

DATA SHEET

1 NAME OF MEDICINE

Milrinone Generic Health, 1 mg/mL injection concentrate

2 QUALITATIVE AND QUANTITATIVE COMPOSITION

Each sterile, single-dose ampoule contains 1 mg/mL milrinone (as lactate)

For the full list of excipients, see section 6.1.

3 PHARMACEUTICAL FORM

Injection concentrate.

Clear, colourless to pale yellow solution, practically free from visible particles.

The pH is between 3.2 and 4.0.

4 CLINICAL PARTICULARS

4.1 THERAPEUTIC INDICATIONS

Milrinone is indicated for the short term intravenous therapy of severe congestive heart failure. The majority of experience with intravenous milrinone has been in patients receiving digoxin and diuretics.

Milrinone is also indicated for low output states following cardiac surgery, including weaning from cardio-pulmonary bypass pump.

4.2 DOSE AND METHOD OF ADMINISTRATION

Milrinone should be administered with a loading dose followed by a continuous infusion (maintenance dose) according to the following guidelines:

Loading dose

50 mcg/kg administered slowly over 10 minutes

Maintenance dose

Table 1

	INFUSION RATE	TOTAL DAILY DOSE (24 HOURS)
MINIMUM	0.375 mcg/kg/min	0.60 mg/kg
STANDARD	0.50 mcg/kg/min	0.77 mg/kg
MAXIMUM	0.75 mcg/kg/min	1.13 mg/kg

Note: Administer as a continuous intravenous infusion.

The infusion rate should be adjusted according to haemodynamic and clinical response. Patients should be closely monitored. Most patients show an improvement in haemodynamic status as evidenced by increases in cardiac output and reductions in pulmonary capillary wedge pressure.

Note: See "Dosage Adjustment in Renally Impaired Patients".

Dosage may be titrated to the maximum haemodynamic effect and should not exceed 1.13 mg/kg/day. Duration of therapy should depend upon patient responsiveness.

Intravenous infusions of milrinone should be administered as described in Table 2.

Table 2 • Milrinone - Rates of Infusion for concentrations of 100 mcg/mL, 150 mcg/mL and 200 mcg/mL. Infusion Delivery Rate

Milrinone (mcg/kg/min)	100 mcg/mL (mL/kg/hr)	150 mcg/mL (mL/kg/hr)	200 mcg/mL (mL/kg/hr)
0.375	0.22	0.15	0.11
0.400	0.24	0.16	0.12
0.500	0.30	0.20	0.15
0.600	0.36	0.24	0.18
0.700	0.42	0.28	0.21
0.750	0.45	0.30	0.22

In order to calculate flow rate (mL/hr) multiply infusion delivery rate by patient weight (in kg).

These ampoules require preparation of dilutions prior to administration to patients intravenously.

For instructions on dilution of the medicine before administration, see section 6.6.

Dosage Adjustment in Renally Impaired Patients

Data obtained from patients with severe renal impairment (creatinine clearance = 0 to 30 mL/min) but without congestive heart failure have demonstrated that the presence of renal impairment significantly increases the terminal elimination half-life of milrinone. Reductions in the starting infusion rate may be necessary in patients with renal impairment. For patients with clinical evidence of renal impairment, the recommended infusion rate can be obtained from Table 3:

Table 3

CREATININE CLEARANCE (mL/min/1.73m²)	INFUSION RATE (mcg/kg/min)
5	0.20
10	0.23
20	0.28
30	0.33
40	0.38
50	0.43

4.3 CONTRAINDICATIONS

Milrinone should not be used in patients with severe obstructive aortic or pulmonary valvular disease, or hypertrophic subaortic stenosis. Milrinone should not be used in lieu of surgical relief of the obstruction. Like other inotropic agents, milrinone may aggravate outflow tract obstruction in these conditions.

Hypersensitivity to milrinone, other bipyridines or any other ingredient in the formulation listed in section 6.1.

4.4 SPECIAL WARNINGS AND PRECAUTIONS FOR USE

Warnings

Myocardial ischaemia or infarction may occur in patients following cardiac surgery. Should these events occur, care should be taken with the use of milrinone as information on the safety of milrinone under these circumstances is limited.

