(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 March 2013 (21.03.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/040478 A3

(51) International Patent Classification:
A61K 36/06 (2006.01) *A61K 38/00* (2006.01)
C07K 14/00 (2006.01) *C12Q 1/68* (2006.01)

(21) International Application Number:
PCT/US2012/055604

(22) International Filing Date:
14 September 2012 (14.09.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/534,734 14 September 2011 (14.09.2011) US
61/564,201 28 November 2011 (28.11.2011) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*
— *with sequence listing part of description (Rule 5.2(a))*

(88) Date of publication of the international search report:
27 June 2013

(54) **Title**: HYR1-DERIVED COMPOSITIONS AND METHODS OF TREATMENT USING SAME

(57) **Abstract**: The disclosure features isolated polypeptides of Hyr1. The disclosure further features vaccines and antibodies useful in treating or preventing candidiasis or Acinetobacter infections or both. Further disclosed are isolated polypeptides consisting of between 14 and 20 amino acids for vaccine preparation. The specific amino acid sequences of isolated polypeptides of Hyr1 are also disclosed.

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HYR1-DERIVED COMPOSITIONS AND METHODS OF TREATMENT USING SAME

STATEMENT AS TO FEDERALLY FUNDED RESEARCH

This invention was made with government support under Public Health Service grants R01 AI19990, R01 AI063382, R01 AI063503, R03 AI083251, and R21 AI082414. The United States Government has certain rights in this invention.

FIELD OF THE INVENTION

The present invention relates generally to compositions and methods for detecting, treating and preventing infectious diseases in a subject.

BACKGROUND OF THE INVENTION

Candida species, the third most common cause of healthcare-associated bloodstream infections, causes approximately 60,000 cases of hematogenously disseminated candidiasis per year in the United States, resulting in billions of dollars of healthcare expenditures. Despite current antifungal therapy, mortality remains unacceptably high. Because of the rising incidence of life-threatening candidiasis and high treatment failure rates, more effective prophylactic and therapeutic strategies are needed.

The primary host defense mechanism against disseminated candidiasis is phagocytic killing of the organism. Only phagocytic cells are capable of directly killing *Candida in vitro*. Additionally, within thirty-minutes of intravenous inoculation of Candida in mice, rabbits, dogs, or humans, yeasts are retained within the reticuloendothelial system, especially in the liver. The liver, rich in Kupffer macrophages, is capable of clearing 99.9% of yeast in the portal system during a single pass, underscoring the effectiveness of phagocytic defense mechanisms against the fungus. Hence, resistance of *C. albicans* to phagocyte killing is an important virulence function of the organism.

Cell surface glycosyl phosphatidylinositol (GPI)-anchored proteins are at the critical interface between pathogen and host, making these proteins likely participants in host-pathogen interactions.

The identification of effectors in the regulatory pathways of the organism that contribute to virulence offers the opportunity for therapeutic intervention with methods or compositions that are superior to existing antifungal agents. The identification of cell surface proteins or hyphal proteins that affect a regulatory pathway involved in virulence is particularly promising because characterization of the protein enables immunotherapeutic techniques that are likely superior to or synergistic with existing antifungal agents when fighting a candidal infection.

The virulence of *C. albicans* is regulated by several putative virulence factors of which adherence to host constituents and the ability to transform from yeast-to-hyphae are among the most critical in determining pathogenicity. While potent antifungal agents exist that are microbicidal for *Candida*, the attributable mortality of candidemia is approximately 38%, even with treatment with potent anti-fungal agents such as amphotericin B. Also, existing agents such as amphotericin B tend to exhibit undesirable toxicity. Although additional antifungals may be developed that are less toxic than amphotericin B, it is unlikely that agents will be developed that are more potent. Therefore, either passive or active immunotherapy to treat or prevent disseminated candidiasis is a promising alternative to standard antifungal therapy.

Lethal infections of antibiotic resistant pathogenic bacteria, like infections resulting from Candida, are becoming increasingly frequent. Moreover, the risk of contracting these lethal infections is extremely high for many at-risk patients in intensive care units (ICUs) every year as well as for soldiers deployed to front line combat zones. *Acinetobacter* species are a frequent source of infection in hospitalized patients and soldiers, in particular the species *Acinetobacter baumannii*. *Acinetobacter* is a genus of gram negative bacteria belonging to the Gammaproteobacteria. *Acinetobacter* species contribute to the mineralization of aromatic compounds in the soil. Unfortunately, no technology presently exists that prevents *Acinetobacter* infections, aside from standard hand washing and other infection control practices in hospital settings.

Active and passive immunization of individuals against antibiotic resistant pathogenic bacteria presents a convenient and potentially cost effective method of trying to combat these infections. However, identifying and developing effective antigenic targets for implementation of passive and active immunizations against bacteria in general presents a difficult challenge because of the vast array of bacterial species. The identification of compounds that affect the virulence of specific bacterial families or genera provides an opportunity to develop novel therapeutic interventions. In particular, the recognition of ubiquitous cell surface proteins that are present on the bacterial families or genera that can be identified by an individual's immune system will enable immunotherapeutic techniques. These techniques will likely be superior to and also can act in synergy with antibiotics to prevent or treat bacterial infections.

There accordingly exists a need for compounds and methods that reduce the risk of infectious diseases related to Candidia and bacterial infections and provide effective therapies. The present invention satisfies this need and provides related advantages as well.

SUMMARY OF THE INVENTION

It has been discovered that fragments of the *Candida* cell surface protein Hyr1 are useful in immunizing a subject against *Candida* infections. It has also been found that Hyr1 protein combats *Acinetobacter* infections as well.

Accordingly, in a first aspect, the invention features an isolated polypeptide including the amino acid sequence of any one of SEQ ID NOs: 3-10, or a variant sequence thereof having up to three substitutions, deletions, or additions to the amino acid sequence of any one of SEQ ID NOs: 3-10, wherein the polypeptide does not include more than 20 contiguous amino acids of SEQ ID NO: 2. In some embodiments, the polypeptide includes the amino acid sequence of any one of SEQ ID NOs: 3-10. In some embodiments, the polypeptide consists of between 14 and 20 amino acids. In some embodiments, the N-terminal amino acid residue or C-terminal amino acid residue of the polypeptide is cysteine. In other embodiments, the amino acid sequence of the polypeptide includes or consists of the amino acid sequence of any one of SEQ ID NOs: 11-18.

In a second aspect, the invention features an isolated conjugate including a polypeptide of the first aspect conjugated to a carrier. For example, the carrier may be keyhole limpet hemocyanin (KLH), CRM197, or tetanus toxoid, or may be a phage, a yeast, a virus, virosome, or a recombinant virus-like particle. In some embodiments, the conjugate is a recombinant fusion protein.

In a third aspect, the invention features a vaccine including an immunogenic amount of a polypeptide of the first aspect or a conjugate of the second aspect, and a pharmaceutically acceptable excipient. In some embodiments, the vaccine includes a mixture of distinct polypeptides of the first aspect or conjugates of the second aspect. In some embodiments, the vaccine further includes an adjuvant, e.g., Alhydrogel. In some embodiments, a polypeptide of the first aspect or conjugate of the second aspect is produced synthetically or recombinantly. In some embodiments, the vaccine is for use in the vaccination of a mammal, e.g,. a human, against candidiasis or vaccinating a mammal against Acinetobacter. In some embodiments, the vaccine is to be administered by intramuscular, subcutaneous, or intradermal administration. In some embodiments, the vaccination further includes administering a booster dose. In some embodiments, the candidiasis is disseminated candidiasis, e.g., hematogenously disseminated candidiasis, or the candidiasis is mucosal candidiasis, or the candidiasis is vagina candidiasis, or the candidiasis is caused by *Candida* such a *Candida albicans*, *Candida glabrata*, *Candida krusei*, *Candida parapsilosis*, or *Candida tropicalis*.

In a fourth aspect, the invention features a method of vaccinating a mammal, e.g., a human, against candidiasis including administering to the mammal the vaccine of the third aspect, thereby vaccinating the mammal against candidiasis or vaccinating the mammal against Acinetobacter. In some embodiments, the vaccine is administered by intramuscular, subcutaneous, or intradermal administration. In some embodiments, the administering further includes administering a booster dose. In some embodiments, the candidiasis is disseminated candidiasis, e.g., hematogenously disseminated candidiasis, or the candidiasis is mucosal or vaginal candidiasis, or the candidiasis is caused by Candida such as *Candida albicans*, *Candida glabrata*, *Candida krusei*, *Candida parapsilosis*, or *Candida tropicalis*.

In a fifth aspect, the invention features a method of producing a chimeric vaccine including the steps of: (a) providing a phage, yeast, or virus; (b) inserting into the phage, yeast, or virus a nucleic acid molecule that encodes a polypeptide of the first aspect; (c) allowing expression of the polypeptide in the phage, yeast, or virus; (d) isolating the phage, yeast, or virus of step (c) including the expressed polypeptide; and (e) adding a pharmaceutically acceptable excipient to the isolated phage, yeast, or virus of step (d). In some embodiments, the polypeptide is displayed on the surface of the phage, yeast, or virus following step (c).

In a sixth aspect, the invention features an isolated monoclonal antibody that binds to a polypeptide of the first aspect or a conjugate of the second aspect. In some embodiments, the antibody is human or humanized, or is chimeric. In some embodiments, the antibody is produced recombinantly or is chemically synthesized.

In a seventh aspect, the invention features a diagnostic composition including an antibody of the sixth aspect.

In an eighth aspect, the invention features a pharmaceutical composition including an antibody of the sixth aspect and a pharmaceutically acceptable excipient. In some embodiments, the pharmaceutical composition includes a mixture of antibodies of the sixth aspect with a plurality of distinct specificities.

In a ninth aspect, the invention features a pharmaceutical composition including polyclonal antibodies that bind to a polypeptide of the first aspect or a conjugate of the second aspect, or that bind to a mixture of distinct polypeptides of the first aspect or conjugates of the second aspect.

In some embodiments of the eighth or ninth aspect, the pharmaceutical composition is for use in the passive immunization of a mammal, e.g., a human, against candidiasis or a human, against Acinetobacter. For example, the pharmaceutical composition may be administered by intramuscular, subcutaneous, or intradermal administration. In some embodiments, the candidiasis is disseminated candidiasis, e.g., hematogenously disseminated candidiasis, or the candidiasis is mucosal such as vaginal candidiasis, or the candidiasis is caused by *Candida* such as *Candida albicans*, *Candida glabrata*, *Candida krusei*, *Candida parapsilosis*, or *Candida tropicalis*.

In a tenth aspect, the invention features a method of passive immunization of a mammal, e.g., a human, against candidiasis including administering to the mammal an effective amount of a pharmaceutical composition of the eighth or ninth aspect, thereby passively immunizing the mammal against the candidiasis or against Acinetobacter. In some embodiments, the pharmaceutical composition is administered by intramuscular, subcutaneous, or intradermal administration or even intranasally. In some embodiments, the candidiasis is disseminated candidiasis, e.g., hematogenously disseminated candidiasis, or the candidiasis is mucosal candidiasis such as vaginal candidiasis, or the candidiasis is caused by *Candida* such as *Candida albicans*, *Candida glabrata*, *Candida krusei*, *Candida parapsilosis*, or *Candida tropicalis*.

In still other aspects, the invention features compositions and methods as disclosed herein that are based, at least in part, on the identification that an immune response, such as antibodies and other mechanisms, that target the *Candida* HYR1 polypeptide and confer protection from *Acinetobacter* infection such as *Acinetobacter baumannii*. Active or passive immunization approaches using the HYR1 polypeptide or specific *Acinetobacter baumannii* proteins disclosed herein are useful to protect against infections caused by gram negative rod bacteria, including, but not limited to, *Acinetobacter baumannii*. Some uses of the compositions and methods disclosed herein include passive vaccination of acutely at-risk patients with a dose of anti-HYRl antibody to prevent the acquisition of *Acinetobacter baumannii* infection. Additionally, patients with active *Acinetobacter baumannii* infection can be treated with the antibody alone or combined with other antibacterial agents. Alternatively, patients who are at risk of developing such infections, such as, for example, military personnel, can be actively vaccinated with a

HYR1 polypeptides or specific *Acinetobacter baumannii* polypeptides disclosed herein to prevent such infections.

In other aspects, the invention, in this context, features passive or active vaccination as disclosed herein having the ability to markedly reduce the acquisition of drug-resistant, lethal *Acinetobacter baumannii* infection. Because there presently are no antibiotics with activity against the *Acinetobacter* genus, prevention of such infections is of paramount concern. Additionally, the vaccine and pharmaceutical compositions disclosed herein have potential to work against other infections caused by gram negative rods because the passive and active strategies provided by the invention are raised against a xeno-antigen from *Candida albicans* that has considerable structural homology to gram negative rod antigens including those from *Acinetobacter baumannii* origin. The use of a non-*Acinetobacter* antigen to protect against *Acinetobacter* infection provides a major advantage to combat infection.

The invention therefore provides an active vaccination useful to prevent infections in hospitalized patients using a HYR1 polypeptide or fragment thereof or *Acinetobacter baumannii* proteins disclosed herein. The invention also provides methods and compositions for active vaccination to prevent *Acinetobacter* infection in military personnel, which is highly desirable since *Acinetobacter* is one of the most common causes of combat wound infections. The invention still further provides methods and compositions for passive immunization as an adjunct therapy for active infection using an antibody, either polyclonal or monoclonal, raised against an HYR1 polypeptide or *Acinetobacter baumannii* proteins disclosed herein. Still further, the invention provides a diagnostic biomarker, by antibody or PCR detection, to determine the presence of *Acinetobacter* in infected fluids or tissues. The invention also provides that the above applications can extended to other medically important gram negative bacteria.

