

# PRODUCT INFORMATION

## REVATIO<sup>®</sup>

(sildenafil citrate)

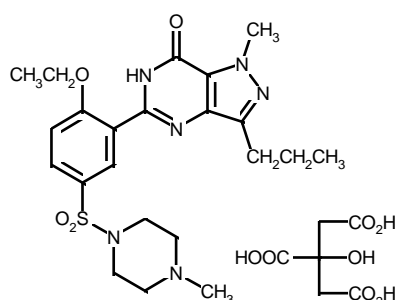
### NAME OF THE MEDICINE

REVATIO<sup>®</sup>, an oral therapy for pulmonary arterial hypertension, is the citrate salt of sildenafil, a selective inhibitor of cyclic guanosine monophosphate (cGMP)-specific phosphodiesterase type-5 (PDE5).

**Sildenafil citrate is 1-[4-ethoxy-3-(6,7-dihydro-1-methyl-7-oxo-3-propyl-1H-pyrazolo[4,3-d]pyrimidin-5-yl)phenylsulphonyl]-4-methylpiperazine citrate. CAS number 171,599-83-0.**

The empirical formula for sildenafil citrate is  $C_{22}H_{30}N_6O_4S.C_6H_8O_7$

Sildenafil citrate has the following structural formula:-



### DESCRIPTION

Sildenafil citrate is an off-white, crystalline powder with a molecular weight of 666.7. Its aqueous solubility is equivalent to 2.6 mg sildenafil per mL at 25°C.

In addition to sildenafil citrate, each REVATIO tablet contains the following inactive ingredients: microcrystalline cellulose, calcium hydrogen phosphate (anhydrous), croscarmellose sodium, magnesium stearate, hypromellose, titanium dioxide, lactose, glycerol triacetate.

### PHARMACOLOGY

#### Pharmacological actions

Sildenafil is a potent and selective inhibitor of cGMP specific phosphodiesterase type-5 (PDE5) in the smooth muscle of the pulmonary vasculature, where PDE5 is responsible for

degradation of cGMP. Sildenafil, therefore, increases cGMP within pulmonary vascular smooth muscle cells resulting in relaxation. In patients with pulmonary hypertension, this can lead to selective vasodilation of the pulmonary vascular bed and, to a lesser degree, vasodilatation in the systemic circulation.

Studies *in vitro* have shown that sildenafil is selective for PDE5. Its effect is more potent on PDE5 than on other known phosphodiesterases. There is a 10-fold selectivity over PDE6 which is involved in the phototransduction pathway in the retina. There is an 80-fold selectivity over PDE1, and over 700-fold over PDE 2, 3, 4, 7, 8, 9, 10 and 11. In particular, sildenafil has greater than 4,000-fold selectivity for PDE5 over PDE3, the cAMP-specific phosphodiesterase isoform involved in the control of cardiac contractility.

In addition to pulmonary vascular smooth muscle and the corpus cavernosum, PDE5 is also found in other tissues including vascular and visceral smooth muscle and in platelets. The inhibition of PDE5 in these tissues by sildenafil may be the basis for the enhanced platelet anti-aggregatory activity observed *in vitro*, and the mild peripheral arterial-venous dilatation *in vivo*.

Sildenafil causes mild and transient decreases in systemic blood pressure which, in the majority of cases, do not translate into clinical effects. The mean maximum decrease in supine systolic blood pressure following 100 mg oral dosing of sildenafil was 8.3 mmHg. The corresponding change in supine diastolic blood pressure was 5.3 mmHg. After chronic dosing of 80 mg three times a day to healthy male volunteers, the largest average change from baseline of supine systolic blood pressure was a decrease of 9.0 mmHg. The corresponding change in supine diastolic blood pressure was a decrease of 8.4 mmHg.

After chronic dosing of 80 mg three times a day to patients with systemic hypertension the mean change from baseline in systolic and diastolic blood pressure was a decrease of 9.4 mmHg and 9.1 mm Hg respectively.

After chronic dosing of 80 mg three times a day to patients with pulmonary arterial hypertension lesser effects in blood pressure reduction were observed (a reduction in both systolic and diastolic pressure of 2 mmHg). This may be due to improvements in cardiac output secondary to the beneficial effects of sildenafil on pulmonary vascular resistance.

Single oral doses of sildenafil up to 100 mg in healthy volunteers produced no clinically relevant effects on ECG. After chronic dosing of 80 mg three times a day to patients with pulmonary arterial hypertension no clinically relevant effects on the ECG were reported.

Sildenafil has no effect on visual acuity or contrast sensitivity. Mild and transient differences in colour discrimination (blue/green) were detected in some subjects using Farnsworth-Munsell 100 hue test at 1 hour following a 100 mg dose, with no effects evident after 2 hours post-dose.

The postulated mechanism for this change in colour discrimination is related to inhibition of PDE6, which is involved in the phototransduction cascade of the retina. *In vitro* studies show that sildenafil is 10-fold less potent against PDE6 than PDE5.

## PHARMACOKINETICS

### Absorption

Sildenafil is rapidly absorbed. Maximum observed plasma concentrations are reached within 30 to 120 minutes (median 60 minutes) of oral dosing in the fasted state. The mean absolute oral bioavailability is 41% (range 25-63%). After oral doses of 80 mg three times a day a more than dose proportional increase in sildenafil plasma levels has been observed. In pulmonary arterial hypertension patients, the oral bioavailability of sildenafil after 80 mg three times a day was on average 43 % (90 % CI: 27% - 60%) higher compared to the lower doses.

When sildenafil is taken with a high fat meal, the rate of absorption is reduced with a mean delay in Tmax of 60 minutes and a mean reduction in Cmax of 29%.

### Distribution

The mean steady state volume of distribution (Vss) for sildenafil is 105 L, indicating distribution into the tissues. After oral doses of 20 mg three times a day, the mean maximum total plasma concentration of sildenafil at steady state is approximately 113 ng/mL. Sildenafil and its major circulating N-desmethyl metabolite are both approximately 96% bound to plasma proteins. Protein binding is independent of total drug concentrations.

