Pharmacopoeias. In *Eur.* (see p.vii) and *Jpn.*
Ph. Eur. 6.2 (Trapidil). A white or almost white crystalline powder. Freely soluble in water; soluble in dehydrated alcohol and in dichloromethane. Protect from light.

Profile
Trapidil is a vasodilator and an inhibitor of platelet aggregation. It is also an antagonist of platelet-derived growth factor. It is used orally in the management of ischaemic heart disease in doses of 400 to 600 mg daily, in divided doses; doses of up to 600 mg daily may be used to prevent restenosis after angioplasty (but see below). Ischaemic heart disease is discussed under Atherosclerosis (p.1159) and the treatment of its clinical manifestations is described under Angina Pectoris (p.1157) and Myocardial Infarction (p.1175).

◊ References to anti-platelet activity.

1. Yasue H, *et al.* Effects of aspirin and trapidil on cardiovascular events after acute myocardial infarction: Japanese Antiplatelets Myocardial Infarction Study (JAMIS) Investigators. *Am J Cardiol* 1999; **83:** 1308–13.

◊ References to pharmacokinetics.

1. Harder S, *et al.* Pharmacokinetics of trapidil, an antagonist of platelet derived growth factor, in healthy subjects and in patients with liver cirrhosis. *Br J Clin Pharmacol* 1996; **42:** 443–9.

Angioplasty and stenting. Although angiographic studies[1-3] have found that trapidil reduces the rate of restenosis after balloon angioplasty (see Reperfusion and Revascularisation Procedures, p.1181), no effect on clinical outcomes[3] has been shown. Studies investigating the use of trapidil after coronary stenting[3,4] have shown no benefit in terms of restenosis or clinical events, and it was concluded that trapidil is not indicated for this purpose.

1. Okamoto S, *et al.* Effects of trapidil (triazolopyrimidine), a platelet-derived growth factor antagonist, in preventing restenosis after percutaneous transluminal coronary angioplasty. *Am Heart J* 1992; **123:** 1439–44.
2. Maresta A, *et al.* Trapidil (triazolopyrimidine), a platelet-derived growth factor antagonist, reduces restenosis after percutaneous transluminal coronary angioplasty: results of the randomized, double-blind STARC study. *Circulation* 1994; **90:** 2710–15.
3. Maresta A, *et al.* Starc II, a multicenter randomized placebo-controlled double-blind clinical trial of trapidil for 1-year clinical events and angiographic restenosis reduction after coronary angioplasty and stenting. *Catheter Cardiovasc Interv* 2005; **64:** 375–82.
4. Serruys PW, *et al.* The TRAPIST study: a multicentre randomized placebo controlled clinical trial of trapidil for prevention of restenosis after coronary stenting, measured by 3-D intravascular ultrasound. *Eur Heart J* 2001; **22:** 1938–47.

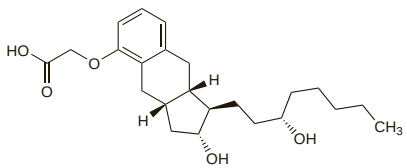
Preparations
Proprietary Preparations (details are given in Part 3)
Austria: Rocornal†; ***Braz.:*** Travisco; ***Cz.:*** Rocornal†; ***Ger.:*** Rocornal; ***Ital.:*** Avantrin†; Travisco; ***Jpn:*** Rocornal.

Treprostinil *(USAN, rINN)*

LRX-15; Tréprostinil; Treprostinilo; Treprostinilum; Treprostinol; 15AU81; U-62840; UT-15. ({(1*R*,2*R*,3a*S*,9a*S*)-2,3,3a,4,9,9a-Hexahydro-2-hydroxy-1-[(3*S*)-3-hydroxyoctyl]-1*H*-benz[*f*]inden-5-yl}oxy)acetic acid.

Трепростинил

$C_{23}H_{34}O_5$ = 390.5.
CAS — 81846-19-7.
ATC — B01AC21.
ATC Vet — QB01AC21.



Treprostinil Sodium *(rINNM)*

Natrii Treprostinilum; Tréprostinil Sodique; Treprostinilo sódico.

Натрий Трепростинил

$C_{23}H_{33}NaO_5$ = 412.5.
CAS — 289480-64-4.
ATC — B01AC21.
ATC Vet — QB01AC21.

Adverse Effects and Precautions
Infusion site pain and reactions, including erythema, induration, and rash, are the most common adverse effects reported during subcutaneous infusion of treprostinil. Other effects include headache, nausea, diarrhoea, jaw pain, oedema, vasodilatation, dizziness, hypotension, and pruritus.

Abrupt cessation of the infusion should be avoided, because symptoms of pulmonary hypertension may worsen. Treprostinil should be used with caution in hepatic impairment.