Use in Acute Myocardial Infarction

Use of inotropic agents such as milrinone during the acute phases of a myocardial infarction may lead to an undesirable increase in myocardial oxygen consumption (MVO₂). Milrinone has not increased MVO₂ in patients with chronic heart failure, however, until further clinical experience with this class of drugs is gained, milrinone is not recommended during the acute phase of post myocardial infarction.

Precautions

Supraventricular and ventricular arrhythmias have been observed in the high-risk population treated. In some patients, milrinone has been shown to increase ventricular ectopy, including non-sustained ventricular tachycardia. The potential for arrhythmia, present in congestive heart failure itself, may be increased by many drugs or combinations of drugs. Patients receiving milrinone should be closely monitored (including heart rate, clinical state, electro-cardiogram, fluid balance, electrolytes and renal function) during infusion.

Milrinone produces a slight shortening in A-V node conduction time, indicating a potential for an increased ventricular response rate in patients with atrial flutter/fibrillation which is not being controlled with digitalis therapy. In these patients, prior digitalisation or treatment with other agents to prolong A-V node conduction time should be considered.

Milrinone may induce hypotension as a consequence of its vasodilatory action. Caution should therefore be exercised in patients with hypotension prior to treatment or in those showing excessive decreases in blood pressure during therapy with milrinone lactate. In such cases, the infusion should be stopped until the hypotensive effect has been resolved, then resumed at a lower rate if resumption is considered necessary.

If prior vigorous diuretic therapy is suspected to have caused significant decreases in cardiac filling pressure, milrinone should be cautiously administered with monitoring of blood pressure, heart rate, and clinical symptomatology.

There is no experience in controlled trials with infusions of milrinone for periods exceeding 48 hours. Cases of infusion site reaction have been reported with intravenous milrinone therapy (see section 4.8). Consequently, careful monitoring of the infusion site should be maintained so as to avoid possible extravasation.

Fluid and electrolyte changes, as well as serum creatinine levels and renal function should be carefully monitored during milrinone therapy. Improvement in cardiac output with resultant diuresis may necessitate a reduction in the dose of diuretic. Potassium loss due to excessive diuresis may predispose digitalised patients to arrhythmias. Therefore, hypokalaemia should be corrected by potassium supplementation in advance of or during milrinone use.

Use in Elderly Patients

There are no special dosage recommendations for the elderly patient.

Ninety percent of all patients administered milrinone in clinical studies were within the age range of 45-70 years, with a mean age of 61 years. Patients in all age groups demonstrated clinically and statistically significant responses. No age-related effects on the incidence of adverse reactions have been observed.

Controlled pharmacokinetic studies have not disclosed any age-related effects on the distribution and elimination of milrinone.

Use in Renal Impairment

In patients with severe renal impairment the dose should be adjusted (see section 4.2).

Paediatric population

Safety and effectiveness in children have not been established.

4.5 INTERACTION WITH OTHER MEDICINES AND OTHER FORMS OF INTERACTION

No untoward clinical manifestations have been observed in patients in whom milrinone was used concurrently with the following drugs: digitalis glycosides, lignocaine, quinidine, hydralazine, prazosin, isosorbide dinitrate, glyceryl trinitrate, chlorthalidone, frusemide, hydrochlorothiazide, spironolactone, captopril, heparin, warfarin, diazepam, insulin, and potassium supplements.

See section 6.2 for incompatibility information.

4.6 FERTILITY, PREGNANCY AND LACTATION

Pregnancy

Category B3

Oral administration of milrinone to pregnant rats and rabbits during organogenesis produced no evidence of teratogenicity at dose levels up to 40 mg/kg/day and 12 mg/kg/day respectively. Milrinone did not appear to be teratogenic when administered intravenously to pregnant rats at doses up to 3 mg/kg/day or pregnant rabbits at doses up to 12 mg/kg/day, although an increased resorption rate was apparent at dose levels above 3 mg/kg/day (intravenous) in the latter species. There are no adequate and well-controlled studies in pregnant women. Milrinone should be used during pregnancy only if the potential benefit justifies the potential risk to the foetus.

Breast-feeding

Caution should be exercised when milrinone is administered to nursing women since it is not known whether it is excreted in human milk.

Fertility

In reproductive performance studies in rats, milrinone had no effect on male or female fertility at oral doses up to 32 mg/kg/day.