### Metabolism

Sildenafil is cleared predominantly by the CYP3A4 (major route) and CYP2C9 (minor route) hepatic microsomal isoenzymes. The major circulating metabolite results from N-demethylation of sildenafil. This metabolite has a PDE selectivity profile similar to sildenafil and an *in vitro* potency for PDE5 approximately 40% of the parent drug. In healthy volunteers, plasma concentrations of this metabolite are approximately 40% of those seen for sildenafil. The N-desmethyl metabolite is further metabolised, with a terminal half-life of approximately 4 h. In patients with pulmonary arterial hypertension, however, the ratio of the N-desmethyl metabolite to sildenafil is higher. Plasma concentrations of the N-desmethyl metabolite are approximately 72% those of sildenafil after 20 mg three times a day dosing (translating into a 36% contribution to sildenafil's pharmacological effects). The subsequent effect on efficacy is unknown.

### Elimination

The total body clearance of sildenafil is 41 L/h with a resultant terminal phase half-life of 3-5 hours. After either oral or intravenous administration, sildenafil is excreted as metabolites predominantly in the faeces (approximately 80% of administered oral dose) to a lesser extent in the urine (approximately 13% of administered oral dose).

### Renal impairment

In volunteers with mild (Clcr = 50-80 mL/min) and moderate (Clcr = 30-49 mL/min) renal impairment, the pharmacokinetics of a single oral dose of sildenafil (50 mg) were not altered. In volunteers with severe (Clcr = <30 mL/min) renal impairment, sildenafil clearance was

reduced, resulting in increases in AUC (100%) and Cmax (88%) compared to age-matched volunteers with no renal impairment.

### **Hepatic impairment**

In volunteers with hepatic cirrhosis (Child-Pugh A and B), sildenafil clearance was reduced, resulting in increases in AUC (84%) and Cmax (47%) compared to age-matched volunteers with no hepatic impairment. The pharmacokinetics of sildenafil in patients with severe hepatic impairment has not been studied.

### **Elderly (over 65 years of age)**

Healthy elderly volunteers (65 years or over) had a reduced clearance of sildenafil, resulting in approximately 90 % higher plasma concentrations of sildenafil and the active N-desmethyl metabolite compared to those seen in healthy younger volunteers (18-45 years). Due to age-differences in plasma protein binding, the corresponding increase in free sildenafil plasma concentration was approximately 40 %.

### **Population pharmacokinetics**

Age, gender, race, and renal and hepatic function were included as factors assessed in the population pharmacokinetic model to evaluate sildenafil pharmacokinetics in pulmonary arterial hypertension patients. None of these factors had a statistically significant impact on sildenafil pharmacokinetics in patients with pulmonary hypertension. The data set available for the population pharmacokinetic evaluation contained a wide range of demographic data and laboratory parameters associated with hepatic and renal function.

Population pharmacokinetic analysis of clinical trial data indicated a reduction in sildenafil clearance and/or an increase of oral bioavailability when administered with CYP3A4 substrates and the combination of CYP3A4 substrates and beta-blockers. These were the only factors with a statistically significant impact on the pharmacokinetics in patients with pulmonary arterial hypertension (PAH). The exposure to sildenafil in patients on CYP 3A4 substrates and CYP3A4 substrates plus beta-blockers was 43% and 66% higher respectively, compared to patients not receiving these drug classes.

In patients with pulmonary hypertension, the average steady-state concentrations were 20-50% higher over the investigated dose range of 20-80 mg three times daily (t.d.s.), when compared to those of healthy volunteers. There was also a doubling of Cmin levels compared to healthy volunteers. Both findings suggest a lower clearance and/or a higher oral bioavailability of sildenafil in patients with pulmonary hypertension compared to healthy volunteers.

## **CLINICAL STUDIES**

A randomized, double-blind, placebo-controlled study was conducted in 277 patients with pulmonary arterial hypertension (PAH), defined as a mean pulmonary artery pressure of  $\geq 25$  mmHg at rest with a pulmonary capillary wedge pressure  $< 15$  mmHg. Allowed background therapy included a combination of anticoagulation, digoxin, calcium channel blockers,

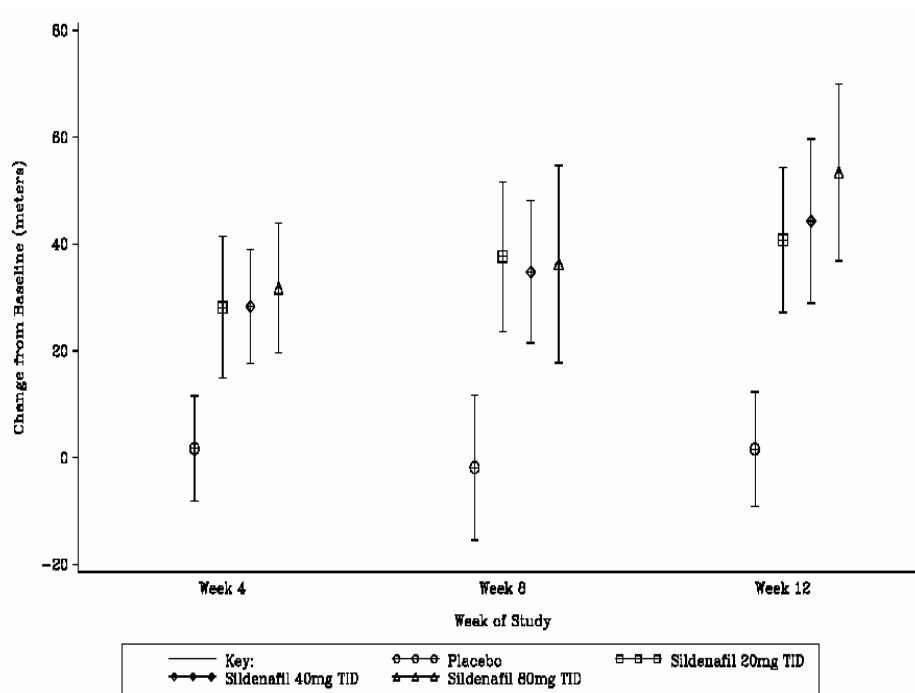
diuretics or oxygen. The use of prostacyclin analogues, endothelin receptor antagonists, and arginine supplementation were not permitted. Subjects who had failed to respond to bosentan were also excluded. Patients with left ventricular ejection fraction <45% or left ventricular shortening fraction <0.2 also were not studied.

