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(54) **Title:** TREATMENT OF FUNGAL INFECTIONS WITH POLYENE OR BETA GLUCAN SYNTHASE INHIBITOR ANTI-FUNGALS COMBINED WITH ANTI HSP90 ANTIBODIES

(57) **Abstract:** The present invention relates to novel compositions and preparations that are effective antifungal agents, and a novel antibody which can be incorporated into the compositions and preparations.

TREATMENT OF FUNGAL INFECTION WITH POLYENE OR BETA GLUCAN SYNTHASE INHIBITOR ANTIFUNGALS COMBINED WITH ANTI HSP90 ANTIBODIES

The present invention relates to novel compositions and preparations that are effective antifungal agents, and a novel antibody which can be incorporated into the compositions and preparations.

Fungal infections are a major cause of patient mortality in the intensive care unit and more generally in immunocompromised and debilitated patients (Gold, J.W.M., 1984, Am. J. Med. 76: 458-463; Klein, R.S. et al., 1984, N. Engl. J. Med. 311: 354-357; Burnie, J.P., 1997, Current Anaesthesia & Critical Care 8: 180-183). The presence and persistence of fungal infections can be attributed to the selective pressure of broad-spectrum antifungals, frequently prolonged stay of patients in facilities such as an intensive care unit, problems in diagnosing the infections, and the lack of efficacy of the fungal agents used in therapy. While strict hygienic control may result in some prevention of fungal infections in a hospital or other environment, outbreaks of infections remain a serious problem and need to be addressed.

Systemic fungal infections such as invasive candidiasis and invasive aspergillosis may be caused by a variety of fungal pathogens, for example the virulent Candida species C. albicans, C. tropicalis and C. krusei and the less virulent species C. parapsilosis and Torulopsis glabrata (the latter referred to in some texts as Candida glabrata). Although C. albicans was once the most common fungal isolate obtained from intensive care units, recent studies indicate that C. tropicalis, C. glabrata, C. parapsilosis and C. krusei now account for about half of such isolates (Pfaller, M.A. et al., 1998, J. Clin. Microbiol. 36: 1886-1889; Pavese, P. et al., 1999, Pathol. Biol. 46: 579-583). The rise of non-albicans species implies the emergence of Candida species resistant to conventional antifungal therapy (Walsh, T.J. et al., New Eng. J. Med. 340: 764-771).

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Detection and diagnosis of the fungal pathogen responsible for an infection is critical for subsequent therapy because antifungal agents may be more effective against certain strains. GB2240979 and EP0406029 (herein incorporated by reference in their entirety) disclosed a fungal stress protein and antibody thereto which could be used in a sensitive and highly specific test for detection of fungal pathogens.

Traditionally, *C. albicans*, *C. tropicalis* and *C. parapsilosis* have been treated by the antifungal agent amphotericin B, regarded as the "gold standard" of systemic antifungal therapy (Burnie, J.P., 1997, *supra*). Unfortunately, amphotericin B is itself highly toxic and its use is tempered by side effects including chills, fever, myalgia or thrombophlebitis. Other antifungal agents include the oral azole drugs (miconazole, ketoconazole, itraconazole, fluconazole) and 5-fluorocytosine. However, fungal species such as *C. krusei* and *T. glabrata* are resistant to fluconazole, and these species often occur in patients where this drug has been administered prophylactically. Furthermore, fluconazole-resistant strains of *C. albicans* have been reported (Opportunistic Pathogens, 1997, 1: 27-31). Thus despite the recent advances made in therapeutic drugs such as fluconazole, itraconazole and systemic liposomal-based variants of amphotericin B (Burnie, J.P., 1997, *supra*), the need for effective agents for treatment of fungal infections remains acute.

The present invention addresses the above-identified need by providing a novel composition that is a significant improvement over prior art fungal agents for the treatment of human or animal fungal infections, and also a novel antibody which can be incorporated into the composition. The composition of the present invention comprises antibody which may bind one or more epitopes of a fungal stress protein, in combination with known antifungal agents. The inventors have found that, surprisingly, the efficacy of antifungal agents against fungal infections is significantly enhanced, allowing for either lower treatment dosages or more effective treatment at the same dose, which allows for reduction of unwanted side-effects. Furthermore, the composition of the present invention

allows for effective treatment of fungal infections which are inherently resistant to the fungal agent used in the composition.

According to the present invention there is provided the use of a composition

5 comprising an antibody or an antigen binding fragment thereof specific for one or more epitopes of a fungal stress protein and an antifungal agent comprising at least one of the group consisting a polyene antifungal agent and an echinocandin antifungal agent in a method of manufacture of a medicament for the treatment of fungal infections, wherein the fungus causing said fungal infection is resistant to said antifungal agent *per se*.

10

Further provided according to the present invention is a combined preparation for simultaneous, separate or sequential use in the treatment of fungal infections, comprising an antibody or an antigen binding fragment thereof specific for one or more epitopes of a fungal stress protein and an antifungal agent comprising at least one of the

15 group consisting a polyene antifungal agent and an echinocandin antifungal agent wherein the fungus causing said fungal infection is resistant to said antifungal agent *per se*.

The antibody may be specific for a heat shock protein from a member of the *Candida* or *Torulopsis* genera. (The *Candida* and *Torulopsis* genera are generally deemed

20 to be synonymous.) In particular, the antibody may be specific for the heat shock protein comprising hsp90 from *Candida albicans*, as described in GB2240979 and EP0406029.

The antibody or an antigen binding fragment thereof may be specific for the epitope comprising the sequence of SEQ ID NO:1.

25

Antibodies, their manufacture and uses are well known and disclosed in, for example, Harlow, E. and Lane, D., Antibodies: A Laboratory Manual, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York, 1999.

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The antibodies may be generated using standard methods known in the art.

Examples of antibodies include (but are not limited to) polyclonal, monoclonal, chimeric,

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single chain, Fab fragments, fragments produced by a Fab expression library, and antigen binding fragments of antibodies.

Antibodies may be produced in a range of hosts, for example goats, rabbits, rats, mice, humans, and others. They may be immunized by injection with heat shock protein from the *Candida* genus, for example hsp90 from *C. albicans*, or any fragment or oligopeptide thereof which has immunogenic properties. Depending on the host species, various adjuvants may be used to increase an immunological response. Such adjuvants include, but are not limited to, Freund's, mineral gels such as aluminum hydroxide, and surface active substances such as lysolecithin, pluronic polyols, polyanions, peptides, oil emulsions, keyhole limpet hemocyanin, and dinitrophenol. Among adjuvants used in humans, BCG (Bacille Calmette-Guerin) and *Corynebacterium parvum* are particularly useful.

Monoclonal antibodies to the heat shock protein from the *Candida* genus, for example hsp90 from *C. albicans,* or any fragment or oligopeptide thereof may be prepared using any technique which provides for the production of antibody molecules by continuous cell lines in culture. These include, but are not limited to, the hybridoma technique, the human B-cell hybridoma technique, and the EBV-hybridoma technique (Koehler *et al.,* 1975, Nature, 256: 495-497; Kosbor *et al.,* 1983, Immunol. Today 4: 72; Cote *et al.,* 1983, PNAS USA, 80: 2026-2030; Cole *et al.,* 1985, Monoclonal Antibodies and Cancer Therapy, Alan R. Liss Inc., New York, pp. 77-96).