Interactions
Since treprostinil is a vasodilator and inhibitor of platelet aggregation, care should be taken in patients receiving other vasodilators or anticoagulants.

Pharmacokinetics
Treprostinil sodium is rapidly and completely absorbed after subcutaneous injection. It is metabolised by the liver and eliminated with a terminal half-life of about 4 hours. About 80% of a dose is excreted in the urine, mainly as metabolites.

◊ References.

1. Wade M, *et al.* Absolute bioavailability and pharmacokinetics of treprostinil sodium administered by acute subcutaneous infusion. *J Clin Pharmacol* 2004; **44:** 83–8.
2. Wade M, *et al.* Pharmacokinetics of treprostinil sodium administered by 28-day chronic continuous subcutaneous infusion. *J Clin Pharmacol* 2004; **44:** 503–9.
3. Laliberte K, *et al.* Pharmacokinetics and steady-state bioequivalence of treprostinil sodium (Remodulin) administered by the intravenous and subcutaneous route to normal volunteers. *J Cardiovasc Pharmacol* 2004; **44:** 209–14.
4. McSwain CS, *et al.* Dose proportionality of treprostinil sodium administered by continuous subcutaneous and intravenous infusion. *J Clin Pharmacol* 2008; **48:** 19–25.

Uses and Administration
Treprostinil, a vasodilator and platelet aggregation inhibitor, is an analogue of the prostaglandin epoprostenol (prostacyclin; p.1279). Treprostinil sodium is given by continuous subcutaneous infusion in the treatment of pulmonary hypertension (p.1179); if this route cannot be tolerated, treprostinil sodium may be given by continuous infusion through a central venous catheter. Doses are calculated in terms of treprostinil: treprostinil sodium 1.32 nanograms is equivalent to about 1.25 nanograms of treprostinil. The infusion is started with a dose equivalent to treprostinil 1.25 nanograms/kg per minute; if this is not tolerated the dose should be halved. The infusion rate can be increased according to patient response, by increments of up to 1.25 nanograms/kg per minute each week for the first 4 weeks, followed by increases of up to 2.5 nanograms/kg per minute each week. There is limited experience with doses above 40 nanograms/kg per minute. The dose of treprostinil should be reduced in hepatic impairment, see below.

Inhaled treprostinil is under investigation in pulmonary hypertension, and intravenous use has been investigated for intermittent claudication.

◊ References.

1. Moller ER, *et al.* Trial of a novel prostacyclin analog, UT-15, in patients with severe intermittent claudication. *Vasc Med* 2000; **5:** 231–7.
2. Simonneau G, *et al.* Continuous subcutaneous infusion of treprostinil, a prostacyclin analogue, in patients with pulmonary arterial hypertension: a double-blind, randomized placebo-controlled trial. *Am J Respir Crit Care Med* 2002; **165:** 800–804.
3. Vachiéry J-L, *et al.* Transitioning from IV epoprostenol to subcutaneous treprostinil in pulmonary arterial hypertension. *Chest* 2002; **121:** 1561–5.
4. Vachiéry JL, Naeije R. Treprostinil for pulmonary hypertension. *Expert Rev Cardiovasc Ther* 2004; **2:** 183–91.
5. Oudiz RJ, *et al.* Treprostinil, a prostacyclin analogue, in pulmonary arterial hypertension associated with connective tissue disease. *Chest* 2004; **126:** 420–7.
6. Gomberg-Maitland M, *et al.* Efficacy and safety of sildenafil added to treprostinil in pulmonary hypertension. *Am J Cardiol* 2005; **96:** 1334–6.
7. Fernandez B, Strootman D. The prostacyclin analog, treprostinil sodium, provides symptom relief in severe Buerger's disease—a case report and review of literature. *Angiology* 2006; **57:** 99–102.
8. Voswinckel R, *et al.* Inhaled treprostinil for treatment of chronic pulmonary arterial hypertension. *Ann Intern Med* 2006; **144:** 149–50.
9. Channick RN, *et al.* Safety and efficacy of inhaled treprostinil as add-on therapy to bosentan in pulmonary arterial hypertension. *J Am Coll Cardiol* 2006; **48:** 1433–7.

Administration in hepatic impairment. Clearance of treprostinil is reduced in patients with hepatic impairment. The manufacturers recommend that the initial dose should be 0.625 nanograms/kg per minute, and should be increased cautiously, in mild to moderate impairment. Treprostinil has not been studied in severe hepatic impairment.

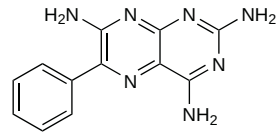
Preparations
Proprietary Preparations (details are given in Part 3)
Austral.: Remodulin; ***Chile:*** Remodulin; ***Cz.:*** Remodulin; ***Fr.:*** Remodulin; ***Gr.:*** Remodulin; ***Israel:*** Remodulin; ***Port.:*** Remodulin; ***Switz.:*** Remodulin; ***USA:*** Remodulin.