Patients were randomized to receive placebo (n=70) or REVATIO 20 mg (n=69), 40 mg (n=67) or 80 mg (n=71) t.d.s. for a period of 12 weeks. They had either primary pulmonary hypertension (63%), PAH associated with connective tissue disease (30%), or PAH following surgical repair of left-to-right congenital heart lesions (7%). The study population consisted of 25% men and 75% women with a mean age of 49 years (range: 18-81 years) and baseline 6-minute walk test distance between 100 and 450 metres. Most patients were functional Class II (107/277, 39%) or Class III (160/277, 58%) with a mean baseline 6 minute walking distance of 378 meters and 326 meters respectively; fewer patients were Class I (1/277, 0.4%) or IV (9/277, 3%).

Sildenafil (or placebo) was added to patients' background therapy which could have included a combination of anticoagulation, digoxin, calcium channel blockers, diuretics or oxygen. The use of prostacyclin, prostacyclin analogues and endothelin receptor antagonists was not permitted as add-on therapy, and neither was arginine supplementation. Patients who previously failed bosentan therapy were excluded from the study.

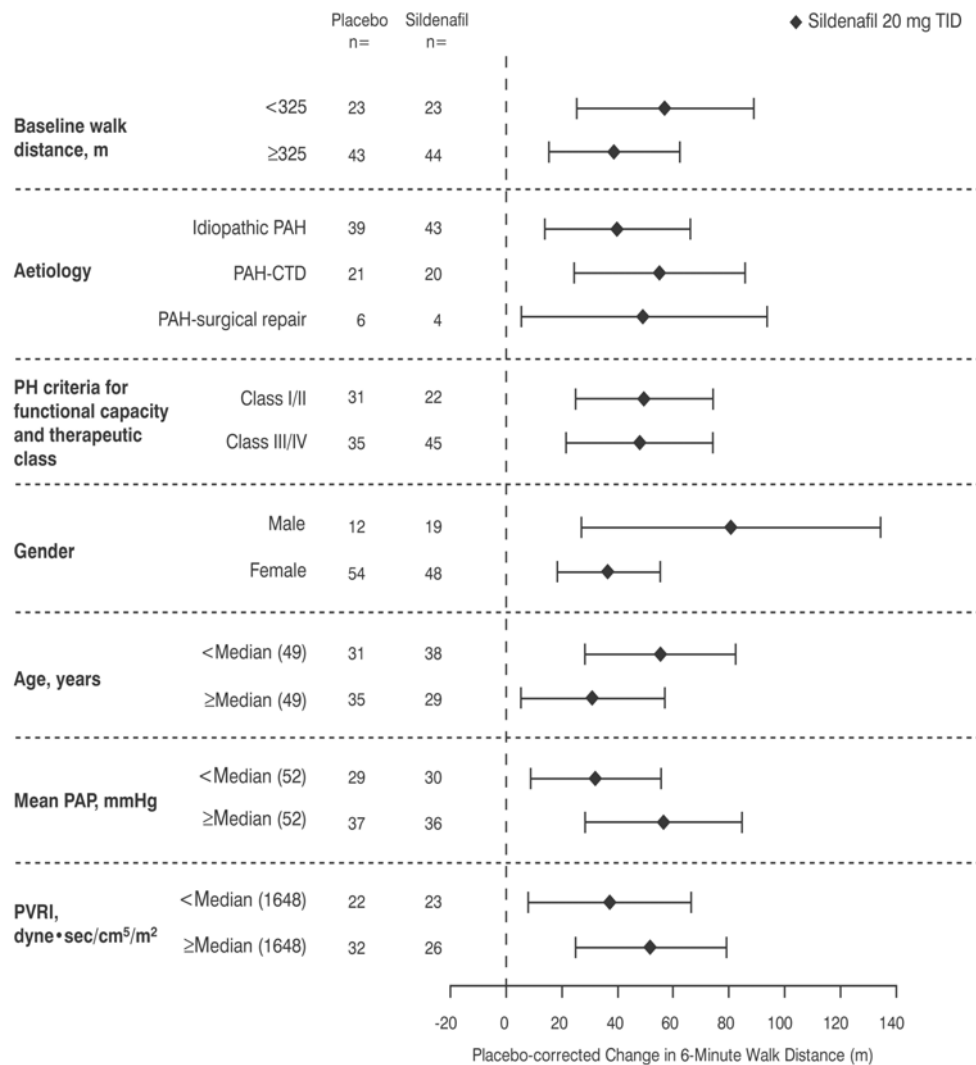
The primary efficacy endpoint was the change from baseline at week 12 in 6-minute walk distance. A statistically significant increase in 6-minute walk distance was observed in all 3 sildenafil dose groups compared to those on placebo. Placebo corrected increases in walk distance were 45 metres (p <0.0001), 46 metres (p <0.0001) and 50 metres (p <0.0001) for sildenafil 20 mg, 40 mg and 80 mg respectively. There was no significant difference in effect between sildenafil doses (see Figure 1).

**Figure 1: Change from Baseline in 6-Minute Walk Distance (metres): Mean (95% Confidence Interval)**



The improvement in walk distance was apparent after 4 weeks of treatment and this effect was maintained at weeks 8 and 12. Results were generally consistent in subgroups according to baseline walking distance, aetiology (primary and CTD-associated PAH), WHO functional class, gender, race, location, mean PAP and PVRI (see Figure 2).

**Figure 2: Placebo Corrected Change From Baseline in 6-Minute Walk Distance (metres) by study subpopulation: Mean (95% Confidence Interval)**



**Key:** PAH = pulmonary arterial hypertension; CTD = connective tissue disease; PH, pulmonary hypertension; PAP = pulmonary arterial pressure; PVRI = pulmonary vascular resistance index; TID = three times daily.

Patients on all REVATIO doses achieved a statistically significant reduction in mean pulmonary arterial pressure (mPAP) compared to those on placebo. Doses of 20 mg, 40 mg, and 80 mg t.d.s. produced a placebo-corrected decrease in mPAP of -2.7 mmHg, -3.0 mmHg, and -5.1 mmHg, respectively. There was no evidence of a difference in effect between sildenafil 20 mg t.d.s. and the higher doses tested (See DOSAGE AND ADMINISTRATION). Data from other haemodynamic parameters can be found in Table 1. The relationship between these effects and improvements in 6-minute walk distance is unknown.