In addition, techniques developed for the production of "chimeric antibodies", the splicing of mouse antibody genes to human antibody genes to obtain a molecule with appropriate antigen specificity and biological activity can be used (Morrison *et al.,* 1984, PNAS USA, 81: 6851-6855; Neuberger *et al.,* 1984, Nature, 312: 604-608; Takeda *et al.,* 1985, Nature, 314: 452-454). Alternatively, techniques described for the production of single chain antibodies may be adapted, using methods known in the art, to produce

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Candida heat shock protein-specific single chain antibodies. Antibodies with related specificity, but of distinct idiotypic composition, may be generated by chain shuffling from random combinatorial immunoglobin libraries (Burton, D.R., 1991, PNAS USA, 88: 11120-11123).

Antibodies may also be produced by inducing *in vivo* production in the lymphocyte population or by screening recombinant immunoglobulin libraries or panels of highly specific binding reagents (Orlandi *et al.*, 1989, PNAS USA, 86: 3833-3837; Winter, G. *et al.*, 1991, Nature, 349: 293-299).

Antigen binding fragments may also be generated, for example the F(ab')2 fragments which can be produced by pepsin digestion of the antibody molecule and the Fab fragments which can be generated by reducing the disulfide bridges of the F(ab')2 fragments. Alternatively, Fab expression libraries may be constructed to allow rapid and easy identification of monoclonal Fab fragments with the desired specificity (Huse *et al.*, 1989, Science, 256: 1275-1281).

Various immunoassays may be used for screening to identify antibodies having the desired specificity. Numerous protocols for competitive binding or immunoradiometric assays using either polyclonal or monoclonal antibodies with established specificities are well known in the art. Such immunoassays typically involve the measurement of complex formation between the heat shock protein from the *Candida* genus, for example hsp90 from *C. albicans*, or any fragment or oligopeptide thereof and its specific antibody. A two-site, monoclonal-based immunoassay utilizing monoclonal antibodies specific to two non-interfering *Candida* heat shock protein epitopes may be used, but a competitive binding assay may also be employed (Maddox *et al.*, 1983, J. Exp. Med., 158: 1211-1216).

The antibody may comprise the sequence of SEQ ID NO: 2.

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The polyene antifungal agent may, for example, comprise amphotericin B, a derivative of amphotericin B, or nystatin. Derivatives of amphotericin B include formulations such as AmBisome (supplied for example by NexStar Pharmaceuticals, Cambridge, UK), amphotericin-B lipid complex (Abelcet), amphotericin-B colloidal

5   dispersion (Amphocil) and amphotericin-B intralipid emulsion (Burnie, J.P., 1997, *supra*), may be used. Amphotericin B may be used in combination with another antifungal agent, 5-fluorocytosine (Burnie, J.P., 1997, *supra*).

The echinocandin antifungal agent may, for example, be Anidulafungin

10   (LY303366; Eli Lilly & Co., Indianapolis, USA). Echinocandins are cyclic lipopeptides that inhibit synthesis of β-1,3-glucan in fungi (Redding, J.A. *et al.*, 1998, Antimicrob. Agents Chemo. Ther. 42(3): 1187-1194).

The fungal infection which may be treated by the composition or combined

15   preparation may be Mucormycosis, Blastomycosis, Coccidioidomycosis or Paracoccidioidomycosis, or the fungal infection may be caused by a Candida, Cryptococcus, Histoplasma, Aspergillus, or Torulopsis organism. The term "Coccidioidomycosis" is also referred to in the field as "Coccidiomycosis", and the term "Paracoccidioidomycosis" is likewise synonymous with "Paracoccidiomycosis". The

20   fungal infection may be resistant to the antifungal agent *per se*, ie. fungal infections which are intrinsically untreatable by specific agents because that specific antifungal agent is ineffective as traditionally utilised on its own.

25   Also provided is a composition or combined preparation as described herein for use in a method of treatment of fungal infections of the human or animal body.

Also provided is a method of manufacture of a medicament for the treatment of fungal infections of the human or animal body characterised in the use of a composition

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or combined preparation as described in the present application. Methods of manufacture of medicaments are well known. For example, a medicament may additionally comprise a pharmaceutically acceptable carrier, diluent or excipient (Remington's Pharmaceutical Sciences and US Pharmacopoeia, 1984, Mack Publishing Company, Easton, PA, USA).

5

Also provided is the use of a composition or combined preparation as described in the present application in a method of manufacture of a medicament for the treatment of fungal infections. The fungal infection may be resistant to the antifungal agent *per se*.

10

Also provided is a method of treatment of fungal infections of the human or animal body comprising administering a composition or combined preparation according to the present application to a patient in need of same. The exact dose (i.e. a pharmaceutically acceptable dose) of the composition or combined preparation to be

15 administered to a patient may be readily determined by one skilled in the art, for example by the use of simple dose-response experiments. The composition or combined preparation may be administered orally.

Further provided according to the present invention is a kit comprising an

20 antibody or an antigen binding fragment thereof specific for one or more epitopes of a fungal stress protein and an antifungal agent comprising any one of the group consisting a polyene antifungal agent and an echinocandin antifungal agent, for use in the treatment of fungal infections. The kit may be for use in the treatment of fungal infections, wherein the fungus causing the fungal infection is resistant to the antifungal agent *per se*.

25

The antibody according to the invention may have a diagnostic use. Thus for diagnostic use the antibody may be employed to detect whether the stress protein is present

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in a host organism, to confirm whether the host has a particular fungal infection, for example Mucormycosis, Blastomycosis, Coccidioidomycosis or Paracoccidioidomycosis, or an infection due to a Candida, Cryptococcus, Histoplasma, Aspergillus, or Torulopsis organism, or for example in the diagnosis of fungal abscesses, especially hepatic

5 Candidiasis, and/or to monitor the progress of therapeutic treatment of such infections. Diagnostic methods of this type form a further aspect of the invention and may generally employ standard techniques, for example immunological methods such as enzyme-linked immunosorbent methods, radioimmuno-methods, latex agglutination methods or immunoblotting methods.

10

The antibody according to the invention may be labelled with a detectable label or may be conjugated with effector molecule for example a drug e.g. an anti-fungal agent such as amphotericin B or fluorocytosine or a toxin, such as ricin, or an enzyme, using conventional procedures and the invention extends to such labelled antibodies or

15 antibody conjugates.

Also provided according to the present invention is the use of the antibody or antigen binding fragment according to the present invention in the preparation of a diagnostic for diagnosing one or more fungal infections. The diagnostic may be provided

20 in a kit. The kit may include instructions for use in diagnosing one or more fungal infections. The diagnostic kit as described herein is also provided according to the present invention.

If desired, mixtures of antibodies may be used for diagnosis or treatment, for

25 example mixtures of two or more antibodies recognising different epitopes of a fungal stress protein according to the invention, and/or mixtures of antibodies of a different class, e.g. mixtures of IgG and IgM antibodies recognising the same or different epitope(s) of the invention.

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The contents of each of the references discussed herein, including the references cited therein, are herein incorporated by reference in their entirety.

Reference to any prior art in the specification is not, and should not be taken as, an acknowledgment, or any form of suggestion, that this prior art forms part of the common general knowledge in Australia or any other jurisdiction or that this prior art could reasonably be expected to be ascertained, understood and regarded as relevant by a person skilled in the art.

As used herein, the term "comprise" and variations of the term, such as "comprising", "comprises" and "comprised", are not intended to exclude other additives, components, integers or steps.

The present invention will be further apparent from the following description, which shows, by way of example only, specific embodiments of the composition and experimentation therewith.

EXPERIMENTAL

Experiments described below investigated the antifungal effect of antibody against an hsp90 antigen derived from *Candida albicans* used in combination with antifungals such as amphotericin B or fluconazole. Results show that, in some cases, the combination of antibody and antifungal agent causes an enhanced antifungal effect compared with each of the compounds on their own. A surprisingly strong synergistic effect is demonstrated for amphotericin B in combination with anti-*Candida albicans* hsp90 antibody against a variety of common problematic fungal pathogens. This synergistic effect has significant implications for clinical treatment of fungal infections. A preliminary clinical study involving four patients suffering from *Candida* infections demonstrated the effectiveness of the present invention for humans.