In other aspects, the invention relates to nucleic acids that encode specific HYR1 polypeptides or fragments thereof that can act as antigens for generating an immune response to gram negative bacteria, including bacteria of the *Acinetobacter* genus, for example, *Acinetobacter baumannii*.

For example, in some aspects of the invention, the nucleic acids of the invention encode an HYR1 polypeptide comprising an amino acid sequence selected from one of more of SEQ ID NOS:3-10 or from one or more of CGPSAPESESDLNTP (SEQ ID NO: 11), CGNRDHFRFEYYPDT (SEQ ID NO: 12), CGYDSKLFRIVNSRG (SEQ ID NO: 13), CKIKGTGCVTADEDT (SEQ ID NO: 14), CLKNAVTYDGPVPNN (SEQ ID NO: 15), NSKSSTSFSNFDIGC (SEQ ID NO: 16), CEPTHNFYLKDSKSS (SEQ ID NO: 17), and TSRIDRGGIQGFHGC (SEQ ID NO: 18). Moreover, in some aspects of the invention, the HYR1 polypeptide can comprise less than 937, 936, 935, 934, 933, 932, 931, 930, 920, 910, 900, 890, 880, 870, 860, 850, 840, 830, 820, 810, 800, 790, 780, 770, 760, 750, 740, 730, 720, 710, 700, 690, 680, 670, 660, 650, 640, 630, 620, 610, 600, 590, 580, 570, 560, 550, 540, 530, 520, 510, 500, 490, 480, 470, 460, 450, 440, 430, 420, 410, 400, 390, 380, 370, 360, 350, 340, 320, 310, 300, 290, 280, 270, 260, 250, 240, 230, 220, 210, 200, 190, 180, 170, 160, 150, 140, 130, 120, 110, 100, 90, 80, 70, 60, 50, 40, 30 or 20 amino acid residues in length and can be immunogenic. In some aspects of the invention, the nucleic acids of the invention do not encode the HYR1 polypeptide of SEQ

ID NOS: 1 or 2. Still in other aspects, nucleic acids encode any one of SEQ ID NOS:3-10 or 11-18 alone or in combination.

The invention also provides embodiments wherein the nucleic acid sequence encodes more than one amino acid sequence set forth in any one of SEQ ID NOS: 3-10 or SEQ ID NOS: 11-18 alone or in combination. For example, a nucleic acid sequence of the invention can encode two amino acid sequences such as SEQ ID NO: 15 in combination with SEQ ID NO: 12, or alternatively SEQ ID NO: 11 in combination with SEQ ID NO: 17, or alternatively SEQ ID NO: 13 in combination with SEQ ID NO: 18. It is understood that the nucleic acids of the invention can encode two, three, four, five, six, seven or all eight amino acid sequence selected from SEQ ID NOS: 11-18. It is also understood that the encoded amino acid sequence need not be contiguous and can be linked by intervening spacer sequences, which can, for example, allow for the expressed polypeptide to present the desired amino acid sequence or epitope for generating an immune response.

In some aspects of the invention, the amino acid sequence encoded by the nucleic acids of the invention comprises substantially the same amino acid sequence set forth in any one of SEQ ID NOS: 3-10 or SEQ ID NOS: 11-18. For example, the amino acid sequence can have at least 65%, 70%, 75%, 80%, 85%, 90%, 95%, 98% or 99% sequence identity to any one of SEQ ID NOS: 3-10 or 11-18, wherein the polypeptide can be bound by an anti-HYR1 antibody disclosed herein. In other aspects, the HYR1 polypeptide expressed by the nucleic acids of the invention can be immunogenic and capable of eliciting production of an anti-HYR1 antibody or immunogenic response in a subject.

When incorporated into a variety of protein expression systems known to those of skill in the art, the nucleic acid molecules described herein are useful for producing polypeptide(s) of the invention. In addition, such nucleic acid molecules or fragments thereof can be labeled with a readily detectable substituent and used as hybridization probes for assaying for the presence and/or amount of a gram negative bacteria such as, for example, *Acinetobacter baumannii* in a given sample. The nucleic acid molecules described herein, and fragments thereof, are also useful as primers and/or templates in a PCR reaction for amplifying nucleic acids encoding invention polypeptides or proteins described herein.

The invention also provides vectors containing the nucleic acids of the invention. Suitable expression vectors are well-known in the art and include vectors capable of expressing a nucleic acid operatively linked to a regulatory sequence or element such as a promoter region or enhancer region that is capable of regulating expression of the nucleic acid. Appropriate expression vectors include vectors that are replicable in eukaryotic cells and/or prokaryotic cells and vectors that remain episomal or integrate into the host cell genome.

In other aspects, the invention additionally provides an isolated anti-*Acinetobacter* protein antibody. An "anti-*Acinetobacter* protein antibody" recognizes at least one protein, or fragment thereof, that naturally occurs in *Acinetobacter baumannii*. An anti-HYR1 antibody of the invention, which has specific reactivity to an HYR1 polypeptide disclosed herein, is one example of an anti-*Acinetobacter* protein antibody. As disclosed herein, specific *Acinetobacter baumannii* proteins have been identified that bind to antibodies raised against a HYR1 polypeptide having the amino acid sequence of SEQ ID NO: 15. These *Acinetobacter baumannii* proteins include an outer membrane protein 1 of *Acinetobacter baumannii*, an outer membrane protein 2 of *Acinetobacter baumannii*, an ferric siderophore receptor protein of *Acinetobacter baumannii*, an Dnak heat shock protein of *Acinetobacter baumannii*, an elongation factor G of *Acinetobacter baumannii*, an organic solvent tolerance protein precursor of *Acinetobacter baumannii*, a putative lipoprotein precursor (VacJ) transmembrane of *Acinetobacter baumannii*, a putative glucose-sensitive porin (OprB-like) of *Acinetobacter baumannii*, an AdeA membrane fusion protein of *Acinetobacter baumannii*, a cell division protein of *Acinetobacter baumannii*, or a cell division protein FtsZ of *Acinetobacter baumannii*. The anti-*Acinetobacter* protein antibody of the invention can be a monoclonal antibody or a polyclonal antibody. The invention further provides cell lines producing monoclonal antibodies having specific reactivity with a HYR1 polypeptide fragment disclosed herein, an outer membrane protein 1 of *Acinetobacter baumannii*, an outer membrane protein 2 of *Acinetobacter baumannii*, an ferric siderophore receptor protein of *Acinetobacter baumannii*, an Dnak heat shock protein of *Acinetobacter baumannii*, an elongation factor G of *Acinetobacter baumannii*, an organic solvent tolerance protein precursor of *Acinetobacter baumannii*, a putative lipoprotein precursor (VacJ) transmembrane of *Acinetobacter baumannii*, a putative glucose-sensitive porin (OprB-like) of *Acinetobacter baumannii*, an AdeA membrane fusion protein of *Acinetobacter baumannii*, a cell division protein of *Acinetobacter baumannii*, or a cell division protein FtsZ of *Acinetobacter baumannii*.

In other aspects, the invention further provides a method of diagnosing *Acinetobacter* infection in a subject. These methods can include the steps of: (a) providing a test sample from the subject; (b) contacting the sample with an agent that can bind an isolated nucleic acid that encodes an *Acinetobacter* protein disclosed herein or an *Acinetobacter* protein disclosed herein under suitable conditions; and (c) comparing the amount of the specific binding in the test sample with the amount of specific binding in a control sample, wherein an increased or decreased amount of the specific binding in the test sample as compared to the control sample is diagnostic of *Acinetobacter* infection. The conditions used in the methods of the invention are understood to allow specific binding of the agent to the nucleic acid or protein.

As described herein, *Acinetobacter* proteins encoded by the isolated nucleic acids of the method include an outer membrane protein 1 of *Acinetobacter baumannii*, an outer membrane protein 2 of *Acinetobacter baumannii*, an ferric siderophore receptor protein of *Acinetobacter baumannii*, an Dnak heat shock protein of *Acinetobacter baumannii*, an elongation factor G of *Acinetobacter baumannii*, an organic solvent tolerance protein precursor of *Acinetobacter baumannii*, a putative lipoprotein precursor (VacJ) transmembrane of *Acinetobacter baumannii*, a putative glucose-sensitive porin (OprB-like) of *Acinetobacter baumannii*, an AdeA membrane fusion protein of *Acinetobacter baumannii*, a cell division protein of *Acinetobacter baumannii*, or a cell division protein FtsZ of *Acinetobacter baumannii*.

Agents that can be used in the methods of the invention include an anti-*Acinetobacter* protein antibody as disclosed herein or an oligonucleotide comprising between 15 to 300 contiguous nucleotides that encode an outer membrane protein 1 of *Acinetobacter baumannii*, an outer membrane protein 2 of *Acinetobacter baumannii*, an ferric siderophore receptor protein of *Acinetobacter baumannii*, an Dnak heat shock protein of *Acinetobacter baumannii*, an elongation factor G of *Acinetobacter baumannii*, an organic solvent tolerance protein precursor of *Acinetobacter baumannii*, a putative lipoprotein precursor (VacJ) transmembrane of *Acinetobacter baumannii*, a putative glucose-sensitive porin (OprB-like) of *Acinetobacter baumannii*, an AdeA membrane fusion protein of *Acinetobacter baumannii*, a cell division protein of *Acinetobacter baumannii*, or a cell division protein FtsZ of *Acinetobacter baumannii*.

The invention additionally provides oligonucleotides comprising between 15 and 300 contiguous nucleotides that encode a portion of an outer membrane protein 1 of *Acinetobacter baumannii*, an outer membrane protein 2 of *Acinetobacter baumannii*, an ferric siderophore receptor protein of *Acinetobacter baumannii*, an Dnak heat shock protein of *Acinetobacter baumannii*, an elongation factor G of *Acinetobacter baumannii*, an organic solvent tolerance protein precursor of *Acinetobacter baumannii*, a putative lipoprotein precursor (VacJ) transmembrane of *Acinetobacter baumannii*, a putative glucose-sensitive porin (OprB-like) of *Acinetobacter baumannii*, an AdeA membrane fusion protein of *Acinetobacter baumannii*, a cell division protein of *Acinetobacter baumannii*, or a cell division protein FtsZ of *Acinetobacter baumannii*. As used herein, the term "oligonucleotide" refers to a nucleic acid molecule that includes at least 15 contiguous nucleotides from a reference nucleotide sequence, and can include at least 16, 17, 18, 19, 20 or at least 25 contiguous nucleotides, and often includes at least 30, 40, 50, 60, 70, 80, 90, 100, 125, 150, 175, 200, 225, 250, 275, 300, 325, up to 350 contiguous nucleotides from the reference nucleotide sequence. The reference nucleotide sequence can be the sense strand or the anti-sense strand.

The isolated nucleic acid molecules of the invention can be used in a variety of diagnostic and therapeutic applications. For example, the isolated nucleic acid molecules of the invention can be used as probes and primers. The invention thus provides methods for detecting nucleic acid in a sample. The methods of detecting nucleic acid in a sample can be either qualitative or quantitative, as desired. For example, the presence, abundance, integrity or structure of a can be determined, as desired, depending on the assay format and the probe used for hybridization or primer pair chosen for application.

Accordingly, in some embodiments, the invention provides a method of detecting *Acinetobacter* nucleic acid molecules in a sample, comprising contacting the sample with two or more oligonucleotides comprising between 15 to 300 contiguous nucleotides that encode a portion of an outer membrane protein 1 of *Acinetobacter baumannii*, an outer membrane protein 2 of *Acinetobacter baumannii*, an ferric siderophore receptor protein of *Acinetobacter baumannii*, an Dnak heat shock protein of *Acinetobacter baumannii*, an elongation factor G of *Acinetobacter baumannii*, an organic solvent tolerance protein precursor of *Acinetobacter baumannii*, a putative lipoprotein precursor (VacJ) transmembrane of *Acinetobacter baumannii*, a putative glucose-sensitive porin (OprB-like) of *Acinetobacter baumannii*, an AdeA membrane fusion protein of *Acinetobacter baumannii*, a cell division protein of *Acinetobacter baumannii*, or a cell division protein FtsZ of *Acinetobacter baumannii*, amplifying a nucleic acid molecule, and detecting said amplification. In some aspects of the invention, the amplification is performed using polymerase chain reaction. Thus, in some aspects, the invention provides a kit for detecting the presence of *Acinetobacter* in a sample comprising at least one oligonucleotide comprising between 15 to 300 contiguous nucleotides that encode a portion of an outer membrane protein 1 of *Acinetobacter baumannii*, an outer membrane protein 2 of *Acinetobacter baumannii*, an ferric siderophore receptor protein of *Acinetobacter baumannii*, an Dnak heat shock protein of *Acinetobacter baumannii*, an elongation factor G of *Acinetobacter baumannii*, an organic solvent tolerance protein precursor of *Acinetobacter baumannii*, a putative lipoprotein precursor (VacJ) transmembrane of *Acinetobacter baumannii*, a putative glucose-sensitive porin (OprB-like) of *Acinetobacter baumannii*, an AdeA membrane fusion protein of *Acinetobacter baumannii*, a cell division protein of *Acinetobacter baumannii*, or a cell division protein FtsZ of *Acinetobacter baumannii*.

In some embodiments of the invention, a kit is also provided for detecting the presence of *Acinetobacter* in a sample comprising an isolated anti-*Acinetobacter* protein antibody as disclosed herein.