**Table 1. Changes from Baseline to Week 12 in Haemodynamic Parameters at Sildenafil 20 mg t.d.s. Dose**

<b>PARAMETER [mean (95% CI)]</b>	<b>Placebo (N=65)*</b>	<b>Sildenafil 20 mg t.d.s (N=65)*</b>
<b>PVR (dyn·s/cm<sup>5</sup>)</b>	49 (-54, 153)	-122 (-217, -27)
<b>SVR (dyn·s/cm<sup>5</sup>)</b>	-78 (-197, 41)	-167 (-307, -26)
<b>RAP (mmHg)</b>	0.3 (-0.9, 1.5)	-0.8 (-1.9, 0.3)
<b>CO (L/min)</b>	-0.1 (-0.4, 0.2)	0.4 (0.1, 0.7)
<b>HR (beats/min)</b>	-1.3 (-4.1, 1.4)	-3.7 (-5.9, -1.4)

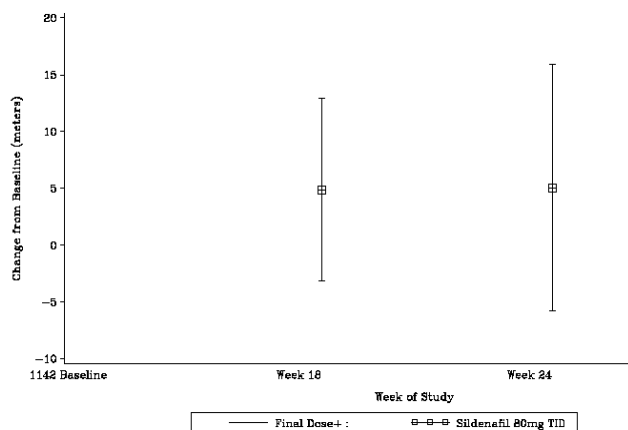
\*The number of patients per treatment group varied slightly for each parameter due to missing assessments.

### **Extension Study**

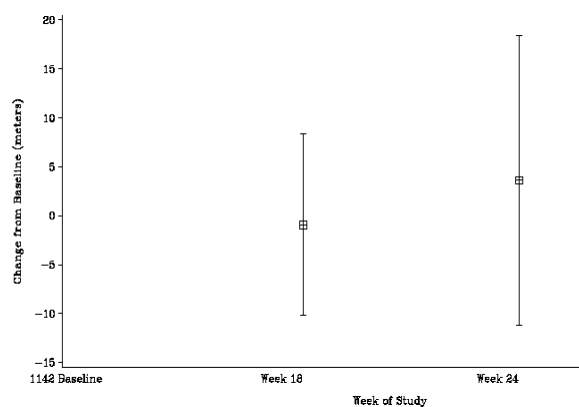
Following the pivotal study, 259 of the 277 REVATIO-treated patients entered an extension study, for which an interim data analysis was performed after 24 weeks of therapy. In the extension study, patients were allocated to either one of two dosage regimens (A or B). In regimen A patients received 40 mg sildenafil for 6 weeks and were then titrated to 80 mg for the remainder of the study. In regimen B, patients received 80 mg sildenafil for 6 weeks and were then dummy titrated to 80 mg. Patients who had initially been on 20 mg or 40 mg were allocated to regimen A while those initially on 80 mg were allocated to continue 80 mg in Regimen B. Patients could be down-titrated if they did not tolerate the 40 mg or 80 mg dose. There was no placebo arm in the extension study. Results of the extension study are represented in Figure 3.

**Figure 3. Changes in 6-Minute Walk distance from A1481142 baseline to Week 24 for patients randomised in Study A1481140 to sildenafil 20 mg (A), sildenafil 40 mg (B), and sildenafil 80 mg (C)**

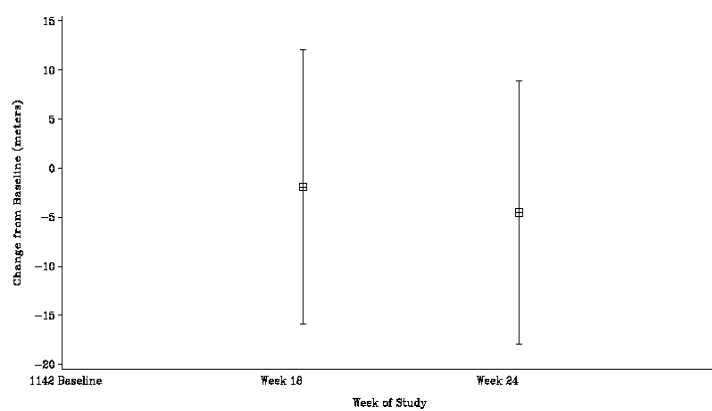
**(A)**



**(B)**



**(C)**



The long term effects of REVATIO on mortality or functional class have not been established.

## INDICATIONS

REVATIO is used to treat patients with pulmonary arterial hypertension classified as WHO functional classes II and III, to improve exercise capacity. Efficacy has been shown in primary pulmonary hypertension and pulmonary hypertension associated with connective tissue disease.

The efficacy of REVATIO has not been evaluated in patients currently on bosentan therapy.

## CONTRAINDICATIONS

Use of sildenafil is contraindicated in patients with known hypersensitivity to any component of the tablet.

**Nitrates and sildenafil must not be used concomitantly. Sildenafil was shown to potentiate the hypotensive effects of both acute and chronic nitrate administration and therefore, its co-administration with nitric oxide donors, organic nitrates or organic nitrites in any form, either regularly or intermittently is contraindicated. Drugs which must not be used concomitantly include glyceryl trinitrate (injection, tablets, sprays or patches), isosorbide salts, sodium nitroprusside, amyl nitrite, nicorandil or organic nitrates in any form.**

Combination with potent CYP3A4 inhibitors (e.g. ketoconazole, itraconazole, ritonavir).

REVATIO is not recommended in patients with pulmonary arterial hypertension with a previous episode of non-arteritic anterior ischaemic optic neuropathy (NAION) (see PRECAUTIONS, ADVERSE EFFECTS - Post Marketing Data, Other events).

The safety of sildenafil has not been studied in the following sub groups of patients and its use is therefore contraindicated: severe hepatic impairment, severe hypotension (blood pressure <90/50 mmHg) at initiation, recent history of stroke or myocardial infarction and known hereditary degenerative retinal disorders such as retinitis pigmentosa (a minority of patients have genetic disorders of retinal phosphodiesterases).