Material and Methods

Strains:

Non-*Aspergillus* yeast strains used (Table 1) were plated onto Sabouraud's dextrose agar (Oxoid, Basingstoke, UK) and incubated at 37°C for 24 hours. The strains were identified with the API 20C system (BioMerieux, Marcy L'Etoile, France). If needed, microscopical examinations of morphology on cornmeal agar (Oxoid) was used to confirm the identity.

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Isolates of *Aspergillus spp* (Table 1) were grown on Sabouraud's dextrose agar (Oxoid, Basingstoke, UK) at 35°C for 24 hours.

Table 1. Origin of strains

Strain	Reference
1. *Candida albicans* (outbreak)	B.M.J., 1985, 290: 746-748
2. *C. albicans* (Fluconazole resistant)	Opportunistic Pathogens, 1997, 1: 27-31
3. *C. krusei* (FA/157)	Int. J. Systemic Bacteriol., 1996, 46: 35-40
4. *C. tropicalis* (NCPF #3111)	National Collection of Pathogenic Fungi
5. *C. parapsilosis* (NCPF #3104)	National Collection of Pathogenic Fungi
6. *Torulopsis glabrata* (NCPF #3240)	National Collection of Pathogenic Fungi
7. *Aspergillus fumigatus* (NCPF#2109)	National Collection of Pathogenic Fungi
8. *Aspergillus flavus*	Clinical isolate, identified by characteristic morphology
9. *Aspergillus niger*	Clinical isolate, identified by characteristic morphology

Inoculum:

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For non-*Aspergillus* strains, suspensions were prepared from individual colonies (diameter ≥ 1mm) in 5 ml of sterile 0.85% saline to a density of 1 x 10⁴ cells/ml as established by counting on a haemocytometer grid. For *Aspergillus* strains, see below.

Antifungal agents:

Amphotericin B was purchased from Sigma (Poole, Dorset) as a lyophilized powder for intravenous administration (Fungizone). Fluconazole was supplied as a solution for intravenous administration (Diflucan) by Pfizer. Amphotericin B was dissolved in dimethyl sulphoxide at a concentration of 1.2 mg/ml and fluconazole was dissolved in 0.85% saline also at a concentration of 1.2 mg/ml. Stock solutions were stored at –70°C until used. Abelcet (liposomal amphotericin B) manufactured by Bristol-Meyers Squib (USA) and prepared according to the manufacturers guidelines was used in the clinical study.

Antibody:

The DNA sequence of a former antibody specific for the *Candida albicans* hsp90 epitope disclosed in GB2240979 and EP0406029 was genetically modified by codon optimisation for expression in *Escherichia coli* (Operon Technologies Inc., Alameda, CA, USA) and inserted into an *E. coli* expression vector. The amino acid sequence of the anti-hsp90 antibody of the present invention comprises the sequence of SEQ ID NO: 2 (includes the heavy, light and spacer domains). The antibody according to the present invention recognises the epitope comprising the sequence of SEQ ID NO: 1.

The anti-hsp90 antibody was expressed in an *Escherichia coli* host and then purified by affinity chromatography and an imidazole exchange column up to 95 % purity. Standard molecular biology protocols were employed (see, for example, Harlow & Lane, *supra*; Sambrook, J. *et al.*, 1989, Molecular Cloning: A Laboratory Manual, 2nd Edition, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York; Sambrook, J. &

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Russell, D., 2001, Molecular Cloning: A Laboratory Manual, 3rd Edition, Cold Spring Harbor Laboratory Press, Cold Spring Harbor).

Formulations of Mycograb (RTM) were prepared as follows: a vial containing 10 mg of pure anti-hsp90 antibody, 150 mg of pharmaceutical grade (Ph Eur) Urea and 174 mg L-Arginine (Ph Eur) were reconstituted in 5 ml water..

Assay media:

RPMI broth was prepared from RPMI 1640 broth medium (Sigma R7880) supplemented with 0.3 g of glutamine per litre, buffered with 34.6 g of morpholine propanesulfonic acid (MOPS) per litre and adjusted to ph 7.0.

The Broth microdilution test:

Twofold dilutions (40 to 0.024 mg/ml for amphotericin B and 400 to 0.4 mg/ml for fluconazole) were prepared in RPMI broth starting from the two stock solutions. A 100 μl suspension of the inoculum diluted 1 in 10 (equivalent to 1×10^3 cfu) was added to the microtiter plates. To this was added 50 μl of the antifungal and then 50 μl of the antibody. Antibody was either neat (0.4 mg/ml), or diluted to 1/10 or 1/100. When antibody was absent, the 50 μl volume was made up by RPMI. The total volume in each well was 200 μl. Final concentrations of antibody in the experiments were: 100 μg/ml ("neat"), 10 μg/ml ("1/10 antibody") or 1 μg/ml ("1/100 antibody").

Plates were incubated at 37°C overnight and the minimum inhibitory concentration (MIC) defined by the lower concentration inhibiting growth.

Colony counts were determined for the wells where there was a visual reduction in yeast growth. Results were represented as colony forming units per ml of broth (cfu/ml).

Aspergillus Studies:

Isolates of *Aspergillus fumigatus*, *Aspergillus flavus* and *Aspergillus niger* were prepared in RPMI 1640 medium. The suspensions were prepared to give a final inoculum of 2×10^4 conidia per ml and these were dispensed in 100 µl aliquots into flat-bottomed microtitre plates. A double dilution series of Amphotericin B ranging from 250 µg/ml to 0.75 µg/ml was prepared and dispensed to the appropriate wells. Mycograb was added to each of the wells at a final concentration of 100 µg/ml in formulation buffer. A control series was also prepared for each isolate which contained formulation buffer only. The plates were then incubated at 35°C/200 rpm for 48 hours and MIC values for each isolate were determined by absence or presence of growth wells.

Animal Synergy:

Thirty CD1 mice (each weighing about 25 g) were injected with 100 µl of *C. albicans* outbreak strain (equivalent to 1.5×10^7 cfu) and after 2 hours the mice were split into three groups and injected with:

(A) Group 1 - 100 µl solution of 10 mM ammonium acetate (AAT; pH 9), followed by 100 µl amphotericin B equivalent to 0.6 mg/kg in a 5% (w/v) glucose solution;

(B) Group 2 - 100 µl solution of 10 mM AAT (pH 9) solution containing 500 µg anti-hsp90 antibody, followed by 100 µl amphotericin B equivalent to 0.6 mg/kg in a 5 % (w/v) glucose solution; and

(C) Group 3 - 100 µl solution of 10 mM AAT (pH 9) containing 50 µg anti-hsp90 antibody, followed by 100 µl amphotericin B equivalent to 0.6 mg/kg in a 5% (w/v) glucose solution.

The animals were culled after 48 hours and yeast counts on Sabouraud's plates of liver, spleen and kidney tissue performed.

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Clinical study:

An open-label safety and pharmacokinetics study of the anti-hsp90 antibody (in the form of Mycograb; see above) involving four patients suffering from *Candida* infections was conducted at the Central Manchester Health Care Trust Hospital and the Wythenshawe Hospital, both in Manchester, UK. Patients were examined for the signs of sepsis due to *Candida*, including: positive cultures of *C. albicans* from multiple or deep sites; high or swinging temperature (pyrexia); high pulse rate (tachycardia) and high white cell count ("WBC").