Thus, in accordance with embodiments of the present invention, diagnostic systems, in kit form, are provided comprising at least one invention nucleic acid or antibody in a suitable packaging material. The diagnostic kits containing nucleic acids are derived from the encoding nucleic acids described herein. In one embodiment, for example, the diagnostic nucleic acids are derived from any portion of a nucleic acid sequence encoding of an outer membrane protein 1 of *Acinetobacter baumannii*, an outer membrane protein 2 of *Acinetobacter baumannii*, an ferric siderophore receptor protein of *Acinetobacter baumannii*, an Dnak heat shock protein of *Acinetobacter baumannii*, an elongation factor G of *Acinetobacter baumannii*, an organic solvent tolerance protein precursor of *Acinetobacter baumannii*, a putative lipoprotein precursor (VacJ) transmembrane of *Acinetobacter baumannii*, a putative glucose-sensitive porin (OprB-like) of *Acinetobacter baumannii*, an AdeA membrane fusion protein of *Acinetobacter baumannii*, a cell division protein of *Acinetobacter baumannii*, or a cell division protein FtsZ of *Acinetobacter baumannii*, or any one of the oligonucleotides of the invention. Invention diagnostic systems are useful for assaying for the presence or absence of nucleic acid in either genomic DNA or mRNA.

A suitable diagnostic system includes at least one invention nucleic acid or antibody, and a separately packaged chemical reagent(s) in an amount sufficient for at least one assay. For a diagnostic kit containing nucleic acids of the invention, the kit will generally contain two or more nucleic acids. When the diagnostic kit is to be used in PCR, the kit will contain at least two oligonucleotides that can serve as primers for PCR. Those of skill in the art can readily incorporate invention nucleic probes and/or primers or invention antibodies into kit form in combination with appropriate buffers and solutions for the practice of the invention methods as described herein. A kit containing an antibody can contain a reaction cocktail that provides the proper conditions for performing an assay, for example, an ELISA or other immunoassay, for determining the level of expression of a polypeptide in a sample, and can contain control samples that contain known amounts of the polypeptide and, if desired, a second antibody specific for the antibody.

The contents of the kit of the invention, for example, nucleic acids or antibodies, are contained in packaging material, preferably to provide a sterile, contaminant-free environment. In addition, the packaging material contains instructions indicating how the materials within the kit can be employed both to detect the presence or absence of a particular sequence or protein or to diagnose the presence of, or a predisposition for a condition associated with bacterial infection. The instructions for use typically include a tangible expression describing the reagent concentration or at least one assay method parameter, such as the relative amounts of reagent and sample to be admixed, maintenance time periods for reagent/sample admixtures, temperature, buffer conditions, and the like.

By “adjuvant” is meant one or more substances that cause stimulation of the immune system. In this context, an adjuvant is used to enhance an immune response to one or more vaccine antigens or antibodies. An adjuvant may be administered to a subject before, in combination with, or after administration of the vaccine or antibody. Examples of chemical compounds used as adjuvants include, but are not limited to, aluminum compounds (e.g., alum, Alhydrogel), oils, block polymers, immune stimulating complexes, vitamins and minerals (e.g., vitamin E, vitamin A, selenium, and vitamin B12), Quil A (saponins), bacterial and fungal cell wall components (e.g., lipopolysaccarides, lipoproteins, and glycoproteins), hormones, cytokines, and co-stimulatory factors. Other exemplary adjuvants include, for example, Freud’s complete adjuvant, Freud’s incomplete adjuvant, aluminum adjuvants, MF59, QS21 an immune modulating adjuvant such as a toxin, a cytokine, and a mycobacterial derivative; an oil formulation, a polymer, a micelle forming adjuvant, a saponin, an immunostimulating complex matrix (ISCOM® matrix), a particle, DDA (dimethyldioctadecylammonium bromide, DNA adjuvants, and an encapsulating adjuvant. Liposome formulations are also known to confer adjuvant effects, and therefore liposome adjuvants are included according to the invention. Adjuvants can facilitate uptake of the vaccine molecules by antigen presenting cells (APCs), such as dendritic cells, and activate these cells. An adjuvant’s ability to increase an immune response is manifested by an increase in immune mediated protection. Enhancement of humoral immunity can be determined by, for example, an increase in the titer of antibody raised to the antigen. Enhancement of cellular immunity can be measured by, for example, a positive skin test, cytotoxic T-cell assay, ELISPOT assay for IFN-gamma or IL-2.

By “antibody” is meant whole antibodies, immunoglobulins, or any antigen-binding fragment or single chains thereof. Antibodies, as used herein, can be mammalian (e.g., human or mouse), humanized, chimeric, recombinant, synthetically produced, or naturally isolated, and can be, e.g., monoclonal or polyclonal. In most mammals, including humans, whole antibodies have at least two heavy (H) chains and two light (L) chains connected by disulfide bonds. Each heavy chain consists of a heavy chain variable region (abbreviated herein as V_H) and a heavy chain constant region. The heavy chain constant region consists of three domains, C_H1, C_H2, and C_H3 and a hinge region between C_H1 and C_H2. Each light chain consists of a light chain variable region (abbreviated herein as V_L) and a light chain constant region. The light chain constant region consists of one domain, C_L. The V_H and V_L regions can be further subdivided into regions of hypervariability, termed complementarity determining regions (CDR), interspersed with regions that are more conserved, termed framework regions (FR). Each V_H and V_L is composed of three CDRs and four FRs, arranged from amino-terminus to carboxy-terminus in the following order: FR1, CDR1, FR2, CDR2, FR3, CDR3, FR4. The variable regions of the heavy and light chains contain a binding domain that interacts with an antigen. The constant regions of the antibodies may mediate the binding of the immunoglobulin to host tissues or factors, including various cells of the immune system (*e.g.*, effector cells) and the first component (Clq) of the classical complement system.

Antibodies of the present invention include all known forms of antibodies and other protein scaffolds with antibody-like properties. For example, the antibody can be a human antibody, a humanized antibody, a bispecific antibody, a chimeric antibody, or a protein scaffold with antibody-like properties, such as fibronectin or ankyrin repeats. The antibody also can be a Fab, Fab'2, scFv, SMIP, diabody, nanobody, aptamers, or a domain antibody. The antibody can have any of the following isotypes: IgG (e.g., IgG1, IgG2, IgG3, and IgG4), IgM, IgA (e.g., IgA1, IgA2, and IgAsec), IgD, or IgE.

The term "antibody fragment," as used herein, refers to one or more fragments of an antibody that retain the ability to specifically bind to an antigen. The antigen-binding function of an antibody can be performed by fragments of a full-length antibody, which include but are not limited to: (i) a Fab fragment, a monovalent fragment consisting of the V_L, V_H, C_L, and C_H1 domains; (ii) a $F(ab')_2$ fragment, a bivalent fragment comprising two Fab fragments linked by a disulfide bridge at the hinge region; (iii) a Fd fragment consisting of the V_H and C_H1 domains; (iv) a Fv fragment consisting of the V_L and V_H domains of a single arm of an antibody, (v) a dAb including V_H and V_L domains; (vi) a dAb fragment (Ward *et al., Nature* 341:544-546 (1989)), which consists of a V_H domain; (vii) a dAb which consists of a V_H or a V_L domain; (viii) an isolated complementarity determining region (CDR); and (ix) a combination of two or more isolated CDRs which may optionally be joined by a synthetic linker. Furthermore, although the two domains of the Fv fragment, V_L and V_H, are coded for by separate genes, they can be joined, using recombinant methods, by a synthetic linker that enables them to be made as a single protein chain in which the V_L and V_H regions pair to form monovalent molecules (known as single chain Fv (scFv); see *e.g.*, Bird *et al., Science* 242:423-426 (1988) and Huston *et al., Proc. Natl. Acad. Sci. USA* 85:5879-5883 (1988)). These antibody fragments are obtained using conventional techniques known to those with skill in the art, and the fragments are screened for utility in the same manner as are intact antibodies. Antibody fragments can be produced by recombinant DNA techniques, or by enzymatic or chemical cleavage of intact immunoglobulins.

By "antigen" is meant a molecule to which an antibody can selectively bind. The target antigen may be a protein (e.g., an antigenic peptide), carbohydrate, nucleic acid, lipid, hapten, or other naturally occurring or synthetic compound. The target antigen may be a polypeptide or peptide mimic. An antigen may also be administered to an animal to generate an immune response in the animal.

By “carrier” in the context of a conjugate is meant a moiety or particle, e.g., KLH, CRM197, tetanus toxoid, a phage, a yeast, a virus, a virosome, or a recombinant virus-like particle, that is suitable for being linked to or displaying a polypeptide as described herein.

By “chimeric antibody” is meant an immunoglobulin or antibody whose variable regions derive from a first species and whose constant regions derive from a second species. Chimeric antibodies can be constructed, for example, by genetic engineering, from immunoglobulin gene segments belonging to different species (e.g., from a mouse and a human).

By “chimeric vaccine” is meant a vaccine that includes at least two distinct antigens, e.g., joined covalently. An example of a chimeric vaccine is a composition that includes a polypeptide displayed, e.g., on the surface of a particle such as a phage, virus, yeast, virosome, or recombinant virus-like particle.

By “conjugate” is meant a compound that includes a polypeptide of the invention linked to another moiety or particle, e.g., KLH, CRM197, tetanus toxoid, a phage, a yeast, a virus, a virosome, or a recombinant virus-like particle.

By “conservative substitution” in an amino acid sequence is meant replacement of an amino acid for another within a family of amino acids that are related in the chemical nature of their side chains.

Genetically encoded amino acids can be divided into four families: acidic (aspartate, glutamate); basic (lysine, arginine, histidine); nonpolar (alanine, valine, leucine, isoleucine, proline, phenylalanine, methionine, tryptophan); and uncharged polar (glycine, asparagine, glutamine, cysteine, serine, threonine, tyrosine). Phenylalanine, tryptophan, and tyrosine are sometimes grouped as aromatic amino acids. In similar fashion, the amino acids can also be separated into the following groups: acidic (aspartate, glutamate); basic (lysine, arginine, histidine); alipathic (glycine, alanine, valine, leucine, isoleucine, serine, threonine), with serine and threonine optionally grouped separately as alipathic-hydroxyl; aromatic (phenylalanine, tyrosine, tryptophan); amide (asparagine, glutamine); and sulfur-containing (cysteine, methionine).

Whether a change in the amino acid sequence results in a functional variant can be determined by assessing the ability of the variant polypeptide to function in a fashion similar to the wild-type polypeptide using standard methods such as those described herein.

By “diagnostic composition” is meant a composition containing a polypeptide, conjugate, vaccine, or antibody of the invention, formulated for use in conjunction with a diagnostic method.

By “effective amount” in the context of passive immunization using a pharmaceutical composition, e.g., comprising an antibody, is meant the amount of the pharmaceutical composition required to passively immunize in a clinically relevant manner. An effective amount of pharmaceutical composition used to practice the methods of passive immunization described herein varies depending upon the manner of administration, the age, body weight, and general health of the subject. Ultimately, the prescribers will decide the appropriate amount and dosage regimen.

By “flanking amino acid” is meant an amino acid in a polypeptide sequence that is immediately adjacent to the N- or C-terminus of a particular defined sequence. Desirably, a flanking amino acid is present on the N- and/or C-terminus of the amino acid sequence of SEQ ID NO: 1 or 2 or a fragment thereof; and more desirably, 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 flanking amino acids are present at the N- and/or C-terminus of the amino acid sequence of SEQ ID NO: 1 or 2, or fragment thereof.

By “fusion protein” is meant a protein that includes a polypeptide of the invention, e.g., a HYR1 fragment or variant, and a fusion partner.

By “fusion partner” is meant a heterologous sequence that can be fused to a polypeptide of the invention, e.g., a HYR1 fragment or variant. Examples of fusion partners are described herein and include detection markers, stabilizing domains, sequences which aid in production or purification of the protein, or domains which increase the antigenicity of the polypeptide.

By “HYR1 polypeptide” is meant a polypeptide that is substantially identical to the amino acid sequence of SEQ ID NO: 1. Desirably, a HYR1 polypeptide has at least 70, 75%, 80%, 85%, 90%, 95%, 99%, or even 100% identity to the amino acid sequence of SEQ ID NO: 1.

By “HYR1 fragment” or “fragment of a HYR1 polypeptide” is meant a portion of a HYR1 polypeptide containing fewer than 937, 936, or 935 amino acids. In some embodiments, HYR1 fragments are between 300 and 350 or 250 to 500 amino acids in length. In some embodiments, the fragment is fewer than 937, 936, 935, 934, 933, 932, 931, or 930, 920, 910, 900, 890, 880, 870, 860, 850, 840, 830, 820, 810, 800, 790, 780, 770, 760, 750, 740, 730, 720, 710, 700, 690, 680, 670, 660, 650, 640, 630, 620, 610, 600, 590, 580, 570, 560, 550, 540, 530, 520, 510, 500, 490, 480, 470, 460, 450, 440, 430, 420, 410, 400, 390, 380, 370, 360, 350, 340, 330, 320, 310, 300, 290, 280, 270, 260, 250, 240, 230, 220, 210, 200, 190, 180, 170, 160, 150, 140, 130, 120, 110, 100, 90, 80, 70, 60, 50, 40, 30, 25, 20, 15, or 10 amino acids, and, in some instances, is immunogenic.

An exemplary HYR1 fragment is Hyr1p-N (SEQ ID NO: 2), or a fragment thereof. In some instances, Hyr1p-N fragments are between 14 and 20 amino acids in length. In general, the fragment may be fewer than, e.g., 325, 320, 310, 300, 290, 280, 270, 260, 250, 240, 230, 220, 210, 200, 190, 180, 170, 160, 150, 140, 130, 120, 110, 100, 90, 80, 70, 60, 50, 40, 30, 25, 20, 19, 18, 17, 16, 15, 14, 13, 12, or 11 amino acids, and desirably, is immunogenic. In some instances, a Hyr1p-N fragment is between 14 and 20 amino acids.