## PRECAUTIONS

### General

The efficacy of REVATIO has not been established in patients with severe pulmonary arterial hypertension (functional class IV). If the clinical situation deteriorates, therapies that are recommended for the severe stage of the disease should be considered.

Sildenafil has vasodilator properties, resulting in mild and transient decreases in blood pressure and, as such, potentiates the hypotensive effect of nitrates (see CONTRAINDICATIONS). Prior to prescribing sildenafil, physicians should carefully consider whether their patients with certain underlying conditions could be adversely affected by such vasodilatory effects, for example patients with resting hypotension (blood pressure

<90/50 mmHg), patients with fluid depletion, severe left ventricular outflow obstruction or autonomic dysfunction.

There are no controlled clinical data on the safety and efficacy of sildenafil in patients with coronary artery disease causing unstable angina, life-threatening arrhythmia within the last 6 months, patients with hypertension (BP > 170/110 mmHg), or who are currently on bosentan or prostacyclin therapy.

In post-marketing experience with sildenafil for male erectile dysfunction, serious cardiovascular events, including myocardial infarction, unstable angina, sudden cardiac death, ventricular arrhythmia, cerebrovascular haemorrhage, transient ischaemic attack, hypertension and hypotension have been reported post-marketing in temporal association with the use of sildenafil. Most, but not all, of these patients had pre-existing cardiovascular risk factors. Many events were reported to occur during or shortly after sexual intercourse and a few were reported to occur shortly after the use of sildenafil without sexual activity. Others were reported to have occurred hours to days after the use of sildenafil and sexual activity.\*\* It is not possible to determine whether these events are related directly to sildenafil, to sexual activity, to the patient's underlying cardiovascular disease, to a combination of \*\* these factors or to other factors.

Physicians should advise patients to stop use of all PDE5 inhibitors, including REVATIO, and seek immediate\*\* medical attention in the event of a sudden loss of vision in one or both eyes. Such an event may be a sign of non-arteritic anterior ischaemic optic neuropathy (NAION), a cause of decreased vision including permanent loss of vision, that has been reported rarely post-marketing in temporal association with the use of all PDE5 inhibitors when used in the treatment of male-erectile dysfunction. It is not possible to determine whether these events are related directly to the use of PDE5 inhibitors or to other factors (see CONTRAINDICATIONS and ADVERSE EFFECTS – Post Marketing Data-Other Events).

Sildenafil should be used with caution in patients with anatomical deformation of the penis (such as angulation, cavernosal fibrosis or Peyronie's disease), or in patients who have conditions which may predispose them to priapism (such as sickle cell anaemia, multiple myeloma or leukaemia).

Caution is advised when sildenafil is administered to patients taking an alpha-blocker, as the co-administration may lead to symptomatic hypotension in a few susceptible individuals (see INTERACTIONS WITH OTHER MEDICINES). In order to minimise the potential for developing postural hypotension, patients should be haemodynamically stable on alpha-blocker therapy prior to initiating sildenafil treatment. Physicians should advise patients what to do in the event of postural hypotensive symptoms.

Sildenafil had no effect on bleeding time, including during co-administration with aspirin. *In vitro* studies with human platelets indicate that sildenafil potentiates the antiaggregatory effect of sodium nitroprusside (a nitric oxide donor). There is no safety information on the administration of sildenafil to patients with bleeding disorders or active peptic ulceration. Therefore sildenafil should be administered with caution to these patients.

The incidence of epistaxis was higher in patients with PAH secondary to connective tissue disease (sildenafil 12.9%, placebo 0%) than in PPH patients (sildenafil 3.0%, placebo 2.4%). Incidence was also higher in sildenafil-treated patients with concomitant oral Vitamin K antagonist (8.8% versus 1.7% not treated with concomitant Vitamin K antagonist).

Pulmonary vasodilators may significantly worsen the cardiovascular status of patients with pulmonary veno occlusive disease. Since there are no clinical data on administration of sildenafil to patients with pulmonary veno occlusive disease, administration of sildenafil to such patients is not recommended.

There are limited safety data in patients with diabetic retinopathy. The safety of sildenafil in patients with untreated diabetic retinopathy has not been studied and therefore sildenafil should be administered to these patients only after careful benefit-risk assessment.

Sudden decrease or loss of hearing, which may be accompanied by tinnitus and dizziness<sup>+</sup> has been reported in a small number of postmarketing and clinical trials cases with the use of all PDE5 inhibitors, including sildenafil. Most of these patients had risk factors for sudden decrease or loss of hearing. No causal relationship has been made between the use of PDE5 inhibitors and sudden decrease or loss of hearing. In case of sudden decrease or loss of hearing patients should be advised to consult a physician promptly.\*\*

### **Effects on Ability to Drive and Use Machines**

No studies on the ability to drive or use machines have been performed. However, as transient visual disturbances and dizziness have been reported in some patients taking sildenafil, patients should be aware of how they react to sildenafil before driving or operating machinery, and the doctor should advise accordingly.

### **Effects on Fertility**

There was no impairment of fertility in rats given sildenafil for 36 days to females and 102 days to males at plasma exposure levels more than 25 times the human male AUC at an oral dose of 100 mg.

There was no effect on sperm motility or morphology after single 100 mg oral doses of sildenafil in healthy volunteers.

### **Use in Pregnancy**

Pregnancy category B1

No evidence of teratogenicity, embryotoxicity or fetotoxicity was observed in rats and rabbits, which received up to 200 mg/kg/day during organogenesis. These doses represent, respectively, about 30 and 70 times the recommended human dose (RHD) on a mg/m<sup>2</sup> basis in a 50 kg subject. In the rat, pre- and postnatal development study, the no-observed-adverse-effect dose was 30 mg/kg/day given for 36 days. In the non-pregnant rat the AUC for unbound sildenafil and its major metabolite at this dose was about 20 times the unbound human AUC at the MHRD of 20 mg three times a day. There are no adequate and well-controlled studies of sildenafil in pregnant women.

### **Use in Lactation**

No information is available on its secretion into breast milk. Sildenafil should not be administered to breast-feeding mothers.

## Paediatric Use

Safety and effectiveness in paediatric pulmonary hypertension patients has not been established.

