoluble in alcohol. A 5% solution in water has a pH of 4.0 to 5.5. Protect from light.

USP 31 (Edetate Disodium). A white crystalline powder. Soluble in water. pH of a 5% solution in water is between 4.0 and 6.0.

Trisodium Edetate

Edetate Trisodium *(USAN)*; Edetato trisódico. Trisodium hydrogen ethylenediaminetetra-acetate .

$C_{10}H_{13}N_2Na_3O_8$ = 358.2.

CAS — 150-38-9.

ATC — S01XA05.

ATC Vet — QS01XA05.

Tetrasodium Edetate

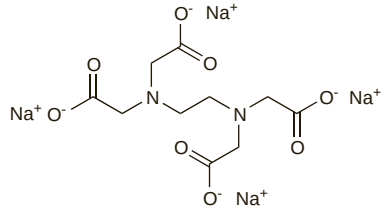
Edetate Sodium *(USAN)*.

$C_{10}H_{12}N_2Na_4O_8$ = 380.2.

CAS — 64-02-8.

ATC — S01XA05.

ATC Vet — QS01XA05.



Incompatibility. See under Edetic Acid, p.1445.

Adverse Effects and Treatment

In common with other edetates (see Sodium Calcium Edetate, p.1462), sodium edetate may cause gastrointestinal effects such as nausea, vomiting, and diarrhoea. Pain at the site of injection and thrombophlebitis may also occur. Other adverse effects include fever, headache, skin rashes, hypotension, and hyperuricaemia; nephrotoxicity has also been reported, particularly following overdosage.

Hypocalcaemia can occur, particularly if sodium edetate is infused too rapidly or in too concentrated a solution and tetany, convulsions, respiratory arrest, and cardiac arrhythmias may result.

The rate of infusion should be decreased if signs of muscle reactivity occur. The infusion should be discon-

tinued if tetany occurs and should only be restarted cautiously after plasma ionised and total calcium concentrations indicate a need for further treatment and tetany has stopped. Calcium supplements may be given intravenously for hypocalcaemia but should be used with extreme caution in patients with tetany, particularly in digitalised patients since the effect of the digitalis may be reversed.

◊ References.

1. Morgan BW, *et al.* Adverse effects in 5 patients receiving EDTA at an outpatient chelation clinic. *Vet Hum Toxicol* 2002; **44:** 274–6.
2. Prabha A, *et al.* Chelation therapy for coronary heart disease. *Am Heart J* 2002; **144:** E10.

Inappropriate administration. There have been fatalities in both children and adults when they were given sodium edetate instead of *sodium calcium edetate* (p.1462), which is a chelator used for the treatment of lead poisoning.[1,2] The FDA had received reports of 11 deaths associated with the use of sodium edetate over the period 1971 to 2007;[3] in 5 cases, sodium edetate was given instead of sodium calcium edetate, and in 2 cases, sodium edetate was given instead of *etomidate* (p.1783). In some cases, confusion had arisen due to the use of the term EDTA in prescribing the drug. The FDA has subsequently recommended that the full product name be used, and that prescribers should consider including the indication for use on the prescription.[2]

1. CDC. Deaths associated with hypocalcemia from chelation therapy—Texas, Pennsylvania, and Oregon, 2003-2005. *MMWR* 2006; **55:** 204–7. Also available at: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5508a3.htm (accessed 25/01/08)
2. FDA Public Health Advisory. Edetate disodium (marketed as Endrate and generic products) (issued 16th January 2008). Available at: http://www.fda.gov/cder/drug/advisory/edetate_disodium.htm (accessed 25/01/08)
3. FDA. Questions and answers on edetate disodium (marketed as Endrate and generic products) (issued 16th January 2008). Available at: http://www.fda.gov/cder/drug/infopage/edetate_disodium/QA.htm (accessed 25/01/08)

Precautions

Sodium edetate is contra-indicated in patients with renal impairment and should be used with caution in patients with hypokalaemia, tuberculosis, impaired cardiac function, diabetes mellitus, or a history of seizures. Plasma-electrolyte concentrations, particularly ionised calcium, and renal function should be monitored regularly; daily urinalysis is also recommended. Sodium edetate is irritant to the tissues and must be diluted before infusion; the recommended rate should not be exceeded.