In addition, HYR1 fragments, for example, may contain one or more conservative amino acid substitutions in the sequence of SEQ ID NO: 2. Additional desirable HYR1 fragments contain one or more conservative amino acid substitutions in the sequence of SEQ ID NO: 2 and/or at least one flanking amino acid (e.g., 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 flanking amino acids) at the N- and/or C-terminus of the sequence of SEQ ID NO: 2. Other preferred HYR1 fragments contain seven or more continuous amino acids of the sequence of SEQ ID NO: 2.

Non-limiting examples of a HYR1 fragment include amino acids 1-40, 10-50, 20-60, 30-70, 40-80, 50-90, 60-100, 70-110, 80-120, 90-130, 100-140, 110-150, 120-160, 130-170, 140-180, 150-190, 160-200, 170-210, 180-220, 190-230, 200-240, 210-250, 220-260, 230-270, 240-280, 250-290, and 260-300, 270-310, 280-320, and 290-331 amino acids of the sequence of SEQ ID NO: 2; and these fragments having one or more of the following features: one or more conservative amino acid substitutions (e.g., 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, or 16 conservative amino acid substitutions) in the sequence of SEQ ID NO: 2; one or more amino acids (e.g., 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, or 16 amino acids) truncated from the N and/or C-terminus of the sequence of SEQ ID NO: 2; and at least one flanking amino acid (e.g., 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 flanking amino acids) at the N- and/or C-terminus of the sequence of SEQ ID NO: 2.

By "immunogenic" is meant any substance that is capable of inducing an immune response in a subject.

By "immunogenic amount" in the context of a vaccine is meant an amount of the vaccine required to induce an immune response in a subject in a clinically relevant manner. An immunogenic amount of vaccine used to practice the methods of vaccination as described herein varies depending upon the manner of administration, the age, body weight, and general health of the subject. Ultimately, the prescribers will decide the appropriate amount and dosage regimen.

The term "immunogenic amount" as used herein refers an effective amount of a particular polypeptide of the invention or a fragment thereof that can induce the host immune response against the polypeptide or the infectious agent expressing the polypeptide. This amount is generally in the range of 20 μg to 10 mg of antigen per dose of vaccine and depends on the subject to be treated, capacity of the subject's immune system to synthesize antibodies, and the degree of protection desired. The precise amount of immunogenic required can be calculated by various methods such as, for example, antibody titration. The term effective amount refers to an amount of a compound or compositions that is sufficient to provide a desired result. Thus, as used to describe a vaccine, an effective amount refers to an amount of a compound or composition (e.g., an antigen) that is sufficient to produce or elicit a protective immune response. An effective amount with respect to an immunological composition is an amount that is sufficient to elicit an immune response, whether or not the response is protective.

By "isolated" or "purified" is meant separated from other naturally accompanying components. Typically, a compound (e.g., nucleic acid, polypeptide, antibody, or small molecule) is substantially isolated when it is at least 60%, by weight, free from the proteins and/or naturally occurring organic molecules with which it is naturally associated. The definition also extends, e.g., to a polypeptide or nucleic acid molecule separated from its flanking sequences (e.g., for an amino acid sequence, isolated refers to a sequence that is free from the flanking amino acids with which the sequence is naturally associated in a polypeptide). In some instances, the compound is at least 75%, more preferably at least 90%, and most preferably at least 99%, by weight, isolated. An isolated compound, e.g., polypeptide, may be obtained by standard techniques, for example, by extraction from a natural source (e.g., purification from a cell infected with *Candida*); by expression of a recombinant nucleic acid encoding a HYR1 fragment or variant, or a fusion protein thereof; or by chemically synthesizing the polypeptide.

Purity can be measured by any appropriate method, e.g., by column chromatography, polyacrylamide gel electrophoresis, or HPLC analysis. Use of the terms "isolated" and/or "purified" in the present specification and claims as a modifier of DNA, RNA, polypeptides or proteins means that the DNA, RNA, polypeptides or proteins so designated have been produced in such form by the hand of man, and thus are separated from their native *in vivo* cellular environment.

By "linked to" or "conjugated to" in the context of a conjugate is meant a covalent or non-covalent interaction between the polypeptide and the carrier or fusion partner. Non-covalent interactions include, but are not limited to, hydrogen bonding, ionic interactions among charged groups, electrostatic binding, van der Waals interactions, hydrophobic interactions among non-polar groups, lipophobic interactions, and LogP-based attractions.

By "monoclonal antibody" is meant an antibody obtained from a population of substantially homogeneous antibodies, i.e., the individual antibodies comprising the population are identical except for possible naturally occurring mutations that may be present in minor amounts. Monoclonal antibodies are highly specific, being directed against a single antigenic site. Furthermore, in contrast to conventional (polyclonal) antibody preparations which typically include different antibodies directed against different determinants (epitopes), each monoclonal antibody is directed against a single determinant on the antigen. Monoclonal antibodies can be prepared using any art recognized technique and those described herein such as, for example, a hybridoma method, as described by Kohler *et al.*, *Nature* 256:495 (1975), a transgenic animal (*e.g.*, Lonberg *et al., Nature* 368(6474):856-859 (1994)), recombinant DNA methods (*e.g.*, U.S. Pat. No. 4,816,567), or using phage, yeast, or synthetic scaffold antibody libraries using the techniques described in, for example, Clackson *et al.*, *Nature* 352:624-628 (1991) and Marks *et al., J. Mol. Biol.* 222:581-597 (1991).

By "nucleic acid molecule" is meant a molecule, e.g., RNA or DNA, having a sequence of two or more covalently bonded, naturally occurring or modified nucleotides. The nucleic acid molecule may be, e.g., single or double stranded, and may include modified or unmodified nucleotides, or mixtures or combinations thereof. Various salts, mixed salts, and free acid forms are also included.

The term "nucleic acid", also referred to as polynucleotides, encompasses ribonucleic acid (RNA) or deoxyribonucleic acid (DNA), probes, oligonucleotides, and primers and can be single stranded or double stranded. DNA can be either complementary DNA (cDNA) or genomic DNA, and can represent the sense strand, the anti-sense strand or both. Examples of nucleic acids are RNA, cDNA, or isolated genomic DNA. Such nucleic acids include, but are not limited to, nucleic acids comprising substantially the same nucleotide sequences as described herein.

By "patient" or "subject" is meant a mammal, including, but not limited to, a human or non-human mammal, such as a bovine, equine, canine, ovine, or feline. A "subject," "individual" or "patient" is used interchangeably herein, and refers to a vertebrate, preferably a mammal, more preferably a human. Mammals include, but are not limited to, murines, rats, rabbits, simians, bovines, ovines, porcines, canines, felines, farm animals, sport animals, pets, equines, and primates, particularly humans.

The terms "pharmaceutically acceptable carrier" and "pharmaceutically acceptable excipient" are used interchangeably and mean a carrier or excipient that is physiologically acceptable to the treated patient while retaining the therapeutic properties of the compound with which it is administered. One exemplary pharmaceutically acceptable carrier substance is physiological saline. Other physiologically acceptable carriers and their formulations are known to those skilled in the art and described, for example, in Remington's Pharmaceutical Sciences, (20^{th} edition), ed. A. Gennaro, 2000, Lippincott, Williams & Wilkins, Philadelphia, PA.

By "pharmaceutical composition" is meant a composition containing a polypeptide, conjugate, vaccine, or antibody of the invention, formulated with a pharmaceutically acceptable excipient, and manufactured or sold with the approval of a governmental regulatory agency as part of a therapeutic regimen for the treatment or prevention of a disease or event in a mammal. Pharmaceutical compositions can be formulated, for example, for intravenous administration (e.g., as a sterile solution free of particulate emboli and in a solvent system suitable for intravenous use), for oral administration (e.g., a tablet, capsule, caplet, gelcap, or syrup), or any other formulation described herein, e.g., in unit dosage form. The invention also provides a pharmaceutical composition comprising a pharmaceutically acceptable carrier and a compound comprising an anti-*Acinetobacter* protein antibody as disclosed herein or an anti-HYR1 antibody having specific reactivity to an HYR1 protein (SEQ ID NO: 1) or a fragment thereof as is disclosed herein. The invention additionally provides a method of treating or preventing infections from gram negative bacteria such as bacteria from the *Acinetobacter* genus including, for example, *Acinetobacter baumannii,* in a subject in need thereof. The methods of the invention can include administering a therapeutically effective amount of a pharmaceutical composition containing a pharmaceutically acceptable carrier and a compound comprising an anti-*Acinetobacter* protein antibody as disclosed herein or an anti-HYR1 antibody having specific reactivity to an HYR1 protein (SEQ ID NO: 1) or a fragment thereof. The invention additionally provides a method of treating or preventing a bacterial infection in a subject in need thereof by administering a therapeutically effective amount of a vaccine composition as disclosed herein.

As used herein, the term "polypeptide" is intended to refer to two or more amino acids. Such polypeptides typically are continuous and unbranched peptide. A peptide is a short polymer of amino acid monomers. "Proteins" are intended to include one or more polypeptides arranged in a biologically functional way. The amino acids comprising the polypeptides of the invention may be linked by peptide bonds or other bonds, for example, ester or ether bonds. The amino acids comprising the polypeptides of the invention can include non-genetically coded amino acids that either occur naturally or are chemically synthesized. A polypeptide of the invention can also encompass one or more conservative substitutions. Conservative substitutions of encoded amino acids include, for example, amino acids that belong within the following groups: (1) non-polar amino acids (Gly, Ala, Val, Leu, and Ile); (2) polar neutral amino acids (Cys, Met, Ser, Thr, Asn, and Gln); (3) polar acidic amino acids (Asp and Glu); (4) polar basic amino acids (Lys, Arg and His); and (5) aromatic amino acids (Phe, Trp, Tyr, and His). Other minor modifications are also included within polypeptides of the invention so long as the polypeptide retains some or all of its function as described herein.

The invention polypeptides can also include derivatives, analogues and functional mimetics thereof, provided that such polypeptide retains some or all of its function as disclosed herein. For example, derivatives can include chemical modifications of the polypeptide such as alkylation, acylation, carbamylation, iodination, or any modification that derivatizes the polypeptide. Such derivatized molecules include, for example, those molecules in which free amino groups have been derivatized to form amine hydrochlorides, p-toluene sulfonyl groups, carbobenzoxy groups, t-butyloxycarbonyl groups, chloroacetyl groups or formyl groups. Free carboxyl groups can be derivatized to form salts, methyl and ethyl esters or other types of esters or hydrazides. Free hydroxyl groups can be derivatized to form O-acyl or O-alkyl derivatives. The imidazole nitrogen of histidine can be derivatized to form N-im-benzylhistidine. Also included as derivatives or analogues are those peptides which contain one or more naturally occurring amino acid derivatives of the twenty standard amino acids, for example, 4-hydroxyproline, 5-hydroxylysine, 3-methylhistidine, homoserine, ornithine or carboxyglutamate, and can include amino acids that are not linked by peptide bonds. Polypeptides of the present invention also include any polypeptide having one or more additions and/or deletions of residues, relative to the sequence of a polypeptide whose sequence is shown herein, so long as immunogenic activity as disclosed herein is maintained.

The invention polypeptides can be isolated by a variety of methods well-known in the art, for example, recombinant expression systems, precipitation, gel filtration, ion-exchange, reverse-phase and affinity chromatography, and the like. Other well-known methods are described in Deutscher et al., *Guide to Protein Purification: Methods in Enzymology* Vol. 182, (Academic Press, (1990)). Alternatively, the isolated polypeptides of the present invention can be obtained using well-known recombinant methods (see, for example, Ausubel et al., "Immunology," *Short Protocols in Molecular Biology*, *John Wiley & Sons, Inc.* Chapter 11. Page 11.1-11.29 (1999); Sambrook and Russell, "Molecular Cloning: A Laboratory Manual," *Cold Spring Harbor Laboratory* (2001)). The methods and conditions for biochemical purification of a polypeptide of the invention can be chosen by those skilled in the art, and purification monitored, for example, by an immunological assay or a functional assay.

An example of the means for preparing an invention polypeptide is to express nucleic acids encoding a polypeptide of the invention in a suitable host cell, such as a bacterial cell, a yeast cell, an amphibian cell such as an oocyte, or a mammalian cell, using methods well known in the art, and recovering the expressed polypeptide, again using well-known purification methods, so described herein. Invention polypeptides can be isolated directly from cells that have been transformed with expression vectors as described herein. The invention polypeptides can also be produced by chemical synthesis. Methods for chemically synthesizing polypeptides are well known in the art and are commercially available.

Recombinantly expressed polypeptides of the invention can also be expressed as fusion proteins with appropriate fusion partners. An appropriate fusion partner can be an amino acid sequence that is not normally connected to the amino acid sequence such as an heterologous sequence, which serves a particular function or provides additional characteristic to the polypeptides of the invention. Non-limiting examples of suitable heterologous sequences include a detectable marker, a stabilizing domain, a carrier protein for the generation of antibodies, a linker sequence and a sequence that aids in the purification of the polypeptide. Sequences that can aid in the purification of the invention polypeptides include affinity tags, such as glutathione S transferase (GST) or poly His. Thus, in some aspects, the invention provide a fusion protein having a polypeptide as disclosed herein fused to a heterologous sequence, a carrier protein, an affinity tag or a linker sequence.

