NAME OF THE MEDICINE



Octafluoropropane and perfluoropropane are synonyms for perflutren.

DESCRIPTION

DEFINITY® contains a clear, colourless, sterile, nonpyrogenic, hypertonic liquid, which upon activation with the aid of a Vialmix™, provides a homogeneous, opaque, milky white injectable suspension of perflutren lipid microspheres.

The perflutren lipid microspheres are composed of perflutren encapsulated in an outer lipid shell consisting of (R) - hexadecanoic acid, 1 - ([phosphonoxy)methyl]-1,2-ethanediyl ester, monosodium salt (abbreviated DPPA); (R) - 4-hydroxy-N,N,N-trimethyl-10-oxo-7-([l-oxohexadecyl)oxy]-3,4,9-trioxa-4-phosphapentacosan-l-aminium, 4-oxide, inner salt (abbreviated DPPC); and (R) $\dot{\alpha}$ -[6-hydroxy-6-oxido-9-[(1-oxohexadecyl)oxy]5,7,11-trioxa-2-aza-6-phosphahexacos-1-yl]- ω -methoxypoly(ox-1,2-ethanediyl), monosodium salt (abbreviated MPEG5000 DPPE).

The CAS number of DEFINITY® is [76-19-7]. The physical and chemical characteristics of perflutren gas are provided in Table 1.

Table 1 Physical and Chemical Characteristics of Perflutren

Physical/Chemical Property	Characteristic
Appearance Boiling point (1 atmosphere) Freezing Point (1 atmosphere) Density, Liquid (20°C)	Colorless gas -36.7°C -183°C 1.350 g/mL

Perflutren is chemically characterized as 1,1,1,2,2,3,3,3-octafluoropropane. It has a molecular weight of 188, empirical formula of C_3F_8 and has the following structural formula:



Prior to Vialmix™ activation, the DEFINITY® vial contains 6.52 mg/mL perflutren in the headspace. Each mL of the clear liquid contains 0.75 mg lipid blend (consisting of 0.045 mg DPPA, 0.401 mg DPPC, and 0.304 mg MPEG5000 DPPE), 103.5 mg propylene glycol, 126.2 mg glycerin, 2.34 mg sodium phosphate monobasic monohydrate, 2.16 mg sodium phosphate dibasic heptahydrate, and 4.87 mg sodium chloride in Water for Injection. The pH is 6.2-6.8.

After activating the contents of the vial in a Vialmix™, each mL of the milky white suspension contains a maximum of 1.2 x 10¹0 perflutren lipid microspheres, and about 1.1 mg/mL perflutren. The microsphere particle size parameters are listed in Table 2 below:

Table 2 Microsphere Size Distribution

	Microsphere particle size parameters
Mean diameter range	1.1 µm — 3.3 µm
Percent less than 10 µm	98%
Maximum diameter	20 µm

PHARMACOLOGY

PHARMACODYNAMICS

When used in conjunction with diagnostic ultrasound, DEFINITY® provides opacification of cardiac chambers, improvement in delineation of endocardial borders and assessment of regional myocardial wall motion. DEFINITY® provides contrast enhancement in ultrasound studies of the liver and kidney and enhancement of Doppler ultrasound assessment of the vasculature of the liver and kidney.

The ultrasound echoes from blood and biological soft tissues such as fat and muscles are generated at interfaces due to small differences in the ultrasonic properties of the tissues. The ultrasonic properties of DEFINITY® are very different from those of soft tissue and will generate strong echoes.

Upon activation, DEFINITY® consists of lipid encapsulated perflutren microspheres. Microspheres in the 1 to < 10 µm diameter size range contribute to the contrast effect by generating strongly enhanced echoes

As DEFINITY® consists of microspheres that are stable and small enough for transpulmonary passage, enhanced echo signals in the left heart, systemic circulation and abdominal organs are obtained.

A strict dose/response relationship cannot be defined, although higher doses have been shown to produce a contrast effect of longer duration. In a crossover study the duration of clinically useful contrast enhancement for fundamental imaging was approximately 3.4 minutes after a 10 μL/kg bolus and approximately 7.1 minutes after a continuous infusion of 1.3 mL activated DEFINITY® in 50 mLs saline at a rate of 4 mL/min.