Following conventional treatment with Abelcet (liposomal amphotericin B) and/or fluconazole, the patients were then additionally given various doses of Mycograb, including an optional test dose (0.1 mg/kg), and therapeutic dose(s) of 1 mg/kg. Patients were monitored for clinical and laboratory signs of infection (laboratory parameters tested include blood chemistry, haematology and clotting factors) and serum and urine levels of Mycograb tested.

<u>Results</u>

In vitro experiments examining the effect of combining an anti-*Candida albicans* hsp90 antibody ("antibody") and antifungal agents are presented in Tables 2 to 18. Animal experimental results are presented in Table 19.

***In vitro* experiments:**

Compositions containing antibody and fluconazole:

Table 2 shows the minimum inhibitory concentrations (MICs) of fluconazole against the test fungal pathogens, with or without the presence of the anti-*C. albicans* hsp90 antibody at different dilutions, as assessed by the Broth microdilution test. In the

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presence of neat antibody and antibody diluted 10-fold, the MIC for the outbreak strain of
C. albicans was reduced four-fold (1.56 μg/ml to 0.39 μg/ml fluconazole), whereas a 100-
fold dilution of the antibody resulted in a two-fold reduction of fluconazole MIC.

A slight reduction in fluconazole MIC was observed for the fluconazole
resistant strain of *C. albicans* and *C. krusei* in the presence of neat antibody. At a dilution
of 1/10 and 1/100, however, the antibody had no effect on the fluconazole MIC of these
strains in comparison with no antibody.

For the remaining fungal strains, ie. *C. tropicalis*, *C. parapsilosis* and *T.
glabrata*, the anti-*C. albicans* hsp90 antibody had no discernable effect on the fluconazole
MICs.

Table 2. MICs to fluconazole

<u>**MIC (μg/ml)**</u>

	<u>Fluconazole</u> <u>No antibody</u>	<u>Fluconazole</u> <u>Neat antibody</u> [100 μg/ml]	<u>Fluconazole</u> <u>1/10 antibody</u> [10 μg/ml]	<u>Fluconazole</u> <u>1/100 antibody</u> [1 μg/ml]
C. albicans Outbreak strain	1.56	0.39	0.39	0.78

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C. albicans Fluconazole Resistant	25	12.5	25	25
C. krusei	100	50	100	100
C. tropicalis	3.125	3.125	3.125	3.125
T. glabrata	1.56	1.56	1.56	1.56
C. parapsilosis	6.25	6.25	6.25	6.25

Further experiments which quantified the number of cell colonies surviving at different fluconazole concentrations with different dilutions of the anti-*C. albicans* hsp90 antibody were undertaken for each of the fungal strains represented in Table 2.

At the fluconazole concentrations examined, the survival rate of *C. albicans* (outbreak strain) was not reduced by the addition of neat antibody or antibody diluted 100-fold (Table 3).

Table 3. Colony counts (in cfu/ml) for *C.albicans* (outbreak strain) against fluconazole

	Fluconazole concentration (µg/ml)		
	<u>0.09</u>	<u>0.19</u>	<u>0.39</u>
No antibody	3.6×10^5	1×10^5	5×10^4
Neat antibody [100 µg/ml]	3.6×10^6	1.3×10^5	1.3×10^4

1/100 antibody

[1 µg/ml]   1 x 10^6 2.6 x 10^4 5.3 x 10^4

(Control 6 x 10^6 cfu/ml)

For the fluconazole-resistant strain of *C. albicans*, a two-fold reduction in colony survival was observed at 12.5 µg/ml fluconazole in the presence of neat antibody (Table 4). Slight reductions in the survival rate of this strain were noticed at lower concentrations of fluconazole in the presence of neat antibody, but no effect was discernable at a 1/100 dilution of the antibody.

Table 4. Colony counts (in cfu/ml) for the fluconazole resistant strain of *C. albicans* against fluconazole

	Fluconazole concentration (µg/ml)			
	1.56	3.12	6.25	12.5
No antibody	3 x 10^7	1.3 x 10^7	3 x 10^6	6 x 10^6
Neat antibody [100 µg/ml]	2 x 10^6	4.3 x 10^5	5.6 x 10^4	6 x 10^3
1/100 antibody [1 µg/ml]	3 x 10^7	1.1 x 10^7	1.1 x 10^7	6.3 x 10^6

(Control 2.6 x 10^7 cfu/ml)

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Neat or diluted antibody had no significant antifungal effect against *C. krusei* at the fluconazole concentrations tested (Table 5).

Table 5. Colony counts (in cfu/ml) for *C. krusei* against fluconazole

	Fluconazole concentration (µg/ml)	
	<u>25</u>	<u>50</u>
No antibody	3.2×10^7	1.6×10^7
Neat antibody [100 µg/ml]	8.3×10^6	6×10^6
1/100 antibody [1 µg/ml]	1.3×10^6	1.6×10^6

(Control 1×10^7 cfu/ml)

For *C. tropicalis*, no marked effect on survival rate could be seen for each of the fluconazole concentrations examined in the presence or absence of antibody (Table 6).

Table 6. Colony counts (in cfu/ml) for *C. tropicalis* against fluconazole

	Fluconazole concentration (µg/ml)		
	<u>0.09</u>	<u>0.19</u>	<u>0.39</u>
No antibody	5×10^5	6×10^3	6×10^2
Neat antibody	7×10^5	6.3×10^4	9×10^2

[100 μg/ml]

1/100 antibody [1 μg/ml]	1 x 10⁵	6 x 10³	2 x 10³

(Control 1.6 x 10⁶ cfu/ml)

Table 7 shows that presence or absence of the antibody had no effect of the survival rate of *T. glabrata* colonies at each of the fluconazole concentrations tested.

Table 7. Colony counts (in cfu/ml) for *T. glabrata* against fluconazole

	Fluconazole concentration (μg/ml)		
	_0.39_	_0.78_	_1.56_
No antibody	2 x 10⁷	1 x 10⁷	6 x 10⁴
Neat antibody [100 μg/ml]	1.5 x 10⁷	1.2 x 10⁷	9.3 x 10⁵
1/100 antibody [1 μg/ml]	2.3 x 10⁷	1.9 x 10⁷	2 x 10⁵

(Control 4.3 x 10⁷ cfu/ml)

Presence or absence of the antibody had no notable effect on the survival rate of *C. parapsilosis* colonies at the fluconazole concentrations as indicated in Table 8.

Table 8. Colony counts (in cfu/ml) for *C. parapsilosis* against fluconazole

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| | **Fluconazole concentration (μg/ml)** | | | |
	0.78	1.56	3.13	6.25
No antibody	7×10^6	5.6×10^6	2.6×10^6	3×10^6
Neat antibody [100 μg/ml]	8.6×10^6	2.3×10^6	1.6×10^6	1.6×10^6
1/100 antibody [1 μg/ml]	4×10^5	3×10^6	2.3×10^6	5×10^6

(Control 1×10^7 cfu/ml)

Compositions with antibody and amphotericin B:

Table 9 shows the minimum inhibitory concentrations (MICs) of amphotericin B against the test fungal pathogens, with or without the presence of the anti-*C. albicans* hsp90 antibody at different dilutions, as assessed by the Broth microdilution test.

In contrast with the results obtained for fluconazole (see Tables 2-8 *supra*), all strains tested here showed at least a four-fold drop in MIC of amphotericin B when undiluted antibody was added to the incubation broth (Table 9). Furthermore, in all strains examined, there was at least a two-fold drop in amphotericin B MIC even when the antibody diluted 100-fold was added to the incubation broth (final antibody concentration: 1 μg/ml).