4.7 EFFECTS ON ABILITY TO DRIVE AND USE MACHINES

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

4.8 UNDESIRABLE EFFECTS

Cardiovascular Effects

Ventricular arrhythmias were reported in 12.1% of patients receiving milrinone: Ventricular ectopic activity, 8.5%; non-sustained ventricular tachycardia, 2.8%; sustained ventricular tachycardia 1% and ventricular fibrillation, 0.2%. Holter recordings have demonstrated in some patients that injection of milrinone increases ventricular ectopy, including non-sustained ventricular tachycardia. Life-threatening arrhythmias are infrequent and when present have been associated with certain underlying factors such as pre-existing arrhythmias, metabolic abnormalities (eg. hypokalaemia), abnormal digoxin levels and catheter insertion.

Very rarely (< 0.01%) cases of torsades de pointes have been reported.

Supraventricular arrhythmias were reported in 3.8% of the patients receiving milrinone. The incidence of both supraventricular and ventricular arrhythmias has not been related to the dose or plasma level of milrinone. There is no evidence for a patient subset which is at higher risk for ventricular arrhythmias.

Other cardiovascular adverse reactions include hypotension 2.9% and angina/chest pain 1.2%.

CNS Effects

Headaches, mostly mild to moderate in severity, have been reported in 2.9% of patients receiving milrinone.

Skin

Dermatological reactions such as rashes have been observed in < 0.01% of patients. Cases of infusion site reaction have been reported.

Liver

Abnormal liver function tests have been observed in < 1% of patients.

Congenital, Familial, and Genetic Disorders

Patent ductus arteriosus has been reported.

Renal and Urinary Disorders

Renal failure, secondary to a concomitant hypotension, has been reported.

Other Effects

Other adverse reactions reported, all with an incidence of less than 1% but not definitely related to the administration of milrinone include hypokalaemia, tremor, and thrombocytopenia. Very rarely (< 0.01%) bronchospasm and anaphylactic shock have occurred.

Reporting of suspected adverse reactions

Reporting suspected adverse reactions after authorisation of the medicine is important. It allows continued monitoring of the benefit/risk balance of the medicine. Healthcare professionals are asked to report any suspected adverse reactions <https://nzphvc.otago.ac.nz/reporting/>

4.9 OVERDOSE

Doses of milrinone may induce hypotension because of its vasodilator effect. If this occurs, administration of milrinone should be reduced or temporarily discontinued until the patient's condition stabilises. No specific antidote is known, but general measures for circulatory support should be taken.

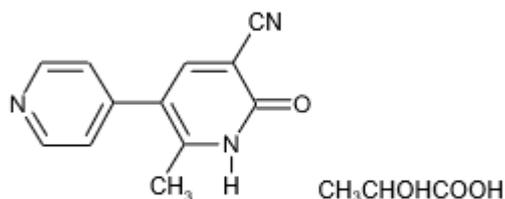
For advice on the management of overdose please contact the National Poisons Centre on 0800 POISON (0800 764766).

5 PHARMACOLOGICAL PROPERTIES

5.1 PHARMACODYNAMIC PROPERTIES

Pharmacotherapeutic group: Cardiac therapy, Phosphodiesterase inhibitor. ATC code: CO1CE02

Milrinone (as lactate), is a member of a new class of bipyridine inotropic/vasodilator agents with phosphodiesterase activity, distinct from digitalis glycosides or catecholamines. Milrinone (as lactate) is designated chemically as 1,6-dihydro-2-methyl-6-oxo-[3,4'-bipyridine]-5-carbonitrile lactate and has the following structure.



Milrinone is an off-white to tan crystalline compound with a molecular weight of 211.2 and an empirical formula of C₁₂H₉N₃O. It is stable and colourless to pale yellow in solution.

Milrinone is available as sterile aqueous solutions of the lactate salt of milrinone for injection or infusion intravenously.

Mechanism of action

Milrinone is a positive inotrope and vasodilator, with little chronotropic activity, different in structure and mode of action from either the digitalis glycosides or catecholamines.

Milrinone, at relevant inotropic and vasorelaxant concentrations, is a selective inhibitor of peak III cAMP phosphodiesterase isozyme in cardiac and vascular muscle. This inhibitory action is consistent with cAMP mediated increases in intracellular ionised calcium and contractile force in cardiac muscle, as well as with cAMP dependent contractile protein phosphorylation and relaxation in vascular muscle. Additional experimental evidence also indicates that milrinone is not a β-adrenergic agonist, and unlike digitalis glycosides, it does not inhibit Na⁺/K⁺ ATPase activity.