PHARMACOKINETICS

The pharmacokinetic properties of perflutren gas were evaluated in normal healthy subjects and subjects with chronic obstructive pulmonary disease (COPD) following intravenous administration of a 50 μ L/kg dose of DEFINITY® Perflutren is a stable gas that is not metabolized.

The perflutren component of DEFINITY® was rapidly cleared from the systemic circulation via the lungs. In most subjects after 4-5 minutes, Perflutren was undetectable in blood and in expired air. Perflutren concentration in blood were shown to decline in a mono-exponential fashion with a mean half-life of 1.3 minutes in healthy subjects and 1.9 minutes in COPD subjects. The systemic clearance of Perflutren was similar in healthy and COPD subjects. Total lung clearance (CL $_{\rm lung}$) of Perflutren was shown to be no different in healthy subjects compared to COPD subjects. CL $_{\rm lung}$ was found to be statistically significantly reduced (51%) in females compared to males (all subjects). These results suggest that overall Perflutren systemic elimination is rapid and is not statistically significantly reduced in COPD patients compared to healthy subjects.

Doppler ultrasound measurements were performed with DEFINITY® in conjunction with the pharmacokinetic evaluation of perflutren. Doppler signal intensity corresponded well with measured and extrapolated perflutren concentrations in blood. The time to maximum Doppler signal intensity t_{\max} was shown to be similar to the perflutren blood t_{\max} (1.13 versus 1.77 minutes). The observed 99% drop in Doppler signal intensity within 10 minutes ($t_{1/2}$ approximately 2 minutes) was in agreement with the decline in measurable blood levels of perflutren.

Human pharmacokinetic information is not available for lipid microspheres. The naturally occurring phospholipids in DEFINITY® are distributed in the endogenous lipid pools in the body (for example, liver) whereas the synthetic component (MPEG5000) has been shown to be excreted in the urine in nonclinical studies. All lipids are metabolized to free fatty acids.

CLINICAL TRIALS

A total of 2827 subjects were evaluated in clinical trials (2538 received activated DEFINITY® and 169 received placebo: there were an additional 60 healthy controls in clinical pharmacology studies). Of those patients that received DEFINITY®, 1545 (61.2%) were male and 980 (38.8%) were female; 1881 (74.6%) were White, 386 (15.3%) were Black and 256 (10.1%) were classified as other racial or ethnic groups. The mean age was 56.3 (range 18 to 93).

Key features of 5 echocardiography studies and 3 Ultrasound imaging of liver and kidney studies evaluating activated DEFINITY® are summarised in Table 3a and Table 3h

Table 3a Key features of the clinical studies in the echocardiography and Ultrasound Imaging of Liver and Kidney indications			
Study	No. Subjects Treated with DMP 115 (Placebo)	Mode of DMP 115 Administration	Main Type of Ultrasound Imaging
PIVOTAL ECHOCARDIOGRAPHY STUDIES			
DMP 115 004 DMP 115 005 DMP 115 006 DMP 115 007 DMP 115 017	69(18) 100(24) 67(-) 59(-) 64(-)	Bolus Bolus Bolus Bolus Bolus + infusion	Fundamental Fundamental Fundamental Fundamental Fundamental
PIVOTAL ULTRASOUND IMAGING OF LIVER AND KIDNEY STUDIES			
DMP 115 009 DMP 115 010 DMP 115 013	111(-) 98(-) 100(-)	Bolus Bolus Bolus + infusion	Fundamental Fundamental Non-linear
Note: Institutional reads were performed in all of the 8 studies.			

Table 3b Key features of the clinical studies in the echocardiography and Ultrasound Imaging of Liver and Kidney indications					
Study	Type of Control B				
	Parallel Placebo Group	Standard Diagnostic Technique	Unenhanced vs Enahanced Images	read	
PIVOTAL ECHO	PIVOTAL ECHOCARDIOGRAPHY STUDIES				
DMP 115 004 DMP 115 005 DMP 115 006 DMP 115 007 DMP 115 017	Yes Yes No No No	– MRI MRI –	Yes Yes Yes Yes Yes	Yes Yes Yes Yes Yes	
PIVOTAL ULTRASOUND IMAGING OF LIVER AND KIDNEY STUDIES					
DMP 115 009	No	Overall clinical diagnosis	Yes	Yes	
DMP 115 010	No	Overall clinical diagnosis	Yes	Yes	
DMP 115 013	No	Final diagnosis Contrast-enhanced CT, MRI**	No	Yes	

^{**}The final diagnosis acted as a comparison for diagnostic accuracy; contrast-enhanced CT or MRI was a comparison for concordance

Note: Institutional reads were performed in all of the 8 studies.