The present invention also provides compositions containing an acceptable carrier and any of the isolated polypeptides disclosed herein, alone or in combination with each other. These polypeptides can be recombinantly derived, chemically synthesized or purified from native sources. As used herein, the term "pharmaceutically acceptable carrier" encompasses any of the standard pharmaceutical carriers known in the art, such as phosphate buffered saline solution, water and emulsions such as an oil and water emulsion, and various types of wetting agents.

The invention also provides a method for expression of a polypeptide as disclosed herein by culturing cells containing a nucleic acid that encodes the polypeptide under conditions suitable for expression of polypeptide. Thus, there is provided a method for the recombinant production of a polypeptide of the invention by expressing the nucleic acid sequences encoding the polypeptide in suitable host cells. Recombinant DNA expression systems that are suitable for production of polypeptides are described herein and are well-known in the art (see, Ausubel et al., *supra*, 1999). For example, the above-described nucleotide sequences can be incorporated into vectors for further manipulation. Vectors can include a recombinant DNA or RNA plasmid or virus containing discrete elements that are used to introduce heterologous DNA into cells for either expression or replication thereof.

By "specifically binds" is meant the preferential association of a binding moiety (e.g., an antibody, antibody fragment, receptor, ligand, or small molecule portion of an agent as described herein) to a target molecule (e.g., a polypeptide or conjugate including same) or to a cell or tissue bearing the target molecule (e.g., a cell surface antigen, such as a receptor or ligand) and not to non-target molecules, cells, or tissues lacking the target molecule. It is recognized that a certain degree of non-specific interaction may occur between a binding moiety and a non-target molecule (present alone or in combination with a cell or tissue). Nevertheless, specific binding may be distinguished as mediated through specific recognition of the target molecule. Specific binding results in a stronger association between the binding moiety (e.g., an antibody) and the target molecule (e.g., a polypeptide or conjugate including same) than between the binding moiety and, e.g., non-target molecules or other compositions lacking the target molecule. Specific binding typically results in greater than 2-fold, preferably greater than 5-fold, more preferably greater than 10-fold and most preferably greater than 100-fold increase in amount of bound binding moiety (per unit time) to e.g., a cell or tissue bearing the target molecule or marker as compared to a cell or tissue lacking that target molecule or marker. Binding moieties bind to the target molecule or marker with a dissociation constant of e.g., less than 10^{-6}M, less than 10^{-7}M, 10^{-8}M, 10^{-9}M, 10^{-10}M, 10^{-11}M, or 10^{-12}M, or even less than 10^{-13}M, 10^{-14}M, or 10^{-15}M. Specific binding to a protein under such conditions requires a binding moiety that is selected for its specificity for that particular protein. A variety of assay formats are appropriate for selecting binding moieties (e.g., antibodies) capable of specifically binding to a particular target molecule. For example, solid-phase ELISA immunoassays are routinely used to select monoclonal antibodies specifically immunoreactive with a protein. See Harlow & Lane, Antibodies, A Laboratory Manual, Cold Spring Harbor Publications, New York (1988), for a description of immunoassay formats and conditions that can be used to determine specific immunoreactivity.

By "substantially identical" is meant an amino acid sequence or nucleic acid sequence that exhibits at least 50% identity to a reference sequence. Such a sequence is generally at least, e.g., 50%, 60%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98%, or 99% identical at the amino acid level or nucleic acid level to a reference sequence. In general, for polypeptides, the length of comparison sequences can be at least five amino acids, e.g., 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 125, 150, 175, 200, 250, 300, or more amino acids, up to the entire length of the polypeptide. For nucleic acids, the length of comparison sequences can generally be at least 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 125, 150, 175, 200, 250, 300, 400, 500, 600, 700, 800, 900, or more nucleotides, up to the entire length of the nucleic acid molecule. It is understood that for the purposes of determining sequence identity when comparing a DNA sequence to an RNA sequence, a thymine nucleotide is equivalent to a uracil nucleotide.

As used herein, when a polypeptide or nucleic acid sequence is referred to as having "at least X% sequence identity" to a reference sequence, it is meant that at least X percent of the amino acids or nucleotides in the polypeptide or nucleic acid are identical to those of the reference sequence when the sequences are optimally aligned. An optimal alignment of sequences can be determined in various ways that are within the skill in the art, for instance, the Smith Waterman alignment algorithm (Smith et al., J. Mol. Biol. 147:195-7, 1981) and BLAST (Basic Local Alignment Search Tool; Altschul et al., J. Mol. Biol. 215: 403-10, 1990). These and other alignment algorithms are accessible using publicly available computer software such as "Best Fit" (Smith and Waterman, Advances in Applied Mathematics, 482-489, 1981) as incorporated into GeneMatcher PlusTM (Schwarz and Dayhof, *Atlas of Protein Sequence and Structure*, Dayhoff, M.O., Ed pp 353-358, 1979), BLAST, BLAST-2, BLAST-P, BLAST-N, BLAST-X, WU-BLAST-2, ALIGN, ALIGN-2, CLUSTAL, or Megalign (DNASTAR). In addition, those skilled in the art can determine appropriate parameters for measuring alignment, including any algorithms needed to achieve optimal alignment over the length of the sequences being compared.

A "target molecule" or "target cell" is meant a molecule (e.g., a polypeptide, epitope, antigen, receptor, or ligand) or cell to which a binding moiety (e.g., an antibody) can specifically bind. In some instances, target molecules are exposed on the exterior of a target cell (e.g., a cell surface or secreted protein), but target molecules may alternately or also be present in the interior of a target cell.

The "therapeutically effective amount" will vary depending on the protein, polypeptide, or antibody compositions used, the disease and its severity and the age, weight, etc., of the patient to be treated, all of which is within the skill of the attending clinician. It is contemplated that a therapeutically effective amount of one or more of a protein, polypeptide, or antibody composition described herein will alter the pathogenicity of gram negative bacteria. A therapeutically effective amount is distinguishable from an amount having a biological effect. A protein, polypeptide, or antibody composition of the present invention may have one or more biological effects *in vitro* or even *in vivo*, such as reducing the function of a protein or polypeptide expressed by a gram negative bacteria. A biological effect, however, may not result in any clinically measurable therapeutically effect as described herein as determined by methods within the skill of the attending clinician.

By "treating" or "treatment" is meant the medical management of a patient with the intent to cure, ameliorate, stabilize, reduce the likelihood of, or prevent a disease, pathological condition, disorder, or event, by administering a pharmaceutical composition. This term includes active treatment, that is, treatment directed specifically toward the improvement or associated with the cure of a disease, pathological condition, disorder, or event, and also includes causal treatment, that is, treatment directed toward removal of the cause of the associated disease, pathological condition, disorder, or event. In addition, this term includes palliative treatment, that is, treatment designed for the relief of symptoms rather than the curing of the disease, pathological condition, disorder, or event; symptomatic treatment, that is, treatment directed toward constitutional symptoms of the associated disease, pathological condition, disorder, or event; preventative treatment, that is, treatment directed to minimizing or partially or completely inhibiting the development of the associated disease, pathological condition, disorder, or event, e.g., in a patient who is not yet ill, but who is susceptible to, or otherwise at risk of, a particular disease, pathological condition, disorder, or event; and supportive treatment, that is, treatment employed to supplement another specific therapy directed toward the improvement of the associated disease, pathological condition, disorder, or event.

By "vaccine," as used herein, is meant a composition that elicits an immune response in a subject to which it is administered.

By "vaccinate," as used herein, is meant to treat a patient by administering a vaccine, e.g., to prevent or ameliorate a disease, pathological condition, disorder, or event.

By "variant" in the context of a polypeptide or portion thereof as described herein, or a nucleic acid molecule encoding same, is meant to include substitutions or alterations in the amino acid sequence or nucleic acid sequence, e.g., resulting in a substantially identical sequence. A polypeptide having a variant sequence may maintain at least one biological activity of the original polypeptide, e.g., immunogenic activity. The term "variant" includes, e.g., amino acid insertional derivatives such as amino and/or carboxylterminal fusions, as well as intrasequence insertions of single or multiple amino acids. Insertional amino acid variants are those in which one or more amino acid residues are introduced into a predetermined site in the protein. Random insertion is also possible with suitable screening of the resulting product. Deletional variants are characterized by removal of one or more amino acids from the sequence. Substitutional amino acid variants are those in which at least one residue inserted in its place. Where the protein is derivatized by amino acid substitution, amino acids are generally replaced by conservative substitutions, e.g., other amino acids having similar physical chemical properties such as hydrophobicity, hydrophilicity, electronegativity, bulky sidechains and the like.

For purposes of the present invention, variants also include single or multiple substitutions, deletions and/or additions of any component(s) naturally or artificially associated with the portion of a naturally occurring protein from which the polypeptide may be derived, such as carbohydrate, lipid and/or other proteinaceous moieties. All such molecules are encompassed by the term "variant."

By "variant sequence" is meant the amino acid or nucleic acid sequence of a variant as defined herein.

Other features and advantages of the invention will be apparent from the following Detailed Description, the drawings, and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1A-1B: rHyr1p-N vaccine improved survival and decreased fungal burden in mice with *Candida albicans* infection. (A) Survival of vaccinated or control mice (n = 15 per group) infected i.v. with *Candida albicans* 15563 strain, a clinical isolate (9×10^5 per dose), *, $P < 0.001$ compared to alum alone by the log-rank test. (B) Kidney fungal burden of mice (n=10 per arm) vaccinated with 30 µg rHyr1p-N + alum or alum alone and harvested 3 days post infection with *C. albicans* 15663 (7×10^5 per dose). Data are presented as median ± interquartile ranges. *, $P < 0.001$ compared to results obtained from kidneys harvested from mice vaccinated with alum alone by the Mann-Whitney U test.

Figures 2A-2C: Representative histopathological sections from kidneys are shown. (A) Control mice infected with *C. albicans* had multiple abscesses showing mostly yeast forms with some hyphae and pseudohyphae throughout the kidneys..(B) rHyr1p-N vaccinated mice (30 µg) infected with *C. albicans* had less abscesses with far less fungi visible. (C) Semiquantitative evaluation of the severity of infection indicated a significant abscess and *Candida* cells reduction in vaccinated mice compared to control mice. Sections were stained by PAS. Thirty random fields were examined by a blinded assessor (GL) to assess the number of lesions per field. Number of organisms per lesion was evaluated in 120 lesions in the control unvaccinated mice. The average number of organisms per lesion was determined by dividing the total number of fungal cells by the number of lesions counted.

Figures 3A-3C: rHyr1p-N vaccine prolonged survival and decreased fungal burden in neutropenic mice infected with *C. albicans*. Balb/c mice (n=20 per arm) were vaccinated with rHyr1p-

N mixed with alum or alum alone, treated with cyclophosphamide, then infected with *C. albicans* 15563 at 1×10^5 blastospores. Two days before cyclophosphamide treatment, half of the mice were bled and individually marked for antibody titer using ELISA (A) and survival (B). The other half mice were used for fungal burden (C). *p<0.05 for vaccinated vs. control by Log Rank test.

Figures 4A-4D: Dose dependent passive immunization with anti-Hyr1p IgG protected against murine hematogenously disseminated candidiasis. Mice were given 0.3 mg (A), 1 mg (B) and 3 mg (C) of anti-Hyr1p IgG through i.p 2 hour before infecting with 6.2×10^5 blastospores of *Candida albicans* 15563 via the tail vein. Survival of mice (n= 10 per group) was monitored twice daily. * *P* = .001 by log-rank test vs. mice receiving isotype-match control IgG. (D) Effect of vaccinated or control $F(ab')_2$ on blocking HL-60 derived neutrophil killing of *C. albicans. C. albicans* overexpressing or suppressing Hyr1p were used in the assay to demonstrate specificity of the $F(ab')_2$ fragments to Hyr1p. Control denotes assay performed in the absence of either $F(ab')_2$ or the presence of $F(ab')_2$ from isotype matching IgG. Data are displayed as median ± interquartile range. * *P* = .001 by Mann-Whitney test.

Figures 5A-5B: Protection against hematogenously disseminated candidiasis using purified pooled IgG is specific to Hyr1p. A) Indirect immunofluorescence with rabbit anti-Hyr1p IgGs demonstrated surface expression of Hyr1p on *C. albicans* hyphae and the successful absorption of anti-Hyr1p antibodies; B) Survival of mice treated with 1 mg of: 1) pooled anti-Hyr1 IgGs (n=20); 2) pooled anti-Hyr1p IgG absorbed with *C. albicans* hyphae (n=10); or 3) control rabbit IgG (n=20) two hours before infecting with 8.7×10^5 blastospores of *C. albicans* 15563 via the tail vein. The antibody dose was repeated 3 days after infection. * p=0.002 vs. absorbed IgG and 0.03 vs. control IgG, ** p=0.28 vs. absorbed IgG by Log Rank test.

Figures 6: rHyr1p-N vaccine reduces tissue fungal burden in BALB/c mice infected with non- *albicans* species of *Candida*. BALB/c mice (*n* = 10 per group) were vaccinated with alum or alum plus rHyr1p-N (30 μg) and boosted three weeks later. Two weeks after the boost, mice were challenged via the tail vein with *C. glabrata* (3.2×10^7), *C. krusei* (3.4×10^7), *C. parapsilosis* (9.6×10^6), or *C. tropicalis* (3.2×10^6). Kidney fungal burden was determined on day 3 post infection. The *y* axis reflects the lower limit of detection of the assay. * *P* < 0.001 versus adjuvant control by the Mann-Whitney U test.

Figure 7 shows active immunization with rHYR1p-N (SEQ ID NO: 2) protects diabetic mice from *Acinetobacter baumannii* bacteremia. Mice were immunized with aluminum hydroxide alone (n=10) or rHYR1p-N (30 mg) mixed with aluminum hydroxide (n=9) on day 0, boosted on day 21 and infected with *Acinetobacter baumannii* on day 35. * P<0.005 vs. control.