## Carcinogenicity

Sildenafil was not carcinogenic when administered to rats for 24 months at a dose resulting in total systemic drug exposure (AUC) for unbound sildenafil and its major metabolite of 33- and 48-times, for male and female rats, respectively, the exposures observed in human males given the RHD of 20 mg three times a day. Sildenafil was not carcinogenic when administered to mice for 18-21 months at dosages up to the maximum tolerated dose of 10 mg/kg/day, but resulting in total systemic drug exposure for unbound sildenafil and its major metabolite of less than the exposures observed in human males given the RHD.

## Genotoxicity

Sildenafil was negative in *in vitro* bacterial and Chinese hamster ovary cell assays to detect mutagenicity, and *in vitro* human lymphocytes and *in vivo* mouse micronucleus assays to detect clastogenicity.

# INTERACTIONS WITH OTHER MEDICINES

## Effects of Other Medicines on REVATIO

### *In vitro studies*

Sildenafil metabolism is principally mediated by the cytochrome P450 (CYP) isoforms 3A4 (major route) and 2C9 (minor route). Therefore, inhibitors of these isoenzymes may reduce sildenafil clearance and inducers of these isoenzymes may increase sildenafil clearance.

### *In vivo studies*

Population pharmacokinetic analysis of pulmonary arterial hypertension clinical trial data indicated a reduction in sildenafil clearance and/or an increase of oral bioavailability when co-administered with CYP3A4 substrates and the combination of CYP3A4 substrates and beta-blockers. These were the only factors with a statistically significant impact on sildenafil pharmacokinetics in patients with pulmonary arterial hypertension. The exposure to sildenafil in patients on CYP3A4 substrates and CYP3A4 substrates plus beta-blockers was 43 % and 66 % higher, respectively, compared to patients not receiving these classes of medicines. Sildenafil exposure was 5-fold higher at a dose of 80 mg three times a day compared to the exposure at a dose of 20 mg three times a day. This concentration range covers the increase in sildenafil exposure observed in specifically designed drug interaction studies with CYP3A4 inhibitors (except more potent CYP3A4 inhibitors e.g. ketoconazole, itraconazole, ritonavir).

CYP3A4 inducers seemed to have a substantial impact on the pharmacokinetics of sildenafil in pulmonary arterial hypertension patients, which was confirmed in the in-vivo interaction study with CYP3A4 inducer bosentan.

In a study of healthy male volunteers co-administration of the endothelin antagonist bosentan, which is a moderate inducer of CYP3A4, CYP2C9 and possibly of CYP2C19, at steady state (125 mg twice a day) with sildenafil at steady state (80 mg three times a day) resulted in a 62.6 % decrease of sildenafil AUC and a 55.4 % decrease in sildenafil  $C_{max}$ . The combination of both drugs did not lead to clinically significant changes of blood pressure (supine and standing).

Efficacy of sildenafil should be closely monitored in patients using concomitant potent CYP3A4 inducers, such as carbamazepine, phenytoin, phenobarbital, St John's wort and rifampicin.

Co-administration of the HIV protease inhibitor ritonavir, which is a highly potent P450 inhibitor, at steady state (500 mg twice daily) with sildenafil (100 mg single dose) resulted in a 300 % (4-fold) increase in sildenafil  $C_{max}$  and a 1,000 % (11-fold) increase in sildenafil plasma AUC. At 24 hours, the plasma levels of sildenafil were still approximately 200 ng/ml, compared to approximately 5 ng/mL when sildenafil was administered alone. This is consistent with ritonavir's marked effects on a broad range of P450 substrates. Based on these pharmacokinetic results co-administration of sildenafil with ritonavir is contraindicated in pulmonary arterial hypertension patients (see CONTRAINDICATIONS).

Co-administration of the HIV protease inhibitor saquinavir, a CYP3A4 inhibitor, at steady state (1200 mg three times a day) with sildenafil (100 mg single dose) resulted in a 140 % increase in sildenafil  $C_{max}$  and a 210 % increase in sildenafil AUC. Sildenafil had no effect on saquinavir pharmacokinetics.

When a single 100 mg dose of sildenafil was administered with erythromycin, a specific CYP3A4 inhibitor, at steady state (500 mg twice daily for 5 days), there was a 182 % increase in sildenafil systemic exposure (AUC). In normal healthy male volunteers, there was no evidence of an effect of azithromycin (500 mg daily for 3 days) on the AUC,  $C_{max}$ ,  $T_{max}$ , elimination rate constant, or subsequent half-life of sildenafil or its principal circulating metabolite. Cimetidine (800 mg), a cytochrome P450 inhibitor and non-specific CYP3A4 inhibitor, caused a 56 % increase in plasma sildenafil concentrations when co-administered with sildenafil (50 mg) to healthy volunteers.

Potent CYP3A4 inhibitors such as ketoconazole and itraconazole would be expected to have effects similar to ritonavir (see CONTRAINDICATIONS). CYP3A4 inhibitors of intermediate potency (e.g. clarithromycin, telithromycin and nefazodone) are expected to have an effect in between that of ritonavir and CYP3A4 inhibitors of medium potency (e.g. saquinavir/erythromycin), a seven-fold increase in exposure is assumed. Therefore downward dose adjustments are recommended when using CYP3A4 inhibitors of intermediate potency and consideration should be given to a downward dose adjustment when using CYP3A4 inhibitors of medium potency.

The population pharmacokinetic analysis in pulmonary arterial hypertension patients suggested that co-administration of beta-blockers in combination with CYP3A4 substrates might result in an additional increase in sildenafil exposure compared with administration of CYP3A4 substrates alone.

Grapefruit juice is a weak inhibitor of CYP3A4 gut wall metabolism and may give rise to modest increases in plasma levels of sildenafil.

Single doses of antacid (magnesium hydroxide/aluminium hydroxide) did not affect the bioavailability of sildenafil.

Co-administration of oral contraceptives (ethinylloestradiol 30 µg and levonorgestrel 150 µg) did not affect the pharmacokinetics of sildenafil.

## **Effects of REVATIO on other medicines**

### ***In vitro studies***

Sildenafil is a weak inhibitor of the cytochrome P450 isoforms 1A2, 2C9, 2C19, 2D6, 2E1 and 3A4 (IC<sub>50</sub> >150 µM).

There are no data on the interaction of sildenafil with non-specific phosphodiesterase inhibitors such as theophylline or dipyridamole.