Echocardiography

Outcome measures in the echocardiology studies included blinded assessment of improvement in ventricular chamber enhancement, endocardial border length (EBL) measured by direct measurement and qualitative assessment of wall motion.

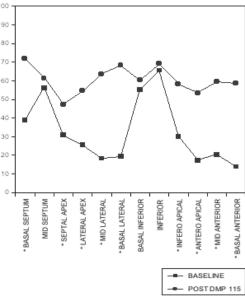
Ventricular Chamber Enhancement: Left ventricular chamber enhancement after activated DEFINITY® was significantly enhanced from baseline compared to placebo. Mean changes from baseline with 10µL/kg of activated DEFINITY® were significantly better than those with placebo in both regions (apex and mid-chamber) and both apical views (4-and 2-chamber views) at each of the three points of the cardiac cycle evaluated.

Endocardial Border Delineation: Activated DEFINITY® significantly improved endocardial border delineation over baseline (non-contrast enhanced) echocardiography examinations (pc 0.05) at both rest and stress. In those subjects with non-diagnostic examinations at baseline (defined as four or more non-evaluable segments at baseline in either the apical 4- or 2-chamber view) the use of activated DEFINITY® converted 76% of non-diagnostic examinations to diagnostic examinations.

Wall Motion: A significant improvement in the number of segments demonstrating exact wall motion concordance with MRI was demonstrated for five out of six blind reads following administration of activated DEFINITY®. When examined on a segment-by-segment basis, the administration of activated DEFINITY® had a significant impact on improving segmental wall motion concordance (normal versus abnormal) with MRI in the apical, lateral and anterior segments which had the poorest correlation at baseline.

Ejection fraction was assessed in several echocardiography studies but DEFINITY® did not reliably improve accuracy of assessment of ejection fraction.

Figure 1 Total Percent Concordance with MRI for Wall Motion by Segment at Baseline and Following DMP 115 Administration for Blinded Reader 5 in Study DMP 115 007 (Echocardiography)



p < 0.05

Ultrasound Imaging of Liver and Kidney

A total of 309 subjects were enrolled and treated with activated DEFINITY® in the three pivotal studies: 230 (74%) had suspected liver pathology and 79 (26%) had suspected kidney pathology. Administration of activated DEFINITY® was clinically effective in providing additional diagnostic information when comparing the unenhanced ultrasound assessment to the post-activated DEFINITY® assessment. The percentages of all subjects having additional diagnostic information ranged from 33% to 76% for the blinded readers and 83% for the institutional read.

Additional diagnostic information included increased lesion conspicuity, improved delineation (extent) of pathology, detection of additional lesions, improved gray-scale vascular assessment, improved lesion characterisation and better visualisation of the length and/or extent of microvasculature.

Diagnostic accuracy was assessed by a prospectively defined diagnostic algorithm and to assess enhancement pattern concordance with CT/MRI

There was a 93% sensitivity and 92% specificity in differentiating benign and malignant focal lesions. The algorithm correctly characterized lesion subtypes as follows: focal nodular hyperplasia (95%), haemangioma (92%), hepatocellular carcinoma (85%) and metastatic disease (71%). Analyses of the blinded read demonstrated that the contrast enhancement patterns observed with activated DEFINITY® were highly concordant with the contrast enhancement patterns observed on CT and MRI.

INDICATIONS

This medicinal product is for diagnostic use only.

DEFINITY® is indicated for use in patients in contrast-enhanced diagnostic ultrasound imaging to improve characterisation of focal lesions of the liver and kidney.

DEFINITY® is indicated for use in patients with suboptimal echocardiograms to provide opacification of cardiac chambers, improvement of left ventricular endocardial border delineation and assessment of regional wall motion at both rest and stress

CONTRAINDICATIONS

Activated DEFINITY® should not be administered to patients with known hypersensitivity to perflutren or any other components of DEFINITY®.

Do not administer DEFINITY® to patients with known or suspected right-to-left, bi-directional, or transient right-to-left cardiac shunts.