Uses and Administration

Sodium edetate is a chelator with a high affinity for calcium, with which it forms a stable, soluble complex that is readily excreted by the kidneys. It has been given intravenously, as the disodium and trisodium salts, in the emergency treatment of hypercalcaemia (p.1668); it has also been used to control digitalis-induced cardiac arrhythmias, although less toxic agents are generally preferred (p.1260). It is also used topically to treat calcium deposits in the eye.

Sodium edetate also chelates other polyvalent metals but, unlike sodium calcium edetate, which is saturated with calcium, it is not used for the treatment of heavy metal poisoning since hypocalcaemia rapidly develops.

In the treatment of hypercalcaemia, injections containing varying amounts of disodium and trisodium edetate are used. In the UK, the trisodium salt is generally used. A dose of up to 70 mg/kg daily has been suggested for adults; children may be given up to 60 mg/kg daily. It should be given by slow intravenous infusion over 2 to 3 hours and each gram of trisodium edetate should be diluted with 100 mL of glucose 5% or sodium chloride 0.9%. In the USA, disodium edetate is given in an adult dose of 50 mg/kg in 24 hours by slow intravenous infusion; the maximum daily dose is 3 g. Children may be given 40 to 70 mg/kg in 24 hours. The injection should be diluted with 500 mL of sodium chloride 0.9% or glucose 5% for adults or to a concentration not greater than 3% for children, and infused over 3 hours or more, preferably 4 to 6 hours. The dosage may be repeated for a further 4 days followed by a two-day interval before subsequent courses of treatment. If necessary, up to fifteen doses may be given in total.

Sodium edetate is used in the treatment of calcium deposits from calcium oxide or calcium hydroxide burns of the eye and in the treatment of calcified corneal opacities, either by topical application after removing the appropriate area of corneal epithelium or by iontophoresis. Irrigation has also been suggested for zinc chloride injury to the eye, but treatment may be ineffective unless started within 2 minutes. In the UK, a 0.4% solution of the trisodium salt is used for topical application to the eye; in the USA, a 0.35 to 1.85% solution of the disodium salt has been suggested.

Sodium edetates are also used in cleaners for contact lenses and as antoxidant synergists in cosmetic and pharmaceutical preparations.

Atherosclerosis. Calcium is thought to be necessary for several steps in atherogenesis and removal of calcium from atherosclerotic plaques using a chelator such as disodium edetate has been tried in patients with atherosclerosis (p.1159). However, reports of beneficial clinical responses are largely anecdotal or from small, short-term, or uncontrolled clinical studies; a meta-analysis[1] of controlled trials concluded that there was insufficient evidence of benefit or harm, and a further randomised trial[2] in patients with coronary heart disease found no benefit with sodium edetate treatment. In addition, adverse effects are common with chelation therapy, and fatalities have been reported;[3] literature reviews[4,5] considering both uncontrolled and controlled studies have concluded that in view of the potential toxicity of such treatment it should be considered obsolete.

1. Villarruz MV, *et al.* Chelation therapy for atherosclerotic cardiovascular disease. Available in The Cochrane Database of Systematic Reviews; Issue 4. Chichester: John Wiley; 2002 (accessed 04/10/05).
2. Knudtson ML, *et al.* Chelation therapy for ischemic heart disease: a randomized controlled trial. *JAMA* 2002; **287:** 481–6.
3. Magee R. Chelation treatment of atherosclerosis. *Med J Aust* 1985; **142:** 514–15.
4. Ernst E. Chelation therapy for peripheral arterial occlusive disease: a systematic review. *Circulation* 1997; **96:** 1031–3.
5. Ernst E. Chelation therapy for coronary heart disease: an overview of all clinical investigations. *Am Heart J* 2000; **140:** 139–41.

Preparations

BP 2008: Trisodium Edetate Intravenous Infusion;
USP 31: Edetate Disodium Injection.

Proprietary Preparations (details are given in Part 3)
Fr.: Chelatran; ***Irl.:*** Limclair; ***UK:*** Limclair†; ***USA:*** Endrate; ***Venez.:*** Edetil.

Multi-ingredient: ***Mex.:*** Adapettes; ***NZ:*** Conditioning Solution†; ***UK:*** Uriflex G; Uriflex R.

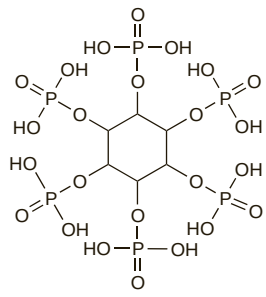
Sodium Fytate *(rINNM)*

Fitato sódico; Fytate de Sodium; Natrii Fytas; Phytate Sodium *(USAN)*; Sodium Phytate; SQ-9343. The nonasodium salt of *myo*-inositol hexakis(dihydrogen phosphate); Sodium cyclohexanehexyl(hexaphosphate).