### ***In vivo studies***

In three specific drug - drug interaction studies, the alpha-blocker doxazosin (4 mg and 8 mg) and sildenafil (25 mg, 50 mg, or 100 mg) were administered simultaneously to patients with benign prostatic hyperplasia (BPH) stabilised on doxazosin therapy. In these study populations, mean additional reductions of supine blood pressure of 7/7 mmHg, 9/5 mmHg, and 8/4 mmHg, and mean additional reductions of standing blood pressure of 6/6 mmHg, 11/4 mmHg, and 4/5 mmHg, respectively, were observed. When sildenafil and doxazosin were administered simultaneously to patients stabilised on doxazosin therapy, there were infrequent reports of patients who experienced symptomatic postural hypotension. These reports included dizziness and lightheadedness, but not syncope. Concomitant administration of sildenafil to patients taking alpha-blocker therapy may lead to symptomatic hypotension in a few susceptible individuals. (See PRECAUTIONS and DOSAGE AND ADMINISTRATION).

No significant interactions were shown when sildenafil (50 mg) was co-administered with tolbutamide (250 mg) or warfarin (40 mg), both of which are metabolised by CYP2C9.

Sildenafil had no significant effect on atorvastatin exposure (AUC increased 11%), suggesting that sildenafil does not have a clinically relevant effect on CYP3A4.

Sildenafil (50 mg) did not potentiate the increase in bleeding time caused by aspirin (150 mg).

Sildenafil causes a small reduction in supine and tilted diastolic blood pressure (3.5 and 6.1 mmHg respectively) in healthy subjects who had a blood alcohol level of 80 mg/dL.

In a study of healthy volunteers sildenafil at steady state (80 mg three times a day) resulted in a 49.8 % increase in bosentan AUC and a 42 % increase in bosentan C<sub>max</sub> (125 mg twice daily).

In a specific interaction study, where sildenafil (100 mg) was co-administered with amlodipine in hypertensive patients, there was an additional reduction on supine systolic blood pressure of 8 mmHg. The corresponding additional reduction in supine diastolic blood pressure was 7 mmHg. These additional blood pressure reductions were of a similar magnitude to those seen when sildenafil was administered alone to healthy volunteers.

Sildenafil (100 mg single dose) did not affect the steady state pharmacokinetics of the HIV protease inhibitor saquinavir, which is a CYP3A4 substrate/inhibitor.

Consistent with its known effects on the nitric oxide/cGMP pathway, sildenafil was shown to potentiate the hypotensive effects of nitrates, and its co-administration with nitric oxide donors or nitrates in any form is therefore contraindicated (see CONTRAINDICATIONS).

Sildenafil had no clinically significant impact on the plasma levels of oral contraceptives (ethinylloestradiol 30 µg and levonorgestrel 150 µg).

## **ADVERSE EFFECTS**

### **Clinical Trial in Pulmonary Arterial Hypertension**

Safety data were obtained from the pivotal study and an open-label extension study in 277 (207 on REVATIO and 70 on placebo) treated patients with pulmonary arterial hypertension. 259 subjects who completed the pivotal study entered a long-term extension study. Doses up to 80 mg t.d.s. (4 times the recommended dose of 20 mg t.d.s.) were studied (N=149 patients treated for at least 1 year).

The overall frequency of discontinuation in REVATIO-treated patients at the recommended dose of 20 mg t.d.s. was low (2.9%) and the same as placebo (2.9%). In the pivotal placebo-controlled trial in pulmonary arterial hypertension, the adverse drug reactions that occurred in at least 3% of REVATIO-treated patients at any of the 20, 40 or 80 mg t.d.s. doses, and more commonly on REVATIO than on placebo, are shown in Table 2.

**Table 2. Sildenafil Adverse Events More Frequent than Placebo in  $\geq 3\%$  of Patients.**

ADVERSE EVENT (%)	Placebo (N=70)	SILDENAFIL TREATMENT GROUPS			
		20 mg (N=69)	40 mg (N=67)	80 mg (N=71)	Total (N=207)
Headache	39	46	42	49	46
Flushing	4	10	9	16	12
Dyspepsia	7	13	8	13	11
Back pain	11	13	13	9	12
Diarrhoea	6	9	12	10	10
Limb pain	6	7	15	9	10
Myalgia	4	7	6	14	9
Cough	6	7	5	9	7
Epistaxis	1	9	8	4	7
Pyrexia	3	6	3	10	6
Influenza	3	6	6	4	5
Vertigo	1	1	5	3	3
Gastritis	0	3	3	4	3
Erythema	0	6	2	1	3
Insomnia	1	7	6	4	6
Visual disturbance*	0	0	5	7	4
Dyspnoea (exacerbated)	3	7	2	1	3
Sinusitis	0	3	5	1	3
Paresthesia	0	3	5	1	3
Rhinitis	0	4	2	3	3

\*Visual disturbance: Mild and transient, predominately colour tinge to vision, but also increased sensitivity to light, or blurred vision.

The adverse reactions that occurred in  $\geq 1\%$  and  $< 3\%$  and more frequently with REVATIO than with placebo were the following.

**Blood and lymphatic disorders:** Anaemia NOS

**Ear:** Vertigo

**Eye disorders:** Abnormal sensation in eye, chromatopsia, cyanopsia, diplopia, eye irritation, photophobia, retinal haemorrhage, visual acuity reduced.

**Gastrointestinal disorders:** Abdominal distension, gastritis (not otherwise specified, NOS), gastroenteritis NOS, gastroesophageal reflux disease, haemorrhoids.

**Infections and infestations:** Sinusitis NOS, cellulitus.

**Investigations:** Weight increased

**Metabolism disorders:** Fluid retention

**Nervous system disorders:** Paraesthesia, tremor, burning sensation NOS, migraine NOS, hypoaesthesia.

**Psychiatric disorders:** Anxiety

**Respiratory, thoracic and mediastinal disorders:** Bronchitis NOS, rhinitis NOS

**Reproductive system disorders:** Gynaecomastia

**Skin and subcutaneous tissue disorders:** Alopecia, erythema

## **Post Marketing Data**

### ***Cardiovascular***

In post-marketing experience at doses indicated for male erectile dysfunction, serious cardiovascular events, including myocardial infarction, sudden cardiac death, ventricular arrhythmia, cerebrovascular haemorrhage, transient ischaemic attack and hypertension, have been reported post marketing in temporal association with the use of sildenafil. Most, but not all, of these patients had pre-existing cardiovascular risk factors. Many of these events were reported to occur during or shortly after sexual activity, and a few were reported to occur shortly after the use of sildenafil without sexual activity. Others were reported to have occurred hours to days after the use of sildenafil and sexual activity. It is not possible to determine whether these events are related directly to sildenafil, to sexual activity, to the patient's underlying cardiovascular disease, to a combination of these factors, or to other factors. Tachycardia, hypotension, syncope, and epistaxis have also been reported post-marketing.