Activated DEFINITY® should not be administered by direct intra-arterial injection (see PRECAUTIONS)

PRECAUTIONS

General

Diagnostic procedures that involve the use of contrast agents should be carried out under the direction of a physician with a thorough knowledge of the

The safety of microspheres in patients on mechanical ventilation has not been

Serious Cardiopulmonary Reactions:

Serious cardiopulmonary reactions, including fatalities, have occurred during or following DEFINITY® administration. The risk for these reactions may be in creased among patients with pulmonary hypertension or unstable cardiopulmonary conditions (acute myocardial infraction, acute coronary artery syndromes, worsening or unstable congestive heart failures, serious ventricular arrhythmias or respiratory failure, including patients receiving mechanical ventilation). In these patients, monitor vital signs, electrocardiography, and cutaneous oxygen saturation during and for at least 30 minutes after DEFINITY® administration. In the absence of these underlying conditions, observe patients closely during and following DEFINITY® administration.

Always have cardiopulmonary resuscitation personnel and equipment readily available prior to DEFINITY® administration and monitor all patients for acute

Cardiac Shunts:

The safety of activated DEFINITY® in patients with right-to-left, bi-directional, or transient right-to-left cardiac shunts has not been studied. In these patients, phospholipid-encapsulated microspheres can bypass the pulmonary particlefiltering mechanisms and directly enter the arterial circulation with potential for microsphere trapping in small arterioles (< 15µm) and in capillaries. Extreme caution should be exercised when considering the administration of activated DEFINITY® in patients that may have cardiac shunts.

Pulmonary Vascular Compromise:

The safety of activated DEFINITY® in humans with compromised pulmonary vascular beds or with small cross-sectional vascular area has not been studied. Therefore, activated DEFINITY® should be administered with caution to patients with chronic pulmonary vascular disorders (e.g., severe emphysema, pulmonary vasculitis or other causes of reduced pulmonary vascular cross sectional area)

High Ultrasound Mechanical Index:

High ultrasound mechanical index values may cause microsphere cavitation or rupture and lead to ventricular arrhythmias. Additionally, end-systolic triggering with high mechanical indices has been reported to cause ventricular arrhythmias. The safety of activated DEFINITY® at mechanical indices greater than 0.8 has not been established. The safety of activated DEFINITY® with the use of end-systolic triggering has not been established.

QTc Prolongation:

ECG parameters for doses up to 10 μ L/kg were monitored in 221 subjects at multiple time points from 1 hour to 72 hours after the first bolus injection. In the 221 subjects, QTc prolongations of >30 msec were noted in 64 (29%) subjects. Forty-six out of 64 subjects with QTc prolongations were further evaluated and 39% (18/46) showed associated cardiac rhythm changes. No malignant cardiac symptomatology or events of syncope were reported as a result of these ECG changes. However, predisposing conditions may increase the risk of ventricular arrhythmias associated with QTc prolongation. DEFINITY® should be used only after careful consideration in patients with ongoing proarrhythmic conditions, previous history of symptomatic arrhythmias, family history of congenital long QT syndrome and on drugs known to cause QTc prolongation.

Carcinogenesis

Studies with activated DEFINITY® have not been performed to evaluate

Mutagenesis

No evidence of genotoxicity was found in the following studies with activated

1) bacterial mutagenesis assay (Ames assay), 2) in vitro mammalian

mutagenesis assay, 3) *in vitro* human lymphocyte chromosome aberration assay, and 4) *in vivo* rat micronucleus assav.

Impairment of Fertility

No effect on male or female fertility was found when rats were treated with DEFINITY® at up to 5 mL/kg/day IV (35x the maximal human dose based on body surface area).

Pregnancy Category B1

There was no evidence for a direct fetotoxic or teratogenic effect of DEFINITY® in rats or rabbits given 1 mL/kg/day IV (7x and 18x the maximal human dose based on body surface area, respectively) Adequate and well-controlled studies in pregnant women have not been conducted. Because animal reproduction studies are not always predictive of human response, this drug should be used during pregnancy only if clearly needed.



Use in Lactation

Studies to detect if activated DEFINITY® is excreted in human milk have not been conducted

Because many drugs are excreted in human milk, caution should be exercised when activated

DEFINITY® is administered to a nursing woman.

Paediatric Use

The safety and effectiveness of activated DEFINITY® have not been established in the paediatric population (see PRECAUTIONS).