The greatest effect of the composition comprising antibody and amphotericin B at reducing the MIC of amphotericin B was observed with the fluconazole resistant strain of *C. albicans*. Neat antibody yielded a ten-fold reduction in the amphotericin B

MIC, and even at a 100-fold antibody dilution, the amphotericin B MIC was reduced by approximately 25 % (Table 9).

Table 9. MICs to amphotericin B

MIC (μg/ml)

	Amphotericin No antibody	Amphotericin Neat antibody [100 μg/ml]	Amphotericin 1/10 antibody [10 μg/ml]	Amphotericin 1/100 antibody [1 μg/ml]
C. albicans (outbreak)	0.156	0.039	0.039	0.078
C. albicans Fluconazole Resistant	0.312	0.039	0.078	0.078
C. krusei	0.625	0.156	0.312	0.312
C. tropicalis	0.078	0.019	0.039	0.039
T. glabrata	0.039	<0.009	<0.009	0.019
C. parapsilosis	0.625	0.156	0.313	0.313

Detailed experiments which quantified the number of cell colonies surviving at different amphotericin B concentrations with different dilutions of the anti-*C. albicans* hsp90 antibody were undertaken for each of the fungal strains represented in Table 9.

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Table 10 shows survival rates for the outbreak strain of *C. albicans* incubated with amphotericin B in the presence or absence of antibody. A dramatic reduction (at least 10-fold) in the number of surviving colonies was effected by the antibody at all the amphotericin concentrations tested. For example, at 0.078 μg/ml amphotericin B, the survival rate of *C. albicans* (outbreak strain) was 0.2% in the presence of antibody diluted 100-fold compared with the survival rate of the strain without antibody. The inhibitory effect of the antibody diluted 100-fold at 0.078 μg/ml amphotericin B was equivalent to the survival rate of this strain at 0.156 μg/ml amphotericin B (without antibody). Therefore, even very diluted antibody is able to effect a reduction in the amount of amphotericin B required to achieve a specific mortality rate in this strain.

Table 10. Colony counts (in cfu/ml) for the outbreak strain of *C. albicans* against amphotericin B

| | **Amphotericin B concentration (μg/ml)** | | | |
	0.019	0.039	0.078	0.156
No antibody	1×10^7	1.6×10^7	4.1×10^5	1.3×10^3
Neat antibody [100 μg/ml]	5.3×10^5	6×10^3	3×10^2	4.3×10^2
1/10 antibody [10 μg/ml]	5×10^5	1×10^4	3.0×10^2	3×10^1
1/100 antibody [1 μg/ml]	6.6×10^6	3.2×10^5	8.0×10^2	1×10^2

(Control 1×10^7 cfu/ml)

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Table 11 shows the survival rate of colonies of *C. albicans* (fluconazole resistant strain) at different concentrations of amphotericin B and at different antibody dilutions. No noticeable effect of the antibody or amphotericin B could be seen at lower concentrations of the antifungal agent. However, at amphotericin B levels approaching the MIC of the antifungal agent (see Table 9, *supra*), the antibody was observed to have a marked effect on colony survival. For example, at 0.078 μg/ml amphotericin B, antibody at a 100-fold dilution effected a survival rate of this strain of 0.1 % compared with no antibody.

Table 11. Colony counts (in cfu/ml) for the fluconazole resistant strain of *C. albicans* against amphotericin B

	Amphotericin B concentration (μg/ml)		
	0.019	0.039	0.078
No antibody	4.6×10^6	4.3×10^6	6×10^6
Neat antibody [100 μg/ml]	5.3×10^5	3.0×10^3	3×10^3
1/10 antibody [10 μg/ml]	2.2×10^6	6.3×10^4	1.6×10^3
1/100 antibody [1 μg/ml]	3.4×10^6	1.6×10^5	5.3×10^3

(Control 1.6×10^7 cfu/ml)

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Colony survival rates of *C. krusei* in the presence of amphotericin B and different amounts of antibody are represented in Table 12. The antibody can be seen to be very effective against this strain at the higher concentrations of amphotericin B examined. Even at a 100-fold dilution, the number of *C. krusei* colonies detected in the presence of 0.312 μg/ml amphotericin B was 0.01 % of those surviving without antibody.

Table 12. Colony counts (in cfu/ml) for *C. krusei* against amphotericin B

	Amphotericin B concentration (μg/ml)		
	0.078	0.156	0.312
No antibody	1×10^7	1.7×10^7	9×10^5
Neat antibody [100 μg/ml]	1×10^6	1.76×10^5	$<10^2$
1/10 antibody [10 μg/ml]	6.3×10^6	1.6×10^5	$<10^2$
1/100 antibody [1 μg/ml]	1.6×10^7	1.53×10^6	1.3×10^2

(Control 1×10^7 cfu/ml)

For all concentrations of amphotericin B tested (range from 0.019 - 0.156 μg/ml), the antibody was seen to be effective at reducing the colony survival rate of the strain *C. tropicalis* (Table 13). The effect was enhanced at higher antibody and amphotericin B concentrations.

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Table 13. Colony counts (in cfu/ml) for _C. tropicalis_ against amphotericin B

| | Amphotericin concentration (µg/ml) | | | |
	0.019	0.039	0.078	0.156
No antibody	1.3×10^6	1×10^6	2.6×10^5	6.6×10^3
Neat antibody [100 µg/ml]	1.1×10^4	2.3×10^4	2×10^2	0
1/10 antibody [10 µg/ml]	1×10^4	3.4×10^4	4×10^2	3×10^1
1/100 antibody [1 µg/ml]	1.1×10^6	2×10^4	2.6×10^3	0

(Control 1.6×10^6 cfu/ml)

Table 14 shows the survival rate for _T. glabrata_ in the presence of various concentrations of amphotericin B and antibody. The antibody was observed to be highly effective at inhibiting growth of _T. glabrata_ at all concentrations of amphotericin B tested. For example, at a 100-fold dilution of the antibody, the growth of this strain was inhibited by 99.2 % at 0.009 µg/ml amphotericin B, 99.99% at 0.019 µg/ml amphotericin B and 99.91 % at 0.039 µg/ml amphotericin B.

Table 14. Colony counts (in cfu/ml) for _T. glabrata_ against amphotericin B

Amphotericin B concentration (µg/ml)

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	0.009	0.019	0.039
No antibody	1.1×10^7	9.6×10^6	1.4×10^5
Neat antibody [100 µg/ml]	8.6×10^3	8.3×10^2	2.6×10^2
1/10 antibody [10 µg/ml]	9×10^5	6.3×10^3	2.3×10^2
1/100 antibody [1 µg/ml]	9×10^4	1×10^3	1.3×10^2

(Control 1×10^7 cfu/ml)

The survival of the fungal strain *C. parapsilosis* at different levels of antibody and amphotericin B is shown in Table 15. Neat antibody was observed to achieve a reduction in the survival rate of this strain at all levels of amphotericin B tested. At lower concentrations of antibody, the effect was less dramatic than for the other strains examined.

Table 15. Colony counts (in cfu/ml) for *C. parapsilosis* against amphotericin B

	Amphotericin B concentration (µg/ml)		
	0.156	0.313	0.626
No antibody	1.46×10^7	3×10^6	6.3×10^3
Neat antibody [100 µg/ml]	1.3×10^5	3×10^4	6.0×10^2

1/10 antibody

[10 μg/ml]   1.03 x 10^7 1.76 x 10^5 6.0 x 10^3

1/100 antibody   1.8 x 10^7 2.9 x 10^5 3.3 x 10^3

[1 μg/ml]

(Control 1 x 10^7 cfu/ml)

Compositions with antibody but without antifungal agent:

In a further experiment, the effect of different concentrations of the anti-*C. albicans* hsp90 antibody alone (no antifungal agent) on the different fungal strains (used in Tables 2 -15, *supra*) was tested. The results shown in Table 16 reveal that for the most of the strains used, the antibody itself had no effect on their survival. However, some diminution in survival rate which can be attributed to the antibody alone was observed in the strains *T. glabrata*, *C. tropicalis* and *C. parapsilosis*.