Clinical studies in patients with congestive heart failure have shown that milrinone produces dose-related and plasma level-related increases in the maximum rate of increase of left ventricular pressure (dP/dt max). Studies in normal subjects have shown that milrinone produces increases in the slope of the left ventricular pressure-dimension relationship, indicating a direct inotropic effect of the drug.

Milrinone also produces dose-related and plasma concentration-related increases in forearm blood flow in patients with congestive heart failure, indicating a direct arterial vasodilator activity of the drug.

Both the inotropic and vasodilatory effects have been observed over the therapeutic range of plasma milrinone concentrations of 100 ng/mL to 300 ng/mL.

In addition to increasing myocardial contractility, milrinone improves diastolic function as evidenced by improvements in left ventricular diastolic relaxation.

Pharmacodynamic effects

In patients with depressed myocardial function, milrinone produces a prompt increase in

cardiac output and decreases in pulmonary capillary wedge pressure and vascular resistance, without a significant increase in heart rate or myocardial oxygen consumption.

These haemodynamic improvements are both dose and plasma milrinone concentration related. Haemodynamic improvement during intravenous therapy with milrinone was accompanied by clinical symptomatic improvement, as measured by changes in New York Heart Association classification. The great majority of patients experience improvements in haemodynamic function within 5 to 15 minutes of the initiation of therapy.

In studies in congestive heart failure patients, milrinone when administered as a loading injection followed by a maintenance infusion produced significant mean initial increases in cardiac index as presented in Table 4:

Table 4

Cardiac Index	Loading Injection (mcg/kg)	Maintenance Infusion (mcg/kg/min)
25	37.5	0.375
38	50	0.500
42	75	0.750

Over the same range of loading injections and maintenance infusions, pulmonary capillary wedge pressure significantly decreased by 20%, 23% and 36%, respectively, while systemic vascular resistance significantly decreased by 17%, 21% and 37%. The heart rate was generally unchanged (increases of 2%, 3% and 10%, respectively). Mean arterial pressure fell by up to 5%, at the two lower dose regimens, but by 17% at the highest dose. Patients evaluated for 48 hours maintained improvements in haemodynamic function, with no evidence of diminished response (tachyphylaxis). A smaller number of patients have received infusions of milrinone for periods up to 72 hours without evidence of tachyphylaxis.

Milrinone has a favourable inotropic effect in fully digitalised patients without causing signs of glycoside toxicity. Theoretically, in cases of atrial flutter/fibrillation, it is possible that milrinone may increase ventricular response rate because of its slight enhancement of AV node conduction. In these cases, digitalis should be considered prior to the institution of therapy of milrinone.

Improvement in left ventricular function and relief of congestive heart failure symptoms in patients with ischaemic heart disease have been observed. The improvement has occurred without inducing symptoms or ECG signs in myocardial ischaemia.

The steady-state milrinone plasma levels after approximately 6-12 hours of unchanging maintenance infusion of 0.50 mcg/kg/min are approximately 200 ng/mL. Near maximal favourable effects of milrinone on cardiac output and pulmonary capillary wedge pressure are seen at plasma milrinone concentrations in the 150 ng/mL to 250 ng/mL range.

Clinical efficacy and safety

In a double-blind, placebo controlled study in patients being weaned off cardiopulmonary bypass, 100% of patients taking milrinone were successfully weaned off bypass compared to 33% of

the placebo arm patients. All patients who initially failed blinded placebo treatment were successfully weaned from cardiopulmonary bypass support following administration with open-label milrinone.

In acute states following cardiac surgery, it is unlikely that treatment need be maintained for more than 12 hours.

5.2 PHARMACOKINETIC PROPERTIES

Distribution

Following intravenous loading, injections of 12.5 to 125.0 mcg/kg to congestive heart failure patients, milrinone has a volume of distribution of 0.38 litres/kg, a mean terminal elimination half-life of 2.3 hours, and a clearance of 0.13 litres/kg/hr. Following intravenous infusions of 0.20 to 0.70 mcg/kg/min to congestive heart failure patients, milrinone has a volume of distribution of about 0.45 litres/kg, a mean terminal elimination half-life of 2.4 hours, and a clearance of 0.14 litres/kg/hr. These pharmacokinetic parameters were not dose-dependent, and the area under the plasma concentration versus time curve following loading injections was significantly dose-dependent.