Натрий Фэитат

$C_6H_9Na_9O_{24}P_6$ = 857.9.

CAS — 83-86-3 (fytic acid); 7205-52-9 (sodium fytate).



(fytic acid)

Profile

Sodium fytate reacts with calcium in the gastrointestinal tract to form non-absorbable calcium fytate which is excreted in the faeces. Sodium fytate has been used in a similar manner to sodium cellulose phosphate (p.1463) to reduce the absorption of calcium from the gut in the treatment of hypercalciuria. It also binds other metals; fytic acid has been used as an antoxidant, and as an adjunct in topical preparations for hyperpigmentation disorders.

Sodium fytate labelled with technetium-99m (p.2055) has been used intravenously for imaging of the liver.

Preparations

Proprietary Preparations (details are given in Part 3)
Hung.: Fyton.

Multi-ingredient: ***Ital.:*** Lightening; Phytic Acid.

Sodium Nitrite

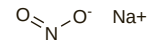
Dusitan sodný; E250; Natrii nitris; Natrio nitritas; Natrium Nitrosum; Natriumnitriitti; Natriumnitrit; Nátrium-nitrit; Nitrito sódico; Sodium, nitrite de; Sodu azotyn; Sodyum Nitrit.

$NaNO_2$ = 69.00.

CAS — 7632-00-0.

ATC — V03AB08.

ATC Vet — QV03AB08.



Pharmacopoeias. In *Chin.*, *Eur.* (see p.vii), *Int.*, and *US.*
Ph. Eur. 6.2 (Sodium Nitrite). Hygroscopic, colourless crystals or mass, or yellowish rods. Freely soluble in water; soluble in alcohol. Store in airtight containers.
USP 31 (Sodium Nitrite). A white to slightly yellow granular powder, or white or practically white, opaque fused masses or sticks. It is deliquescent in air. Soluble 1 in 1.5 of water; sparingly soluble in alcohol. Its solutions are alkaline to litmus. Store in airtight containers at a temperature of 25°, excursions permitted between 15° and 30°.

Adverse Effects

Sodium nitrite may cause nausea and vomiting, abdominal pain, dizziness, headache, flushing, cyanosis, tachypnoea, and dyspnoea; vasodilatation resulting in syncope, hypotension, and tachycardia may occur. Overdosage may result in cardiovascular collapse, coma, convulsions, and death. Ionised nitrites readily oxidise haemoglobin to methaemoglobin, causing methaemoglobinaemia.

Sodium nitrite is a precursor for the formation of nitrosamines, many of which are carcinogenic in *animals*, but a relationship with human cancer has not been established.

Methaemoglobinaemia. Severe methaemoglobinaemia has been reported after the consumption of nitrite-contaminated meat,[1,2] as well as following inadvertent ingestion of sodium nitrite.[3,4]

1. Walley T, Flanagan M. Nitrite-induced methaemoglobinaemia. *Postgrad Med J* 1987; **63:** 643–44.
2. Kennedy N, *et al.* Faulty sausage production causing methaemoglobinaemia. *Arch Dis Child* 1997; **76:** 367–8.
3. Finan A, *et al.* Methaemoglobinaemia associated with sodium nitrite in three siblings. *BMJ* 1998; **317:** 1138–9.
4. Anonymous. Methemoglobinemia following unintentional ingestion of sodium nitrite—New York, 2002. *MMWR* 2002; **51:** 639–42.

Treatment of Adverse Effects

When toxicity results from the ingestion of nitrites, treatment is supportive and symptomatic; oxygen and methylthioninium chloride may be required for methaemoglobinaemia although methylthioninium chloride should not be given if cyanide poisoning is suspected since cyanide may be displaced. Exchange transfusion may be considered when methaemoglobinaemia is severe.

Uses and Administration

Sodium nitrite is used with sodium thiosulfate in the treatment of cyanide poisoning (p.2045). Sodium nitrite produces methaemoglobinaemia and it is thought that cyanide ions combine with the methaemoglobin to produce cyanmethaemoglobin, thus protecting cytochrome oxidase from the cyanide ions; however, other mechanisms may have a significant role. As the cyanmethaemoglobin slowly dissociates, the cyanide is converted to relatively non-toxic thiocyanate and is