Figure 8 shows the effect of active vaccination with rHYR1p-N (SEQ ID NO: 2) on bacterial burden in kidney, lung and spleen tissue. Control mice were immunized with aluminum hydroxide alone, whereas vaccinated mice were immunized with rHYR1p-N (30 mg) mixed with aluminum hydroxide on day 0, boosted on day 21 and infected with *Acinetobacter baumannii* on day 35.

Figure 9 shows passive immunization protects diabetic mice from *Acinetobacter baumannii* bacteremia. Mice were treated with 1 mg rabbit control IgG (n=18) as a control. Experimental mice were treated with pooled polyclonal anti-rHYR1p IgG (n=20) 2 h prior to infecting with *A. baumannii*. Each of the polyclonal anti-rHYR1p antibodies comprising the pool were raised against one of synthetic antigenic polypeptide comprising one of SEQ ID NOS: 11-18. * P<0.005 vs. control IgG.

Figure 10 shows passive immunization protects diabetic mice from *Acinetobacter baumannii* bacteremia. Mice were treated with 1 mg rabbit control IgG (n=18) or polyclonal anti-HYR1p IgG raised individually against one of eight different synthetic HYR1 peptides 2 h prior to infecting with *A. baumannii*. No. 1 was raised against CGPSAPESESDLNTP (SEQ ID NO: 11). No. 2 was raised against CGNRDHFRFEYYPDT (SEQ ID NO: 12). No. 3 was raised against CGYDSKLFRIVNSRG (SEQ ID NO: 13). No. 4 was raised against CKIKGTGCVTADEDT (SEQ ID NO: 14). No. 5 was raised against CLKNAVTYDGPVPNN (SEQ ID NO: 15). No. 6 was raised against NSKSSTSFSNFDIGC (SEQ ID NO: 16). No. 7 was raised against CEPTHNFYLKDSKSS (SEQ ID NO: 17). No. 8 was raised against TSRIDRGGIQGFHGC (SEQ ID NO: 18). Combination 1 (Comb1) includes antibody Nos. 2, 3, 5 and 8. Combination 2 (Comb2) includes antibody Nos. 2, 5 and 8.

Figure 11 shows an exemplary 2D-gel and western blot analysis of *Acinetobacter* cell surface extracts. Rabbit IgG raised against CLKNAVTYDGPVPNN (SEQ ID NO: 15) was used to probe the upper blot, whereas pre-immune serum was used as a control to probe the lower blot.

DETAILED DESCRIPTION OF THE INVENTION

Candida albicans is a common pathogen in humans. For example, *C. albicans*, while normally a harmless commensal, can cause a variety of conditions ranging from superficial mucocutaneous infection such as vaginal and/or oropharyngeal candidiasis, to deep organ involvement in disseminated candidiasis. Prior to causing disease, the fungus colonizes the gastrointestinal tract, and in some cases skin and mucous membranes. Adherence to host mucosal surfaces is a key prerequisite for this initial step. After colonization, C. *albicans* enters the bloodstream via infected intravascular devices or by transmigration through gastrointestinal mucosa compromised by chemotherapy or stress ulcerations. Organisms then disseminate via the bloodstream, bind to and penetrate the vascular endothelium to egress from the vascular tree, and invade deep organs such as liver, spleen, and kidney.

The identification of the HYR1 fragments and other compositions described herein allow, e.g., for the effective treatment of and vaccination against not only candidiasis but also *Acinetobacter* infection.

The invention provides polypeptides, e.g., derived from HYR1 or Hyr1p-N, conjugates, vaccines, antibodies, compositions, methods of vaccination using same, and methods of production of same, as described in further detail below.

Polypeptides

The invention features polypeptides, e.g., isolated polypeptides, derived from HYR1, e.g., Hyr1p (SEQ ID NO: 1) or Hyr1p-N (SEQ ID NO: 2), e.g., including the amino acid sequence of any one of SEQ ID NOs: 3-10, or a variant sequence thereof having zero, one, two, or three substitutions, deletions, or additions to the amino acid sequence of any one of SEQ ID NOs: 3-10, wherein the polypeptide does not include more than 20 contiguous amino acids of SEQ ID NO: 2.

SEQ ID NO:1 is an amino acid sequence of *C. albicans* Hyr1p (SEQ ID NO: 1).

```
MKVVSNFIFTILLTLNLSAALEVVTSRIDRGGIQGFHGDVKVHSGATWAILGTTLCSFFG
GLEVEKGASLFIKSDNGPVLALNVALSTLVRPVINNGVISLNSKSSTSFSNFDIGGSSFT
NNGEIYLASSGLVKSTAYLYAREWTNNGLIVAYQNQKAAGNIAFGTAYQTITNNGQICLR
HQDFVPATKIKGTGCVTADEDTWIKLGNTILSVEPTHNFYLKDSKSSLIVHAVSSNQTFT
VHGFGNGNKLGLTLPLTGNRDHFRFEYYPDTGILQLRAAALPQYFKIGKGYDSKLFRIVN
SRGLKNAVTYDGPVPNNEIPAVCLIPCTNGPSAPESESDLNTPTTSSIETSSYSSAATES
SVVSESSSAVDSLTSSSLSSKSESSDVVSSTTNIESSSTAIETTMNSESSTDAGSSSISQ
SESSSTAITSSSETSSSESMSASSTTASNTSIETDSGIVSQSESSSNALSSTEQSITSSP
GQSTIYVNSTVTSTITSCDENKCTEDVVTIFTTVPCSTDCVPTTGDIPMSTSYTQRTVTS
TITNCDEVSCSQDVVTYTTNVPHTTVDATTTTTTSTGGDNSTGGNESGSNHGPGNGSTEG
SGNGSGAGSNEGSQSGPNNGSGSGSEGGSNNGSGSDSGSNNGSGSGSNNGSGSGSTEGSE
GGSGSNEGSQSGSGSQPGPNEGSEGGSGSNEGSNHGSNEGSGSGSGSGSNNGSGSGSQSG
SGSGSQSGSESGSNSGSNEGSNPGAGNGSNEGSGQGSGNGSEAGSGQGSGPNNGSGSGHN
DGSGSGSNQGSNPGAGSGSGSESGSNAGSHSGSNEGAKTDSIEGFHTESKPGFNTGAHTD
ATVTGNSVANPVTTSTESDTTISVTVSITSYMTGFDGKPKPFTTVDVIPVPHSMPSNTTD
SSSSVPTIDTNENGSSIVTGGKSILFGLIVSMVVLFM (SEQ ID NO:1)
```

SEQ ID NO:2 is an amino acid sequence of a recombinant N-terminal domain of Hyr1p (rHyr1p-N, SEQ ID NO: 2).

```
1          TSRIDRGGIQ GFHGDVKVHS
21         GATWAILGTT LCSFFGGLEV
41         EKGASLFIKS DNGPVLALNV
61         ALSTLVRPVI NNGVISLNSK
81         SSTSFSNFDI GGSSFTNNGE
101        IYLASSGLVK STAYLYAREW
121        TNNGLIVAYQ NQKAAGNIAF
141        GTAYQTITNN GQICLRHQDF
161        VPATKIKGTG CVTADEDTWI
181        KLGNTILSVE PTHNFYLKDS
201        KSSLIVHAVS SNQTFTVHGF
221        GNGNKLGLTL PLTGNRDHFR
241        FEYYPDTGIL QLRAAALPQY
261        FKIGKGYDSK LFRIVNSRGL
281        KNAVTYDGPV PNNEIPAVCL
301        IPCTNGPSAP ESESDLNTPT
321        TSSIET (SEQ ID NO:2)
```

SEQ ID NOs: 3-10 are 14-mer fragments of the amino acid sequence of Hyr1p-N (SEQ ID NO: 2), as shown in Table 1.

Table 1. Exemplary Hyr1p-N Fragments

SEQ ID NO.	Sequence
3	GPSAPESESDLNTP
4	GNRDHFRFEYYPDT
5	GYDSKLFRIVNSRG
6	KIKGTGCVTADEDT
7	LKNAVTYDGPVPNN
8	NSKSSTSFSNFDIG
9	EPTHNFYLKDSKSS
10	TSRIDRGGIQGFHG

The polypeptides of Table 1 or other polypeptides described herein may have a variant or otherwise modified amino acid sequence. For example, in variants of the polypeptides of Table 1, each substitution, deletion, or addition, if any, may be made, e.g., at position 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, or 14, or at the N- or C-terminal end of the polypeptide.

In some instances, the polypeptide is between 14 and 20 amino acids, e.g., 14, 15, 16, 17, 18, 19, or 20 amino acids. In other instances, the polypeptide is shorter than 14 amino acids, e.g., 11, 12, or 13 amino acids. The polypeptide may be longer than 20 amino acids provided that it does not include more than 20 contiguous amino acids of SEQ ID NO: 2.

In some instances, a modification to a polypeptide as described herein does not substantially reduce the biological activity, e.g., immunogenic activity, of the polypeptide. The modified polypeptide may have or may optimize a characteristic of a polypeptide, such as *in vivo* stability, bioavailability, toxicity, immunological activity, immunological identity, or conjugation properties.

Modifications include those by natural processes, such as posttranslational processing, or by chemical modification techniques known in the art. Modifications may occur anywhere in a polypeptide including the polypeptide backbone, the amino acid side chains, and the amino- or carboxy-terminus. The same type of modification may be present in the same or varying degrees at several sites in a given polypeptide, and a polypeptide may contain more than one type of modification.

A variant or otherwise modified polypeptide can also include one or more amino acid insertions, deletions, or substitutions, either conservative or non-conservative (e.g., D-amino acids, desamino acids) in the polypeptide sequence. For example, the addition of one or more cysteine residues to the amino or carboxy terminus of any of the polypeptides of the invention can facilitate conjugation of these polypeptides. Exemplary polypeptides having an N- or C-terminal cysteine include, e.g., the polypeptides of SEQ ID NOs: 11-18, e.g., as shown in Table 2, and as described further in Example 1.

Table 2. Anti-Hyr1 Peptides

Peptide No.	SEQ ID NO.	Sequence	MW (kDa)	pI	Purity (%)
1	11	CGPSAPESESDLNTP	1.5	3.44	86.1
2	12	CGNRDHFRFEYYPDT	1.9	5.69	99.4
3	13	CGYDSKLFRIVNSRG	1.7	9.16	95.7
4	14	CKIKGTGCVTADEDT	1.5	4.70	86.4
5	15	CLKNAVTYDGPVPNN	1.6	6.25	94.1
6	16	NSKSSTSFSNFDIGC	1.6	6.25	91.4
7	17	CEPTHNFYLKDSKSS	1.8	7.19	85.8
8	18	TSRIDRGGIQGFHGC	1.6	8.27	91.8

Amino acid substitutions can be conservative (i.e., wherein a residue is replaced by another of the same general type or group) or non-conservative (i.e., wherein a residue is replaced by an amino acid of another type). In addition, a non-naturally occurring amino acid can be substituted for a naturally occurring amino acid (i.e., non-naturally occurring conservative amino acid substitution or a non-naturally occurring non-conservative amino acid substitution).

Polypeptides made synthetically, e.g., using methods known in the art, can include substitutions of amino acids not naturally encoded by DNA (e.g., non-naturally occurring or unnatural amino acid). Examples of non-naturally occurring amino acids include D-amino acids, an amino acid having an acetylaminomethyl group attached to a sulfur atom of a cysteine, a pegylated amino acid, the omega amino acids of the formula $NH_2(CH_2)_nCOOH$ wherein n is 2-6, neutral nonpolar amino acids, such as sarcosine, t-butyl alanine, t-butyl glycine, N-methyl isoleucine, and norleucine. Phenylglycine may substitute for Trp, Tyr, or Phe; citrulline and methionine sulfoxide are neutral nonpolar, cysteic acid is acidic, and ornithine is basic. Proline may be substituted with hydroxyproline and retain the conformation conferring properties.

Variants may be generated by substitutional mutagenesis and retain or even increase the biological activity, e.g., immunogenic activity, of the original polypeptide.

The polypeptides described herein can be obtained, e.g., by chemical synthesis using a commercially available automated peptide synthesizer. The synthesized protein or polypeptide can be precipitated and further purified, for example by high performance liquid chromatography (HPLC). Alternatively, the proteins and polypeptides can be obtained by recombinant methods, e.g., that are well-known in the art.

Conjugates

Polypeptides of the invention may be conjugated to another moiety or particle.

Protein moieties

In some instances, it may be useful to conjugate the polypeptide to a protein that is immunogenic in the species to be immunized, e.g., keyhole limpet hemocyanin (KLH), CRM197, tetanus toxoid, diptheria toxoid, serum albumin, bovine thyroglobulin, soybean trypsin inhibitor, or a polycation (poly-L-Lysine or poly-L-arginine), e.g., using a bifunctional or derivatizing agent as known in the art, for example, maleimidobenzoyl sulfosuccinimide ester (conjugation through cysteine residues), N-hydroxysuccinimide (through lysine residues), glutaraldehyde, or succinic anhydride.

In some instances, the conjugate may be a recombinant fusion protein, e.g., to facilitate expression and purification of the polypeptide.

Particles for Conjugation or Display of Polypeptides

In some instances, polypeptides are conjugated to or displayed on a particle, e.g., a phage, a yeast, a virus, a virosome, or a recombinant virus-like particle.