### ***Other events***

When used to treat male-erectile dysfunction, non-arteritic anterior ischaemic optic neuropathy (NAION), a cause of decreased vision including permanent loss of vision, has been reported rarely post-marketing in temporal association with the use of phosphodiesterase type 5 (PDE5) inhibitors, including sildenafil citrate. Most, but not all, of these patients had underlying anatomic or vascular risk factors for developing NAION, including but not necessarily limited to: low cup to disc ratio ("crowded disc"), age over 50, diabetes, hypertension, coronary artery disease, hyperlipidaemia and smoking. It is not possible to determine whether these events are related directly to the use of PDE5 inhibitors, to the patient's underlying vascular risk factors or anatomical defects, to a combination of these factors, or to other factors (See CONTRAINDICATIONS and PRECAUTIONS).

Cases of sudden decrease or loss of hearing have been reported post-marketing in temporal association with the use of PDE5 inhibitors, including REVATIO. In some of the cases, medical conditions and other factors were reported that may have also played a role in the otologic adverse events. In many cases, medical follow-up information was limited. It is not possible to determine whether these reported events are related directly to the use of REVATIO, to the patient's underlying risk factors for hearing loss, a combination of these factors, or to other factors (see PRECAUTIONS)<sup>+</sup>

Other events, reported post marketing at doses indicated for male erectile dysfunction, to have been observed in temporal association with sildenafil and not listed in the clinical trials adverse reactions section include:

***Immune system disorders:*** hypersensitivity (including skin rash)

***Gastrointestinal disorders:*** vomiting

***Eye disorders:*** eye pain, red eyes/bloodshot eyes

***Reproductive system and breast disorders:*** prolonged erection and/or priapism.

## **DOSAGE AND ADMINISTRATION**

**Treatment should only be initiated and monitored by a physician experienced in the treatment of pulmonary arterial hypertension. In case of clinical deterioration in spite of REVATIO treatment, alternative therapies should be considered.**

### **Use in Adults (≥ 18 years)**

The recommended dose for REVATIO is 20 mg three times a day (tds). REVATIO tablets should be taken approximately 6-8 hours apart, with or without food.

No greater efficacy was achieved with doses higher than 20 mg tds therefore treatment with doses higher than 20 mg tds is not recommended (See CLINICAL TRIALS). Dosages lower than 20 mg tds have not been examined and the efficacy of these doses is not known.

### **Use in the Elderly (over 65 years of age)**

In general, dose selection of sildenafil for elderly PAH patients should be undertaken cautiously due to higher incidence of compromised renal, hepatic or cardiac function, and of concomitant disease or drug therapy (see PHARMACOKINETICS, Elderly).

### **Use in Patients with Impaired Renal Function**

Initial dose adjustments are not required in patients with renal impairment. A downward dose adjustment to 20 mg twice daily should be considered after a careful benefit-risk assessment only if therapy is not well-tolerated.

### **Use in Patients with Impaired Hepatic Function**

Initial dose adjustments are not required in patients with hepatic impairment (Child-Pugh class A and B). A downward dose adjustment to 20 mg twice daily should be considered after a careful benefit-risk assessment only if therapy is not well-tolerated.

REVATIO is contraindicated in patients with severe hepatic impairment (Child-Pugh class C) (See PHARMACOKINETICS, Hepatic Impairment)

### **Use in Children (< 18 Years)**

The safety and efficacy in children and adolescents have not been studied in large controlled clinical trials. Therefore, the use of sildenafil is not recommended in these patients.

### **Discontinuation of Treatment**

Limited data suggests that the abrupt discontinuation of REVATIO is not associated with rebound worsening of pulmonary arterial hypertension. However to avoid the possible occurrence of sudden clinical deterioration during withdrawal, a gradual dose reduction should be considered. Intensified monitoring is recommended during the discontinuation period.

### **Use in Patients using Other PAH Medicines**

The efficacy and safety of sildenafil co-administered with other treatments for pulmonary arterial hypertension (eg. bosentan, epoprostenol, iloprost) has not been studied in controlled clinical trials. Therefore the concomitant use of sildenafil with these medicinal products cannot be recommended (see PRECAUTIONS – Interaction with Other Medicines).

The safety and efficacy of REVATIO when co-administered with other PDE5 inhibitors has not been studied in pulmonary arterial hypertension patients.

### **Use with CYP3A4 Inhibitors and CYP3A4 Inducers**

Refer to PRECAUTIONS - INTERACTIONS WITH OTHER MEDICINES for dosing instructions.

## **OVERDOSAGE**

Overdose information is limited. In studies with healthy volunteers, of single doses up to 800 mg, adverse events were similar to those seen at lower doses but incidence rates and severities were increased.

In cases of overdose, standard supportive measures should be adopted as required. Sildenafil blood levels are not clinically useful. Monitor ECG and blood pressure in symptomatic patients. Renal dialysis is not expected to accelerate clearance as sildenafil is highly bound to plasma proteins and not eliminated in the urine.

Contact the Poisons Information Centre for advice on the management of an overdose.

## **PRESENTATION AND STORAGE CONDITIONS**

REVATIO tablets contain 20 mg sildenafil (as the citrate). Tablets are white, round film-coated marked “Pfizer” on one side and “RVT 20” on the other and supplied in PVC blister packs of 90 tablets.

Shelf life is 5 years when stored below 30°C.

## **NAME AND ADDRESS OF THE SPONSOR**

Pfizer Australia Pty Ltd  
ABN 50 008 422 348  
38 – 42 Wharf Road  
West Ryde NSW 2114

## **POISON SCHEDULE**

PRESCRIPTION ONLY MEDICINE

## **DATE OF APPROVAL:**

7 August 2006

DATE OF MOST RECENT AMENDMENT: 15 May 2008

\*\* Please note change to product information 27 November 2007.

+ Please note change to product information 15 May 2008.