Fiderly

The pharmacokinetics of activated DEFINITY® in the elderly has not been studied.

Interactions with Other Medicines

Drug-drug interactions for activated DEFINITY® have not been studied.

ADVERSE REACTIONS

The reported adverse effects following the use of DEFINITY in pivotal and supportive trials (total of 2,526 patients) have generally been mild to moderate in intensity, occur within minutes after administration and usually resolve without therapeutic intervention within 15 minutes. The most frequently reported adverse reactions are: headache (2.0%), flushing (1.0%) and back pain (0.9%)

Table 4 New-Onset AEs Occurring in At Least 0.5% of DMP 115-treated Subjects in all Patient Studies, Regardless of Indication

Preferred Term	All AEs		Treatment-	Related AEs
Total Subjects Treated Total Subjects with AEs	2526 646	(25.6%)	2526 193	(7.6%)
Fatigue Headache Dyspnoea Chest pain Flushing Back pain Nausea Dizziness Dysgeusia Chest discomfort Pain NOS Abdominal pain NOS Hypertension NOS Diarrhoea NOS Hypotension NOS Injection site pain	150 88 81 61 41 35 25 21 18 15 14 14 13 13	(5.9%) (3.5%) (3.2%) (2.4%) (1.6%) (1.4%) (1.0%) (0.8%) (0.6%) (0.6%) (0.6%) (0.5%) (0.5%)	4 50 3 8 25 23 19 12 21 2 3 3 3 2 4	(0.2%) (2.0%) (0.1%) (0.3%) (0.9%) (0.8%) (0.5%) (0.1%) (0.1%) (0.1%) (0.1%) (0.1%) (0.2%) (0.2%) (0.2%)
Injection site pain	12	(0.5%)	9	(0.4%)

In addition the following adverse events were reported with the following frequencies:

Table 5 Additional Adverse Events with Frequencies

Adverse Event	Frequency
Throat irritation, Pruritus, Increased Sweating	Uncommon (≥ 1/1,000, <1/100
Paresthesia, Syncope, Periperal Coldness, Cough, Dry Throat, Respiratory Distress, Dyspepsia, Erythema, Erythematous Rash, Rash, Urticaria, Arthralgia, Flank Pain, Neck Pain, Muscle Cramp, Pyrexia, Rigors, Abnormal Electrocardiogram	Rare (≥1/1,000, <1,000

Post Marketing Experience:

The following adverse reactions have been identified during the post-marketing use of DEFINITY®. Because these reactions are reported voluntarily from a population of uncertain size, it is not always possible to reliably estimate their frequency or establish a causal relationship to drug exposure.

Fatal cardiac arrests and other serious but non-fatal adverse reactions were uncommonly reported. Most of these uncommon reactions included cardiopulmonary symptoms and signs such as cardiac or respiratory arrest, hypotension, supraventricular and ventricular arrhythmias, respiratory distress or decreased oxygenation.

Allergic type symptoms (e.g. anaphylactoid like reactions, face oedema, hypotension) have been reported rarely

DOSAGE AND ADMINISTRATION

DEFINITY® IS INTENDED FOR ADMINISTRATION ONLY AFTER ACTIVATION IN THE VIALMIX™ APPARATUS. Before injection, this product must be activated and prepared according to the instructions outlined below

DEFINITY® may be injected by either an intravenous bolus or infusion.

Abdominal Ultrasound of the Liver and Kidney

Bolus intravenous injection using non-linear contrast imaging technique:

The recommended dose for DEFINITY® is multiple injections of 0.1-0.4 mL followed by a 3-5 mL 0.9% sodium chloride solution for injection. The total dose of DEFINITY® should not exceed 1.6 mL.