Table 16. Effect of antibody on its own against yeast growth (expressed as cfu/ml)

Antibody (μg/ml)	C.albicans (outbreak)	C.albicans (fluconazole resistant)	C. krusei	T. glabrata	C. tropicalis	C. parapsilosis
0	1.2 x 10^7	1 x 10^7	3.3 x 10^7	1.3 x 10^7	1 x 10^6	7.0 x 10^6
0.313	5.6 x 10^6	6 x 10^6	1.6 x 10^6	1.2 x 10^7	6.0 x 10^5	2.6 x 10^4
0.625	3.3 x 10^6	5.3 x 10^6	9.3 x 10^6	1 x 10^7	3.3 x 10^5	3.0 x 10^4
1.25	5.0 x 10^6	5.6 x 10^6	6.6 x 10^6	6.6 x 10^6	3.6 x 10^5	1.6 x 10^4

2.5

5.3×10^6 6.3×10^6 4.3×10^6 6×10^5 9×10^4 6.6×10^3

Experiments with *Aspergillus spp*:

The MIC of *Aspergillus fumigatus* to Amphotericin B was 2.5 µg/ml. With the addition of Mycograb, the MIC shifted to 0.125 µg/ml (two-fold decrease). The MIC of *Aspergillus flavus* to Amphotericin B was 2.5 µg/ml. With the addition of 100 µg/ml of Mycograb the MIC shifted to 0.125 µg/ml (two-fold decrease). The MIC of *Aspergillus niger* to Amphotericin B was 2.5 µg/ml. With addition of 100 µg/ml of Mycograb the MIC shifted to 0.125 µg/ml (two-fold decrease).

Summary of *in vitro* results:

The results shown in Tables 2-16 reveal that while the anti-*C. albicans* hsp90 antibody on its own was able to inhibit growth of certain fungal strains, a surprisingly high level of antifungal activity against all the strains examined was observed when the antibody was used in combination with amphotericin B. This surprising effect between the antibody and amphotericin B is not observed with other antifungal agents examined: fluconazole combined with the antibody did not produce a significant and potentially useful outcome.

Using the cut-off criterion of a four-fold difference in MIC improvement, data in Table 2 reveal that fluconazole combined with neat antibody (final concentration 100 µg/ml) or a 10-fold dilution of antibody (final concentration 10 µg/ml) was effective only against the outbreak strain of *C. albicans*. However, using the same criterion, it can be seen from Table 9 that amphotericin B combined with neat antibody or a 10-fold dilution of the antibody was effective against all the fungal strains tested. It can therefore be concluded

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that there is a strong synergy between amphotericin B and the anti-*C. albicans* hsp90 antibody as measured by improvement in MIC.

For the experiments in which fungal colonies were quantified for different antifungal and antibody treatments (see Tables 3-8 and 10-15, *supra*), a different cut-off criterion which defines a two log drop (100-fold) drop in surviving colonies can be employed to assess potentially useful combinations of treatments.

A summary of the results for fluconazole in combination with the anti-*C. albicans* hsp90 antibody is presented in Table 17. Here, the lowest concentration of fluconazole resulting in the desired effect (or the highest concentration used in the experiment) used is shown, together with an indication of the cut-off criterion of at least a 100-fold drop is fungal survival rate was achieved. The results show that only the fluconazole resistant strain of *C. albicans* when combined with fluconazole and neat antibody produced a significant effect.

Table 17. Summary of *in vitro* results for fluconazole

	Fluconazole (μg/ml)	Neat Antibody [100 μg/ml]	Table
C.albicans Outbreak	0.39	-	3
C.albicans Fluconazole resistant	12.5	+	4
C. krusei	50	-	5

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C. tropicalis	0.39	-	6
T. glabrata	1.56	-	7
C. parapsilosis	6.25	-	8

(+ indicates cut-off criterion satisfied; - indicates cut-off criterion not satisfied; cut-off criterion is at least 100-fold reduction in colony count)

A summary of the results for amphotericin B in combination with the anti-*C. albicans* hsp90 antibody is presented in Table 18. It can be seen that the cut-off criterion (100-fold reduction in fungal colony growth) is satisfied with neat antibody for all fungal strains examined, with a 10-fold dilution of the antibody for *C. albicans* (outbreak strain and fluconazole resistant strain), *C. krusei* and *T. glabrata*, and with a 100-fold reduction in antibody for *C. albicans* (outbreak strain) and *T. glabrata*.

It is noteworthy that synergy between amphotericin B and the antibody was observed not only against fluconazole sensitive strains of *C. albicans* but also fluconazole resistant strains of *C. albicans* and yeasts such as *Candida krusei* and *T. glabrata* which are intrinsically resistant to fluconazoles.

Table 18. Summary of *in vitro* results for amphotericin B

Amphotericin (µg/ml)	Antibody Neat [100 µg/ml]	Antibody 1/10 [10 µg/ml]	Antibody 1/100 [1 µg/ml]	Table

C.albicans Outbreak	0.039	+	+	+	10
C.albicans Fluconazole resistant	0.039	+	+	-	11
C. krusei	0.156	+	+	-	12
C. tropicalis	0.019	+	-	-	13
T. glabrata	0.009	+	+	+	14
C. parapsilosis	0.156	+	-	-	15

(+ indicates cut-off criterion satisfied; - indicates cut-off criterion not satisfied; cut-off criterion is at least 100-fold reduction in colony count)

The results with *Aspergillus spp* show that there was synergy between Amphotericin B and Mycograb *in vitro* against the commonest *Aspergillus spp*.

(2) Animal experiments:

Mice infected with the outbreak strain of *Candida albicans* were treated with amphotericin B only (Group 1), amphotericin B and 500 μg anti-hsp90 antibody (Group 2) and amphotericin B and 50 μg anti-hsp90 antibody (Group 3). Yeast colony counts for various tissues from the mice after a treatment period of 48 hours are shown in Table 19. The results show that animals treated with amphotericin B and 500 μg antibody (Group 2) showed a significant reduction (at least one order of magnitude) in the number of yeast counts compared with animals treated with amphotericin B only (Group 1). Animals treated with amphotericin B and 50 μg antibody (Group 3) also showed diminished yeast

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counts compared with the animals treated with amphotericin B only (Group 1). The *in vivo* data therefore corroborates the *in vitro* data and confirms the synergy between the anti-hsp90 antibody and the antifungal agent amphotericin B for the treatment of fungal infections.

Table 19. Colony counts of *C.albicans* (outbreak strain) in tissues of treated mice groups

	Colonies (cfu/ml, in log10 ± standard deviation)		
	Group 1	Group 2	Group 3
Kidney	6.80 ± 0.916	4.42 ± 1.28	4.35 ± 1.37
Liver	4.26 ± 1.42	3.22 ± 0.028	3.83 ± 1.00
Spleen	4.18 ± 1.18	3.07 ± 0.089	3.94 ± 1.25

(3) Clinical Study:

Four patients with evidence of *Candida* infection and who were not responding to conventional antifungal treatment were given a combined treatment of antifungals and anti-hsp90 antibody in the form of Mycograb (see above) and their condition monitored.