For example, one or more polypeptides may be conjugated to a phage, a yeast, or a virus particle, e.g., to the surface of the particle. In one embodiment, a nucleic acid molecule encoding the polypeptide is inserted into the phage, yeast, or virus particle, resulting in expression of the polypeptide in the phage, yeast, or virus, e.g., at the surface of the particle. The phage, yeast, or virus population containing the polypeptide may then be isolated and prepared, e.g., as a vaccine, by adding a pharmaceutically acceptable excipient.

In some embodiments, polypeptides as described herein are conjugated to a virosome or virus-like particle (VLP). Virosomes and VLPs generally contain one or more proteins from a virus optionally combined or formulated with a phospholipid. They are generally non-pathogenic, non-replicating and generally do not contain any of the native viral genome. The viral proteins may be recombinantly produced or isolated from whole viruses. Viral proteins suitable for use in virosomes or VLPs include proteins derived from influenza virus (such as HA or NA), Hepatitis B virus (such as core or capsid proteins), Hepatitis E virus, measles virus, Sindbis virus, Rotavirus, Foot-and-Mouth Disease virus, Retrovirus, Norwalk virus, human Papilloma virus, HIV, RNA-phages, Q.beta.-phage (such as coat proteins), GA-phage, fr-phage, AP205 phage, and Ty (such as retrotransposon Ty protein p 1). Virosomes are discussed further in, e.g., Gluck et al. (2002), *Vaccine* 20:B10-B16, which is incorporated by reference in its entirety.

VLPs are discussed further, e.g., in Niikura et al. (2002), *Virology* 293:273-280; Lenz et al. (2001), *J Immunol* 166:5346-5355; Pinto et al. (2003), *J Infect Dis* 188:327-338; Gerber et al. (2001), *Viral* 75:4752-4760; WO03/024480; and WO03/024481, each of which is incorporated by reference in its entirety.

Antibodies

The invention features monoclonal and polyclonal antibodies that bind to the polypeptides or conjugates described herein.

Monoclonal Antibodies

Monoclonal antibodies may be made, e.g., using the hybridoma method first described by Kohler et al., *Nature* 256:495, 1975, or may be made by recombinant DNA methods (see, e.g., U.S. Patent No. 4,816,567). In the hybridoma method, a mouse or other appropriate host animal, such as a hamster or macaque monkey, is immunized, e.g., using a polypeptide or conjugate described herein, to elicit lymphocytes that produce or are capable of producing antibodies that will specifically bind to the polypeptide or conjugate used for immunization. Alternatively, lymphocytes may be immunized *in vitro*. Lymphocytes then are fused with myeloma cells using a suitable fusing agent, such as polyethylene glycol, to form a hybridoma cell (Goding, Monoclonal Antibodies: Principles and Practice, pp. 59-103, Academic Press, 1986).

The hybridoma cells thus prepared are seeded and grown in a suitable culture medium that can contain one or more substances that inhibit the growth or survival of the unfused, parental myeloma cells. For example, if the parental myeloma cells lack the enzyme hypoxanthine guanine phosphoribosyl transferase (HGPRT or HPRT), the culture medium for the hybridomas typically will include hypoxanthine, aminopterin, and thymidine (HAT medium), which substances prevent the growth of HGPRT-deficient cells.

Exemplary myeloma cells are those that fuse efficiently, support stable high-level production of antibody by the selected antibody-producing cells, and are sensitive to a medium such as HAT medium. Among these, particular myeloma cell lines that may be considered for use are murine myeloma lines, such as those derived from MOPC-21 and MPC-11 mouse tumors available from the Salk Institute Cell Distribution Center, San Diego, CA, USA, and SP-2 or X63-Ag8-653 cells available from the American Type Culture Collection, Manassas, VA, USA. Human myeloma and mouse-human heteromyeloma cell lines also have been described for the production of human monoclonal antibodies (Kozbor, *J. Immunol.* 133:3001, 1984; Brodeur et al., Monoclonal Antibody Production Techniques and Applications, pp. 51-63, Marcel Dekker, Inc., New York, 1987).

Culture medium in which hybridoma cells are growing is assayed for production of monoclonal antibodies directed against the antigen. The binding specificity of monoclonal antibodies produced by hybridoma cells can be determined by immunoprecipitation or by an in vitro binding assay, such as radioimmunoassay (RIA) or enzyme-linked immunoabsorbent assay (ELISA).

After hybridoma cells are identified that produce antibodies of the desired specificity, affinity, and/or activity, clones may be subcloned by limiting dilution procedures and grown by standard methods (Goding, Monoclonal Antibodies: Principles and Practice, pp. 59-103, Academic Press, 1986). Suitable culture media for this purpose include, for example, D-MEM or RPMI-1640 medium. In addition, the hybridoma cells may be grown *in vivo* as ascites tumors in an animal.

The monoclonal antibodies secreted by the subclones are suitably separated from the culture medium, ascites fluid, or serum by conventional immunoglobulin purification procedures such as, for example, protein A-Sepharose, hydroxylapatite chromatography, gel electrophoresis, dialysis, or affinity chromatography.

DNA encoding the monoclonal antibodies is readily isolated and sequenced using conventional procedures (e.g., by using oligonucleotide probes that are capable of binding specifically to genes encoding the heavy and light chains of the monoclonal antibodies). The hybridoma cells serve as a source of such DNA. Once isolated, the DNA may be placed into expression vectors, which are then transfected into host cells such as *E. coli* cells, simian COS cells, Chinese hamster ovary (CHO) cells, or myeloma cells that do not otherwise produce immunoglobulin protein, to obtain the synthesis of monoclonal antibodies in the recombinant host cells. Recombinant production of antibodies will be described in more detail below.

In a further embodiment, antibodies or antibody fragments can be isolated from antibody phage libraries generated using the techniques described, for example, in McCafferty et al., *Nature* 348:552-554, 1990.

Clackson et al., *Nature* 352:624-628, 1991 and Marks et al., *J. Mol. Biol.* 222:581-597, 1991, describe the isolation of murine and human antibodies, respectively, using phage libraries. Subsequent publications describe the production of high affinity (nM range) human antibodies by chain shuffling (Marks et al., *Bio/Technology* 10:779-783, 1992), as well as combinatorial infection and in vivo recombination as a strategy for constructing very large phage libraries (Waterhouse et al., *Nucl. Acids. Res.* 21:2265-2266, 1993). Thus, these techniques are viable alternatives to traditional monoclonal antibody hybridoma techniques for isolation of monoclonal antibodies.

The DNA also may be modified, for example, by substituting the coding sequence for human heavy- and light-chain constant domains in place of the homologous murine sequences (U.S. Patent No. 4,816,567; Morrison et al., *Proc. Natl. Acad. Sci. U.S.A.* 81:6851, 1984), or by covalently joining to the immunoglobulin coding sequence all or part of the coding sequence for a non-immunoglobulin polypeptide.

Typically, such non-immunoglobulin polypeptides are substituted for the constant domains of an antibody, or they are substituted for the variable domains of one antigen-combining site of an antibody to create a chimeric bivalent antibody comprising one antigen-combining site having specificity for an antigen and another antigen-combining site having specificity for a different antigen.

Polyclonal Antibodies

Polyclonal antibodies are typically raised in animals by multiple injections, e.g., subcutaneous or intraperitoneal injections, of the relevant antigen and an adjuvant. In some instances, it may be useful to conjugate the polypeptide to a protein that is immunogenic in the species to be immunized, e.g., keyhole limpet hemocyanin (KLH), CRM197, tetanus toxoid, diptheria toxoid, serum albumin, bovine thyroglobulin, soybean trypsin inhibitor, or a polycation (poly-L-Lysine or poly-L-arginine), e.g., using a bifunctional or derivatizing agent as known in the art, for example, maleimidobenzoyl sulfosuccinimide ester (conjugation through cysteine residues), N-hydroxysuccinimide (through lysine residues), glutaraldehyde, or succinic anhydride.

In addition, an antibody useful in the present invention can be a naturally occurring antibody as well as a non-naturally occurring antibody, including, for example, a single chain antibody, a chimeric, bifunctional or humanized antibody, as well as antigen-binding fragments thereof. Such non-naturally occurring antibodies can be constructed using solid phase peptide synthesis, can be produced recombinantly or can be obtained, for example, by screening combinatorial libraries as described by Ponsel et al. (*Molecules*, 16(5):3675-3700 (2011)). These and other methods of making, for example, chimeric, humanized, CDR-grafted, single chain, and bifunctional antibodies are well known to those skilled in the art and are commercially available.

Anti-*Acinetobacter* protein antibodies can be raised using an immunogenic polypeptide such as an isolated polypeptide having the amino acid sequence of SEQ ID NOS:3-10 or SEQ ID NOS: 11-18 or any of the specific *Acinetobacter baumannii* proteins disclosed herein, or a fragment thereof, which can be prepared from natural sources or produced recombinantly, or a peptide portion of the *Acinetobacter baumannii* protein. Such peptide portions of the *Acinetobacter baumannii* proteins disclosed herein are functional antigenic fragments of the antigenic peptides, which can be used to generate an *Acinetobacter* protein-specific antibody. A non-immunogenic or weakly immunogenic polypeptide or portion thereof can be made immunogenic by coupling the polypeptide to a carrier molecule such as bovine serum albumin (BSA) or keyhole limpet hemocyanin (KLH). Various other carrier molecules and methods for coupling a polypeptide to a carrier molecule are well known in the art (see, for example, Harlow and Lane, *supra*, 1988). An immunogenic polypeptide fragment can also be generated by expressing the peptide portion as a fusion protein, for example, to glutathione S transferase (GST), polyHis or the like. Methods for expressing peptide fusions are well known to those skilled in the art (Ausubel et al., *supra*).

The invention further provides a method for detecting the presence of gram negative bacteria, such as bacteria of the *Acinetobacter* genus in a sample by contacting the sample with a specific antibody, and detecting the presence of specific binding of the antibody to the sample, thereby detecting the presence of the gram negative bacteria in the sample. For example, anti-*Acinetobacter* protein specific antibodies can be used in the diagnostic methods disclosed herein to detect the level of *Acinetobacter* present in a sample.

As used herein, the term "sample" is intended to mean any biological fluid, cell, tissue, organ or portion thereof, that includes or potentially includes nucleic acids or polypeptides. The term includes samples present in an individual as well as samples obtained or derived from the individual. For example, a sample can be a histologic section of a specimen obtained by biopsy, or cells that are placed in or adapted to tissue culture. A sample further can be a subcellular fraction or extract, or a crude or substantially pure nucleic acid or protein preparation.

Immunological procedures useful for *in vitro* detection of target *Acinetobacter* proteins in a sample include immunoassays that employ a detectable antibody. Such immunoassays include, for example, immunohistochemistry, immunofluorescence, ELISA assays, radioimmunoassay, FACS analysis, immunoprecipitation, immunoblot analysis, Pandex microfluorimetric assay, agglutination assays, flow cytometry and serum diagnostic assays, which are well known in the art (Harlow and Lane, *supra*, 1988; Harlow and Lane, *Using Antibodies: A Laboratory Manual*, Cold Spring Harbor Press (1999)).

An antibody can be made detectable by various means well known in the art. For example, a detectable marker can be directly attached to the antibody or indirectly attached using, for example, a secondary agent that recognizes the anti-*Acinetobacter* protein antibody. Useful markers include, for example, radionucleotides, enzymes, binding proteins such as biotin, fluorogens, chromogens and chemiluminescent labels.

Labels that are useful in the invention include single atoms and molecules that are either directly or indirectly involved in the production of a detectable signal. Any label or indicating means can be linked to invention nucleic acids, polypeptides, or antibodies. These atoms or molecules can be used alone or in conjunction with additional reagents. Such labels are themselves well-known in clinical diagnostic chemistry.

In one embodiment, a label can be a fluorescent labeling agent that chemically binds to antibodies without denaturation to form a fluorochrome (dye) that is a useful immunofluorescent tracer. Methods for making and using a fluorescent labeling agent are well known in the art and are commercially available.

In one embodiment, the labeling group can be an enzyme, such as horseradish peroxidase (HRP), glucose oxidase, and the like. In another embodiment, radioactive elements are employed as labeling agents. The linking of a label to a substrate, i.e., labeling of nucleic acids, antibodies and polypeptides, is well known in the art. For instance, an invention antibody can be labeled by metabolic incorporation of radiolabeled amino acids provided in the culture medium. See, for example, Galfre et al., *Meth. Enzymol.*, 73:3-46 (1981). Additionally, an invention antibody can be labeled by incubating the invention antibody conjugated with a bifunctional chelator in a solution of radioisotopes. See, for example, U.S. Patent 7,229,620. Conventional means of protein conjugation or coupling by activated functional groups are commercially available.

Accordingly, in some embodiments, the invention provides a method for detecting the presence of *Acinetobacter* in a sample. These methods can include contacting a sample with an antibody as described here, and detecting the presence of specific binding of the antibody to the sample, thereby detecting the presence of *Acinetobacter* in the sample. In some aspects, the binding of the antibody is to a specific *Acinetobacter* protein identified herein. For example, the method can include binding to an outer membrane protein 1 of *Acinetobacter baumannii*, an outer membrane protein 2 of *Acinetobacter baumannii*, an ferric siderophore receptor protein of *Acinetobacter baumannii*, an Dnak heat shock protein of *Acinetobacter baumannii*, an elongation factor G of *Acinetobacter baumannii*, an organic solvent tolerance protein precursor of *Acinetobacter baumannii*, a putative lipoprotein precursor (VacJ) transmembrane of *Acinetobacter baumannii*, a putative glucose-sensitive porin (OprB-like) of *Acinetobacter baumannii*, an AdeA membrane fusion protein of *Acinetobacter baumannii*, a cell division protein of *Acinetobacter baumannii*, or a cell division protein FtsZ of *Acinetobacter baumannii* that is present in the sample.