Triamterene *(BAN, USAN, rINN)* ⊗

NSC-77625; SKF-8542; Triamtereeni; Triamterén; Triamteren; Triamterenas; Triamtérène; Triamtereno; Triamterenum; Triantereno. 6-Phenylpteridine-2,4,7-triamine; 2,4,7-Triamino-6-phenylpteridine.

Триамтерен

$C_{12}H_{11}N_7$ = 253.3.
CAS — 396-01-0.
ATC — C03DB02.
ATC Vet — QC03DB02.



NOTE. Compounded preparations of triamterene may be represented by the following names:

- Co-triamterzide (*BAN*)—triamterene 2 parts and hydrochlorothiazide 1 part (w/w)
- Co-triamterzide (*PEN*)—triamterene and hydrochlorothiazide.

Pharmacopoeias. In *Chin.*, *Eur.* (see p.vii), *Jpn*, and *US.*
Ph. Eur. 6.2 (Triamterene). A yellow, crystalline powder. Very slightly soluble in water and in alcohol. Protect from light.
USP 31 (Triamterene). A yellow, odourless, crystalline powder. Practically insoluble in water, in chloroform, in ether, in benzene, and in dilute alkali hydroxides; very slightly soluble in alcohol, in acetic acid, and in dilute mineral acids; soluble 1 in 30 of formic acid and 1 in 85 of 2-methoxyethanol. Store in airtight containers. Protect from light.

Adverse Effects
As for Amiloride Hydrochloride, p.1209. Triamterene has also been reported to cause photosensitivity reactions, increases in uric acid concentrations, and blood dyscrasias. Renal calculi may occur in susceptible patients, and megaloblastic anaemia has been reported in patients with depleted folic acid stores such as those with hepatic cirrhosis. Reversible renal failure, due either to acute interstitial nephritis or to an interaction with NSAIDs (see under Interactions, below) has occurred.

Incidence of adverse effects. In a postmarketing surveillance study of 70 898 patients[1] taking triamterene with hydrochlorothiazide the most common adverse effects were fatigue, dizziness, and nausea. Adverse effects necessitated withdrawal in 8.1% of patients. A subgroup analysis of 21 731 patients[2] indicated that hyperkalaemia was more common in elderly patients and in those with diabetes mellitus.

1. Hollenberg NK, Mickiewicz CW. Postmarketing surveillance in 70,898 patients treated with a triamterene/hydrochlorothiazide combination (Maxzide). *Am J Cardiol* 1989; **63:** 37B–41B.
2. Hollenberg NK, Mickiewicz CW. Hyperkalemia in diabetes mellitus: effect of a triamterene-hydrochlorothiazide combination. *Arch Intern Med* 1989; **149:** 1327–30.

Effects on the blood. There have been case reports of pancytopenia associated with triamterene therapy.[1,2] Some patients had hepatic cirrhosis and the antifolate activity of triamterene was considered responsible.[2]

1. Castellano G, *et al.* Pancitopenia aguda y megaloblastosis medular durante el tratemiento con triamterene de la ascitis causada por cirrosis hepática: aportación de dos casos. *Gastroenterol Hepatol* 1983; **6:** 540–4.
2. Remacha A, *et al.* Triamterene-induced megaloblastosis: report of two new cases, and review of the literature. *Biol Clin Hematol* 1983; **5:** 127–34.

Effects on the kidneys. There have been a number of reports[1-4] of renal calculi containing triamterene or its metabolites, generally in patients also taking hydrochlorothiazide. An abnormal urinary sediment was described which was thought to represent precipitated triamterene.[5] These observations were expanded in a crossover study:[6] abnormal urinary sediment was seen in 14 of 26 patients taking triamterene but in none taking amiloride. Triamterene and its metabolites were identified by others in 181 of 50 000 renal calculi.[7] Triamterene either formed the nucleus of the stone or was deposited with calcium oxalate or uric acid. One-third of the 181 stones were entirely or mainly composed of triamterene and its metabolites and it was suggested that supersaturation of the urine with these substances could provide suitable nuclei for the crystallisation of calcium oxalate.[8] However, other workers were unable to confirm this and suggested that triamterene and its metabolites could become incorporated into the protein matrix of existing stones.[9] In addition, an epidemiological study[10] found no evidence that triamterene use was associated with an increased incidence of renal stones. Some authors[11] have therefore considered that there was not enough evidence to contra-indicate the drug in patients with a history of recurrent renal calculi.

Deposition of triamterene in the urine may also play a part in the development of interstitial nephritis, which was diagnosed in 4 patients also taking hydrochlorothiazide, over a period of 4 years.[6]

Triamterene has also been associated with transient decline in renal function and the development of renal failure.[12,13] Several mechanisms may be responsible including interstitial nephritis,