Patient 1 was given a primary diagnosis of acute pancreatitis and the patient had postoperative adult respiratory distress syndrome (ARDS) requiring ventilation. *C albicans* was grown *in vitro* from multiple sites including pancreatic bed. The patient had a very high white cell count (WBC) (78.4), although this was highly variable and may not have been caused by the sepsis alone. Abelcet treatment at 3 mg/kg was initiated.

Five days after initiation of Abelcet treatment, Patient 1 was additionally given a first test dose of Mycograb at 0.1 mg/kg (Day 1). On Day 3, the patient was given a clincal dose of Mycograb at 1 mg/kg. Due to several factors, for example a worsening platelet count which had been low for at least four days, the Abelcet and Mycograb treatments were discontinued on Day 3 after the clinical dose of Mycograb had been given. However, Patient 1 regrew *C. albicans* from ascites six days later (Day 9) and was put on fluconazole (400 mg). The following day (Day 10), the patient was given the final two clinical doses of Mycograb at 1 mg/kg per dose.

Although Patient 1 had been on Abelcet for seven days, before the patient received the clinical dose of Mycograb on Day 3, *C. albicans* was still being grown from the patient's trachyostomy site and the patient had a tachycardia. The combined treatment with Abelcet and Mycograb on Day 3 resulted in a period of five days during which *C. albicans* was not grown. No Mycograb-related changes in blood chemistry, haematology and clotting factors were observed during treatment with Mycograb. Treatment of the subsequent recurrence with fluconazole and Mycograb (two doses on Day 10) was less successful, as would be expected from the *in vitro* synergy results (see for example Tables 2 and 17), but the patient did eventually recover from the candidosis.

Serum levels of Mycograb in Patient 1 at different time intervals following administration of Mycograb doses are shown in Table 20. The test dose at Day 1 did not give measurable serum levels. The 1.0 mg/kg doses at Day 3 and Day 10 did give detectable serum levels, and these levels were comparable with those at which synergy with amphotericin B was demonstrable *in vitro* (see Tables 9 and 18). Following the second dose on Day 10, serum levels of Mycograb improved, indicating some tissue accumulation following the first dose. Mycograb was detectable in the urine at the 1.0 mg/ml doses (data not shown).

Table 20. Serum levels (in μg/ml) of Mycograb in Patient 1

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Time (h)	Day 1 0.1 mg/kg	Day 3 1.0 mg/kg	Day 10 1.0 mg/kg bd 1st dose	Day 10 1.0 mg/kg bd 2nd dose
0	0	0	0	0
0.5	0	4.0	3.0	3.0
1.0	0	2.5	1.2	1.4
2.0	0	2.5	0.5	1.0
4.0	0	1.0	0.3	0.4
6.0	0	-	0.1	0.1
8.0	0	0	0: 2nd dose then given	0
12.0	0	0		
24.0	0	0		
48.0	0	0		

Patient 2 was diagnosed as having a small bowel constriction due to adhesions and had ARDS requiring ventilation. *C. albicans* was grown from multiple sites including ascitic fluid, with the infection associated with a fluctuating temperature (35.8-38.2°C), raised WBC (11.4) and occasional tachycardia (110). The patient was started on Abelcet at 3 mg/kg.

Four days after the commencement of Abelcet treatment, Patient 2 still retained a fluctuating temperature, raised WBC and occasional tachycardia. The patient was given a 0.1 mg/kg test dose of Mycograb (Day 1). The following day, the patient was given a clinical dose of 1 mg/kg Mycograb (Day 2). The last dose of Abelcet was also given on Day 2 due to completion of a 5 day treatment program. Two days later (Day 4), the patient received the final two clinical doses of Mycograb.

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The Mycograb was well tolerated by the patient. The clinical dose of Mycograb on Day 2 was associated with a falling and stabilising temperature (38.2 to 36.7°C on Day 2 after receiving the clinical dose, staying at 36.7-37.4°C through to Day 3) and a falling WBC (from 11.9 to 9.6). On Day 4, the patient was looking clinically better and no *C. albicans* was grown from ascites, blood cultures or urine. No Mycograb-related changes in blood chemistry, haematology and clotting factors were observed during treatment. Subsequent recovery was complicated by an episode of bacterial sepsis but this responded to antibiotics and the patient made a full recovery.

Serum levels of Mycograb in Patient 2 at different time intervals following administration of Mycograb doses are shown in Table 21. The test dose at Day 1 did not give measurable serum levels. The 1.0 mg/kg dose at Day 2 did give detectable serum levels, and these levels were compatible with those at which synergy with amphotericin B was demonstrable *in vitro* (see Tables 9 and 18). Mycograb was detectable in the urine at the 1.0 mg/kg doses (data not shown).

Table 21. Serum levels (in μg/ml) of Mycograb in Patient 2

Time (h)	Day 1 0.1 mg/kg	Day 2 1.0 mg/kg	Day 4 1.0 mg/kg bd 1st dose	Day 4 1.0 mg/kg bd 2nd dose
0	0	0	0	0
0.5	0	1.5	1.0	1.0
1.0	0	0.5	0.5	0.5
2.0	0	0.3	0.1	0.5
4.0	0	0.1	0	0.1
6.0	0	0	0	0
8.0	0	0	0: 2nd dose then given	0

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	Day 1	**Day 2**	**Day 4**	**Day 4**
12.0	0	0		0
24.0	0	0		0
48.0	0	0		0

Patient 3 had a six week history of pancreatitis which led to an 80% pancreatectomy. The patient had moderately raised LFT (liver function test) levels, possibly related to alcohol abuse, and was an MRSA (Methicillin-resistant *Staphylococcus aureus*) carrier. *C. albicans* were grown from multiple sites so the patient was treated with intravenous fluconazole. Twelve days later, after failing to respond to fluconazole, the patient was changed to 300 mg Abelcet. Three days later, the patient was still pyrexial (38.5°C) and *C. albicans* was still growing from multiple sites (abdominal drains and gastroscopy tube), and was therefore given a clinical dose (1 mg/kg) of Mycograb (Day 1) in addition to the Abelcet.

On the same day as the Mycograb dose was given, Patient 3 suffered an acute episode of Gram-negative-type septic shock (high temperature of 39.5°C, hypotensive), probably due to *Pseudomonas aeruginosa*, which was subsequently grown from his pancreatic drain, although he also grew *Enterococcus faecalis* from blood cultures. Due to this episode, no further Mycograb doses were given. The patient subsequently responded to antibiotic therapy (vancomycin and ceftazidime).

Due to the bacterial complications, it was difficult to assess the impact of the single dose of Mycograb on Patient 3. However, it was noted that he stopped growing *C. albicans* (for example, from his gastrostomy tube and wound drain) for 48 hours after the dose and that he became apyrexial on Day 2 and Day 3. No Mycograb-related changes in laboratory parameters (blood chemistry, haematology and clotting factors) were observed.

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On Day 4, the patient had a recurrence of *C. albicans* while he was still on Abelcet but a full recovery was made subsequently.

Serum levels of Mycograb in Patient 3 at different time intervals following administration of the Mycograb dose are shown in Table 22. The single 1.0 mg/kg dose at Day 1 gave detectable serum levels, and these levels were compatible with those at which synergy with amphotericin B was demonstrable *in vitro* (see Tables 9 and 18). Mycograb was also detectable in the urine following the 1.0 mg/kg dose (data not shown).

Table 22. Serum levels (in µg/ml) of Mycograb in Patient 3

	Day 1
Time (h)	1.0 mg/kg bd
0	0
0.5	2.5
1.0	1.5
2.0	1.2
4.0	0.1
6.0	0
8.0	0
12.0	0
24.0	0
48.0	0

Patient 4 was diagnosed with *C. albicans* empyema, although the patient was originally admitted to ITU (Intensive Treatment Unit) with a lung abscess due to *Streptococcus milleri* (isolated from blood cultures). *C. albicans* was grown from two bronchial lavage specimens (right and left lung) and three and four days later from two empyema fluid specimens. Treatment was started the following day with Abelcet (5

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mg/kg). Five days after commencement of Abelcet treatment, some clinical deterioration was noted and the following morning (Day 1) this was associated with high WBC (15.7) and *C. albicans* regrown from an intercostal drain fluid.