Milrinone has been shown (by equilibrium dialysis) to be approximately 70% bound to human plasma protein.

Biotransformation

The primary route of excretion of milrinone in man is via the urine, with much smaller amounts recovered in the faeces. The major urinary excretion products in man are milrinone (83%) and its o-glucuronide metabolite (12%).

Elimination

Elimination in normal subjects via the urine is rapid, with approximately 60% recovered within the first two hours following dosing and approximately 90% recovered within the first eight hours following dosing. The mean renal clearance of milrinone is approximately 0.3 litres/min while that of the metabolites is even greater, indicative of active secretion.

5.3 PRECLINICAL SAFETY DATA

Carcinogenicity / Mutagenicity

Twenty-four months of oral administration of milrinone to mice at doses up to 40 mg/kg/day was unassociated with evidence of carcinogenic potential. Neither was there evidence of carcinogenic potential when milrinone was orally administered to rats at doses up to 5 mg/kg/day for 24 months or at 25 mg/kg/day for up to 18 months in males and 20 months in females.

Whereas the Chinese Hamster Ovary Chromosome Aberration Assay was positive in the presence of a metabolic activation system, results from the Ames Test, the Mouse Lymphoma Assay, the Micronucleus Test and the *in vivo* Rat Bone Marrow Metaphase Analysis indicated an absence of mutagenic potential.

Animal Toxicity

Oral and intravenous administration of toxic dosages of milrinone to rats and dogs resulted in myocardial degeneration/fibrosis and endocardial haemorrhage, principally affecting the left ventricular papillary muscles. Coronary vascular lesions characterised by periarterial oedema and inflammation have been observed in dogs only. The myocardial/endocardial changes are similar to those produced by β -adrenergic receptor agonists such as isoprenaline, while the vascular changes are similar to those produced by minoxidil and hydralazine.

6 PHARMACEUTICAL PARTICULARS

6.1 LIST OF EXCIPIENTS

Glucose
Lactic acid (for pH adjustment)
Sodium hydroxide (for pH adjustment)
Water for injections

6.2 INCOMPATIBILITIES

There is an immediate chemical interaction which is evidenced by the formation of a precipitate when frusemide is injected into an intravenous line of an infusion of milrinone. Therefore frusemide or bumetanide should not be administered in intravenous lines containing milrinone.

Milrinone injection should not be diluted in sodium bicarbonate intravenous solution.

6.3 SHELF LIFE

3 years unopened.

Infusion should be commenced as soon as practicable after preparation of the diluted solutions, in order to reduce microbiological hazards. Preparations not used within 72 hours (when stored at or below 25°C) should be discarded.

6.4 SPECIAL PRECAUTIONS FOR STORAGE

Store at or below 25°C. Protect from light.

For storage conditions after dilution of the medicine, see section 6.3.

6.5 NATURE AND CONTENTS OF CONTAINER

Glass ampoules containing 10 mL in a pack of 10.

6.6 SPECIAL PRECAUTIONS FOR DISPOSAL AND OTHER HANDLING

0.45% saline, 0.9% saline and 5% glucose and Ringer Lactate may be used as diluents.

- 100 micrograms/mL: Prepare by adding 90 mL diluent per 10 mg ampoule (10 mL) milrinone injection concentrate.
- 150 micrograms/mL: Prepare by adding 57 mL diluent per 10 mg ampoule (10 mL) milrinone injection concentrate.
- 200 micrograms/mL: Prepare by adding 40 mL diluent per 10 mg ampoule (10 mL) milrinone injection concentrate.

Note: Intravenous drug products should be inspected visually and should not be used if particulate matter or discolouration is present.

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

7 MEDICINE SCHEDULE

Prescription Medicine

8 SPONSOR

Max Health Ltd
PO Box 65 231
Mairangi Bay
Auckland 0754
Telephone: (09) 815 2664

9 DATE OF FIRST APPROVAL

08 September 1988

10 DATE OF REVISION OF THE TEXT

29 December 2020

Summary table of changes

Section changed	Summary of new information
All	Align with current source datasheet.