Bolus intravenous injection using fundamental imaging technique:

The recommended dose for DEFINITY® is 10 μ L/kg of the product by slow bolus intravenous injection, followed by a 10 mL 0.9% sodium chloride solution for

Echocardiography

Bolus intravenous injection using non-linear contrast imaging technique:

The recommended dose for DEFINITY® is multiple injections of 0.1-0.4 mL followed by a 3-5 mL 0.9% sodium chloride solution for injection to maintain optimal contrast enhancement. The total dose of DEFINITY® should not exceed 1.6 mL

Bolus intravenous injection using fundamental imaging technique

The recommended dose for DEFINITY® is 10 µL/kg of the product by slow bolus intravenous injection, followed by a 10 mL 0.9% sodium chloride solution for injections. If necessary, a second 10 $\mu\text{L/kg}$ dose followed by a second 10 mL 0.9% sodium chloride solution for injection may be administered 5 minutes after the first injection to prolong contrast

Intravenous infusion using non-linear contrast of fundamental imaging technique:

The recommended dose for DEFINITY® is via an intravenous infusion of 1.3 mL added to 50 mL of 0.9% sodium chloride solution for injection. The rate of infusion should be initiated at 4.0 mL/minute, but titrated as necessary to achieve optimal image enhancement, not to exceed 10 mL/minute

DEFINITY® should not be used in patients below 18 years until efficacy and safety in these groups have been established.

Instructions For Use

- Allow the vial to warm to room temperature before starting the activation procedure
- Activate DEFINITY® by shaking the vial for 45 seconds using a Vialmix™.

Note: Illustrations of this procedure are contained in the Vialmix™ Users

WARNING: DO NOT USE THIS DRUG UNLESS IT HAS COMPLETED A FULL 45 SECOND ACTIVATION CYCLE IN THE VIALMIX™. DEFINITY® WILL NOT BE PROPERLY ACTIVATED UNLESS THE FULL 45 SECOND ACTIVATION CYCLE IS COMPLETED. DO NOT REACTIVATE the vial if Vialmix™ did not complete a full 45 second cycle. DO NOT REACTIVATE a successfully activated DEFINITY® vial (see step 3). DO NOT USE a Vialmix™ that is not functioning properly. Refer to the "VIALMIX™ User's Guide" for the "VIALMIX™ CALIBRATION AND REPLACEMENT PROCEDURES" to ensure that a properly functioning Vialmix'TM is used.

- 3. Immediately after activation in the Vialmix™, activated DEFINITY® appears as a milky white suspension and may be used immediately after activation. If the product is not used within 5 minutes of Vialmix™ activation, the microspheres should be resuspended by 10 seconds of hand agitation by inverting the vial before the product is withdrawn in a syringe. The activated DEFINITY® may be used for up to 12 hours from the time of Vialmix™ activation, but only after the microspheres are resuspended by hand agitation. Store the activated DEFINITY® at room temperature in the original product vial.
- 4. Invert the vial and withdraw the activated milky white suspension using a needleless spike (Intellipin®) or an 18- to 20-gauge syringe needle. Position the needle to withdraw the material from the middle of the liquid in the inverted vial. DO NOT INJECT AIR INTO THE DEFINITY® VIAL.
- 5. Use the product immediately after its withdrawal from the vial; do not allow the product to stand in the syringe

USE IN ONE PATIENT ON ONE OCCASION ONLY: DEFINITY® does not contain antimicrobial preservative. Bacterial contamination with the risk of post $administration \ \ septicemia \ \ can \ occur \ following \ the \ puncture \ \ of \ the \ elastomeric$ septum. It is essential to follow directions for activation of DEFINITY® carefully and to adhere to strict aseptic procedures during preparation

*NOTE: When using either a needleless spike (Intellipin®) or an 18- to 20gauge needle, the entire contents of the vial should be removed, then small injections from the syringe should be given to a single patient.

OVERDOSAGE

The clinical consequences of overdosing with activated DEFINITY® are not known. Single doses of up to 100 μ L/kg and multiple doses up to 150 μ L/kg were tolerated well in Phase I clinical trials. Treatment of an overdose should be directed toward the support of all vital functions and prompt institution of symptomatic therapy (see CONTRAINDICATIONS and PRECAUTIONS).

Contact Poisons Information Centre on 131126 for advice on management of

PRESENTATION AND STORAGE CONDITIONS

DEFINITY® is supplied as a single use, clear glass vial containing clear liquid. Each package (clear plastic clamshell) contains four (4) single-use vials.

Store at 2-8°C (Refrigerate. Do not freeze.)

NAME AND ADDRESS OF SPONSOR:

Lantheus Medical Imaging Australia Pty Ltd Suite 3 358 Whitehorse Road Nunawading VIC 3131 Australia

POISON SCHEDULE

Unscheduled Medicine

DATE OF APPROVAL:

11 August 2008