Mycograb (1 mg/kg bd) was given to Patient 4 at 8.30 am and 8.30 pm on Day 1. Apart from a temporary rise in temperature on the night of Day1, the patient improved clinically. *C. albicans* was <u>not</u> grown from empyema fluid specimen cultured on Day 3, and the patient became progressively better.

The Mycograb was well tolerated by Patient 4. No Mycograb-related changes in laboratory parameters (blood chemistry, haematology and clotting factors) were observed. Thus the patient was still growing *C. albicans* from a chest drain six days after commencing Abelcet treatment and his WBC was high (15.7) just before receiving the first Mycograb dose, but thereafter the patient steadily improved and stopped growing *C. albicans*.

Serum levels of Mycograb in Patient 4 at different time intervals following administration of Mycograb doses are shown in Table 23. The 1.0 mg/kg doses given on Day 1 gave detectable serum levels which were compatible with those at which synergy with amphotericin B was demonstrable *in vitro* (see Tables 9 and 18). Following the second dose on Day 1, serum levels of Mycograb improved, indicating some tissue accumulation following the first dose. Mycograb was detectable in the urine at the 1.0 mg/ml doses (data not shown).

Table 23. Serum levels (in μg/ml) of Mycograb in Patient 4

Day 1

Time (h)	1.0 mg/kg bd 1st dose	1.0 mg/kg bd 2nd dose
0	0	8.0
0.5	1.2	2.5
1.0	1.2	1.4
2.0	0.6	1.2
4.0	0.1	0.6
6.0	0	0.3
8.0	0	0.1
12.0	- 2nd dose given	0
24.0	-	0
48.0		0

Conclusions

The data presented here clearly demonstrates that there is a surprising synergism between the anti-*Candida* hsp90 antibody and the antifungal agent amphotericin B which effects enhanced antifungal activity against a wide variety of pathologically important fungal strains. These results allows for the use of novel, highly effective compositions for the treatment of human or animal fungal infections, and also a novel antibody which can be incorporated into the composition. The present invention allows for either lower treatment dosages or more effective treatment at the same dosages, thereby reducing unwanted side-effects.

Clinical implications of the present invention include: (i) the production of a synergistic combination of amphotericin B and anti-hsp90 antibody in the treatment of

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disseminated yeast infection should become the treatment of choice. This would lead to a reduction in mortality and morbidity for these infections. The preliminary clinical study results provided herewith confirm the efficacy of the present invention in comparison with existing methods of treatment; (ii) amphotericin B is a toxic, particularly nephrotoxic, drug. The synergy provided by the present invention means that a lower dose of amphotericin B could be used while maintaining efficacy and concomitantly reducing toxicity; and (iii) the toxicity sparing effect of the anti-hsp90 antibody would allow the clinical efficacy of higher doses of amphotericin B to be explored and further contribute to an improved clinical outcome.

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Claims

1.   The use of a composition comprising an antibody or an antigen binding
fragment thereof specific for one or more epitopes of a fungal stress protein and an
5   antifungal agent comprising at least one of the group consisting a polyene antifungal agent
and an echinocandin antifungal agent in a method of manufacture of a medicament for the
treatment of fungal infections, wherein the fungus causing said fungal infection is resistant
to said antifungal agent *per se*.

10   2.   The use of a composition according to claim 1, wherein said antibody is
specific for a heat shock protein from a member of the *Candida* or *Torulopsis* genera.

3.   The use of a composition according to claim 2, wherein said heat shock
protein comprises hsp90 from *Candida albicans*.

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4.   The use of a composition according to any one of the preceding claims,
wherein said antibody or an antigen binding fragment thereof is specific for the epitope
comprising the sequence of SEQ ID NO: 1.

20   5.   The use of a composition according to claim 4, wherein said antibody
comprises the sequence according to SEQ ID NO: 2.

6.   The use of a composition according to any one of the preceding claims,
wherein said polyene antifungal agent comprises amphotericin B or a derivative of
25   amphotericin B.

7.   The use of a composition according to any one of the preceding claims,
wherein said echinocandin antifungal agent comprises Anidulafungin (LY303366).

8.   The use of a composition according to any one of the preceding claims, wherein said fungal infection is at least one selected from the group comprising Mucormycosis, Blastomycosis, Coccidioidomycosis, or Paracoccidioidomycosis, or said fungal infection is caused by at least one organism selected from the group comprising *Candida, Cryptococcus, Histoplasma, Aspergillus,* or *Torulopsis* organism.

9.   The use of a composition according to either one of claims 4 or 5 wherein said antibody or antigen binding fragment is labelled with a detectable label.

10.   The use of a composition according to any of claims 4, 5 or 9, wherein said antibody or antigen binding fragment is conjugated with an effector molecule.

11.   A kit comprising an antibody or an antigen binding fragment thereof specific for one or more epitopes of a fungal stress protein and an antifungal agent comprising any one of the group consisting of a polyene antifungal agent and an echinocandin antifungal agent, when used in the treatment of fungal infections, wherein the fungus causing said fungal infection is resistant to said antifungal agent *per se.*

12.   A method of treating fungal infections comprising administering an antibody or an antigen binding fragment thereof specific for one or more epitopes of a fungal stress protein and an antifungal agent comprising at least one of the group consisting a polyene antifungal agent and an echinocandin antifungal agent, wherein the fungus causing said fungal infection is resistant to said antifungal agent *per se.*

13.   The use of a composition substantially as hereinbefore described with reference to any one of the examples.

14.   A kit substantially as hereinbefore described with reference to any one of the examples.

15.   A method for treating fungal infections substantially as hereinbefore described with reference to any one of the examples.

Dated : 1 June 2005
Freehills Patent & Trade Mark Attorneys
Patent & Trade Mark Attorneys for the Applicant:
Neutec Pharma PLC

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SEQUENCE LISTING

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        35   40   45

Glu Trp Met Gly Lys Ile Asp Pro Gly Asp Ser Tyr Ile Asn Tyr Ser
    50   55   60

Pro Ser Phe Gln Gly His Val Thr Ile Ser Ala Asp Lys Ser Ile Asn
65   70   75   80

Thr Ala Tyr Leu Gln Trp Asn Ser Leu Lys Ala Ser Asp Thr Ala Met
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Tyr Tyr Cys Ala Arg Gly Gly Arg Asp Phe Gly Asp Ser Phe Asp Tyr
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Trp Gly Gln Gly Thr Leu Val Thr Val Ser Ser Gly Gly Gly Gly Ser

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Cys Arg Ala Ser Ser Gly Ile Ser Arg Tyr Leu Ala Trp Tyr Gln Gln
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Ala Pro Gly Lys Ala Pro Lys Leu Leu Ile Tyr Ala Ala Ser Thr Leu
                180                 185                 190

Gln Thr Gly Val Pro Ser Arg Phe Ser Gly Ser Gly Ser Gly Thr Glu
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Phe Thr Leu Thr Ile Asn Ser Leu Gln Pro Glu Asp Phe Ala Thr Tyr
    210                 215                 220

Tyr Cys Gln His Leu Asn Ser Tyr Pro Leu Thr Phe Gly Gly Gly Thr
225                 230                 235                 240

Lys Val Asp Ile Lys Arg Ala Ala
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