The compositions and methods described for detecting and analyzing Acinetobacter are equally applicable for detecting Candida.

Vaccines and Antibody-Containing Pharmaceutical Compositions

Formulations for vaccines and antibody-containing pharmaceutical compositions (collectively "compositions") as described herein can be prepared using standard pharmaceutical formulation chemistries and methodologies that are readily available to the reasonably skilled artisan. For example, polypeptides, conjugates, or antibodies as described herein can be combined with one or more pharmaceutically acceptable excipients or vehicles. Auxiliary substances, such as wetting or emulsifying agents, pH buffering substances and the like, may be present in the excipient or vehicle. These excipients, vehicles and auxiliary substances are generally pharmaceutical agents that do not induce an immune response in the individual receiving the composition, and which may be administered without undue toxicity. Pharmaceutically acceptable excipients include, but are not limited to, liquids such as water, saline, polyethyleneglycol, hyaluronic acid, glycerol and ethanol. Pharmaceutically acceptable salts can also be included therein, for example, mineral acid salts such as hydrochlorides, hydrobromides, phosphates, sulfates, and the like; and the salts of organic acids such as acetates, propionates, malonates, benzoates, and the like. A thorough discussion of pharmaceutically acceptable excipients, vehicles and auxiliary substances is available in Remington's Pharmaceutical Sciences (Mack Pub. Co., N.J. 1991).

Such compositions may be prepared, packaged, or sold in a form suitable for bolus administration or for continuous administration. Injectable compositions may be prepared, packaged, or sold in unit dosage form, such as in ampoules or in multi-dose containers containing a preservative. Compositions may include, but are not limited to, suspensions, solutions, emulsions in oily or aqueous vehicles, pastes, and implantable sustained-release or biodegradable formulations. Such compositions may further comprise one or more additional ingredients including, but not limited to, suspending, stabilizing, or dispersing agents. In one embodiment of a composition for parenteral administration, the active ingredient is provided in dry (for e.g., a powder or granules) form for reconstitution with a suitable vehicle (e.g., sterile pyrogen-free water) prior to parenteral administration of the reconstituted composition. The compositions may be prepared, packaged, or sold in the form of a sterile injectable aqueous or oily suspension or solution. This suspension or solution may be formulated according to the known art, and may comprise, in addition to the active ingredient, additional ingredients such as the dispersing agents, wetting agents, or suspending agents described herein. Such sterile injectable formulations may be prepared using a non-toxic parenterally-acceptable diluent or solvent, such as water or 1,3-butane diol, for example. Other acceptable diluents and solvents include, but are not limited to, Ringer's solution, isotonic sodium chloride solution, and fixed oils such as synthetic mono- or di-glycerides.

Other parentally-administrable compositions that are useful include those which comprise the active ingredient in microcrystalline form, in a liposomal preparation, or as a component of a biodegradable polymer systems. Compositions for sustained release or implantation may comprise pharmaceutically acceptable polymeric or hydrophobic materials such as an emulsion, an ion exchange resin, a sparingly soluble polymer, or a sparingly soluble salt.

Alternatively, the polypeptides, conjugates, and antibodies described herein may be encapsulated, adsorbed to, or associated with particulate carriers. Suitable particulate carriers include those derived from polymethyl methacrylate polymers, as well as PLG microparticles derived from poly(lactides) and poly(lactide-co-glycolides). See, e.g., Jeffery et al. (1993) Pharm. Res. 10:362-368. Other particulate systems and polymers can also be used, for example, polymers such as polylysine, polyarginine, polyornithine, spermine, spermidine, as well as conjugates of these molecules.

The formulated compositions will include an amount of one or more polypeptides or conjugates described herein that is sufficient to mount an immunological response. An immunogenic amount can be readily determined by one of skill in the art. Such an amount will fall in a relatively broad range that can be determined through routine trials. The compositions may contain from about 0.1% to about 99.9% of the polypeptides, conjugates, or antibodies, and can be administered directly to the subject or, alternatively, delivered *ex vivo*, to cells derived from the subject, using methods known to those skilled in the art.

Compositions can include a mixture of distinct polypeptides, conjugates, or antibodies as described herein. For example, vaccines may include, e.g., 2, 3, 4, 5, 6, 7, 8, or more distinct polypeptides or conjugates as described herein, e.g., containing or consisting of the amino acid sequences of SEQ ID NOs: 3-10 or 11-18, or a variant sequence thereof having up to three substitutions, deletions, or additions to the amino acid sequence of any one of SEQ ID NOs: 3-10 or 11-18. In one embodiment, a vaccine includes eight distinct polypeptides, wherein the amino acid sequence of the eight polypeptides consist of the sequence of SEQ ID NOs: 11-18. In another embodiment, antibody-containing pharmaceutical compositions may include a mixture of monoclonal or polyclonal antibodies, e.g., having distinct specificities to polypeptides or conjugates as described herein.

Substances that stimulate the immune response, e.g., adjuvants, may be included in the compositions, e.g., in vaccines. Examples of chemical compounds used as adjuvants include, but are not limited to, aluminum compounds (e.g., alum, Alhydrogel), oils, block polymers, immune stimulating complexes, vitamins and minerals (e.g., vitamin E, vitamin A, selenium, and vitamin B12), Quil A (saponins), bacterial and fungal cell wall components (e.g., lipopolysaccarides, lipoproteins, and glycoproteins), hormones, cytokines, and co-stimulatory factors.

In still another aspect, the invention provides a vaccine composition having an immunogenic amount of an HYR1 polypeptide as described herein, a fusion protein as described herein, an HYR1 protein (SEQ ID NO: 1) or a fragment thereof, an outer membrane protein 1 of *Acinetobacter baumannii* or a fragment thereof, an outer membrane protein 2 of *Acinetobacter baumannii* or a fragment thereof, an ferric siderophore receptor protein of *Acinetobacter baumannii* or a fragment thereof, an Dnak heat shock protein of *Acinetobacter baumannii* or a fragment thereof, an elongation factor G of *Acinetobacter baumannii* or a fragment thereof, an organic solvent tolerance protein precursor of *Acinetobacter* *baumannii* or a fragment thereof, a putative lipoprotein precursor (VacJ) transmembrane of *Acinetobacter baumannii* or a fragment thereof, a putative glucose-sensitive porin (OprB-like) of *Acinetobacter baumannii* or a fragment thereof, an AdeA membrane fusion protein of *Acinetobacter baumannii* or a fragment thereof, a cell division protein of *Acinetobacter baumannii* or a fragment thereof, or a cell division protein FtsZ of *Acinetobacter baumannii* or a fragment thereof. The vaccine composition can include an adjuvant. The formulation of the vaccine composition of the invention is effective in inducing protective immunity in a subject by stimulating both specific humoral (neutralizing antibodies) and effector cell mediated immune responses against a polypeptide antigen. The vaccine composition of the invention is also used in the treatment or prophylaxis of gram negative bacterial infections such as, for example, those caused by bacteria of the *Acinetobacter* genus including, for example, *Acinetobacter baumannii*.

The vaccine of the present invention will contain an immunoprotective quantity of polypeptide antigens and is prepared by methods well known in the art. The preparation of vaccines is generally described in, for example, M. F. Powell and M. J. Newman, eds., "Vaccine Design (the subunit and adjuvant approach)," Plenum Press (1995); A. Robinson, M. Cranage, and M. Hudson, eds., "Vaccine Protocols (Methods in Molecular Medicine)," Humana Press (2003); and D. Ohagan, ed., "Vaccine Adjuvants: Preparation Methods and Research Protocols (Methods in Molecular Medicine)," Humana Press (2000).

Polypeptides of the invention, and peptide fragments thereof can include immunogenic epitopes, which can be identified using experimental methods well known in the art. Additionally, computational modeling can also be used to identify immunogenic epitopes. See, for example, Tong et al. (*Brief Bioinform.* 8(2):96-108 (2006)) and Ponomarenko et al. (2008) "B-cell epitope prediction," in *Structural Bioinformatics*, Bourne PE and Gu J (eds) Wiley-Liss; 2 edition, pgs. 849-879. Once an epitope bearing reactivity with an antibody raised against the intact protein is identified, the peptide can be tested for specificity by amino acid substitution at every position and/or extension at both C and/or N terminal ends. Such epitope bearing polypeptides typically contain at least six to fourteen amino acid residues, and can be produced, for example, by polypeptide synthesis using methods well known in the art or by fragmenting an existing polypeptide. With respect to the molecule used as immunogens pursuant to the present invention, those skilled in the art will recognize that the polypeptide can be truncated or fragmented without losing the essential qualities as an immunogenic vaccine. For example, a polypeptide can be truncated to yield an N-terminal fragment by truncation from the C-terminal end with preservation of the functional properties of the molecule as an immunogenic. Similarly, C-terminal fragments can be generated by truncation from the N-terminal end with preservation of the functional properties of the molecule as an immunogenic. Other modifications in accordance with the teachings and guidance provided herein can be made pursuant to this invention to create other polypeptide functional fragments, immunogenic fragments, variants, analogs or derivatives thereof, to achieve the therapeutically useful properties described herein with the native proteins and polypeptides.

The vaccine compositions of the invention further contain conventional pharmaceutical carriers. Suitable carriers are well known to those of skill in the art. These vaccine compositions can be prepared in liquid unit dose forms. Other optional components, e.g., pharmaceutical grade stabilizers, buffers, preservatives, excipients and the like can be readily selected by one of skill in the art. However, the compositions can be lyophilized and reconstituted prior to use. Alternatively, the vaccine compositions can be prepared in any manner appropriate for the chosen mode of administration, e.g., intranasal administration, oral administration, etc. The preparation of a pharmaceutically acceptable vaccine, having due regard to pH, isotonicity, stability and the like, is within the skill of the art.

The immunogenicity of the vaccine compositions of the invention can further be enhanced if the vaccine further comprises an adjuvant substance. Various methods of achieving adjuvant effects for a vaccine are known. General principles and methods are detailed in "Vaccine Design: Innovative Approaches and Novel Strategies", 2011, Rappuoli R. and Bagnoli F. (eds.), Caister Academic Press, and also in "Vaccine Adjuvants and Delivery Systems", 2007, Singh, M. (ed.), John Wiley & Sons, Inc.

Vaccines according to the invention refer to a composition that can be administered to an individual to protect the individual against an infectious disease. Vaccines protect against diseases by inducing or increasing an immune response in an animal against the infectious disease. An exemplary infectious disease amenable to treatment with the vaccines of the invention include severe pneumonia, infections of the urinary tract, infections of the bloodstream and infections of other parts of the body. The vaccine-mediated protection can be humoral and/or cell mediated immunity induced in host when a subject is challenged with, for example, or an immunogenic portion of a polypeptide or protein described herein.

In addition to vaccination of subjects susceptible to *Acinetobacter* or *Candida* infections or both, the vaccine compositions of the present invention can also be used to treat, immunotherapeutically, subjects suffering from a variety of gram negative bacterial infections. Accordingly, vaccines that contain one or more of the polypeptides and/or antibody compositions described herein in combination with adjuvants, can act for the purposes of prophylactic or therapeutic treatment of infections from gram negative bacteria. In one embodiment, vaccines of the present invention will induce the body's own immune system to seek out and inhibit gram negative bacteria or Candida or both.

Accordingly, in some embodiments, the invention provides a method of treating or preventing an infection from gram negative bacteria in a subject in need thereof by administering a therapeutically effective amount of a pharmaceutical composition as disclosed herein or a vaccine composition as disclosed herein. For example, the invention provides methods of treating or preventing infections caused by one or more gram negative bacteria including bacteria of the *Acinetobacter* genus, such as *A. baumannii, A. iwoffii, A. haemolyticus, A. calcoaceticus, A. johnsonii, A. radioresistens,* and *A. junii,* bacteria of the *Haemophilus* genus, such as *H. aegyptius, H. aphrophilus, H. avium, H. ducreyi, H. felis, H. haemolyticus, H. influenza, H. parainfluenzae, H. paracuniculus, H. parahaemolyticus, H. pittmaniae,* and *H. somnus*, bacteria of the *Bordetella* genus, such as *B. ansorpii, B avium, B. bronchiseptica, B.*

hinzii, B. holmesii, B. parapertussis, B. pertussis, B. petrii, and *B. trematum,* bacteria of the *Salmonella* genus, such as *S. typhimurium*, *S. bongori*, *S. enterica subsp. enterica*, *S. enterica subsp. salamae*, *S. arizonae*, *S. enterica subsp. diarizonae*, *S. enterica subsp. houtenae*, and *S. enterica subsp. indica*, bacteria of the *Yersina* genus, such as *Yersina pseudotuber, Y. aldovae, Y. aleksiciae, Y. bercovieri, Y. enterocolitica, Y. frederiksenii, Y. intermedia, Y. kristensenii, Y. mollaretii, Y. pestis, Y. pseudotuberculosis, Y. rohdei, and Y. ruckeri,* bacteria of the *Escherichia* genus, such as *E. albertii, E. blattae, E. coli, E. fergusonii, E. hermannii* and *E. vulneris*, bacteria of the Pedobacter genus, such as *P. heparinus, P. roseus sp. nov.* and *P. aquatilis sp. nov*, bacteria of the *Pseudomonas* genus, such as *P. aeruginosa, P. alcaligenes, P. mendocina, P. fluorescens, P. monteilii, P. oryzihabitans, P. luteola, P. putida, P. cepacia, P. stutzeri, P. maltophilia, P. putrefaciens, P. mallei* and *P. pseudomallei*, or bacteria of the *Klebsiella* genus, such as *K. pneumoniae, K. planticola K. oxytoca* and *K. rhinoscleromatis.* In other embodiments, *Candida* species as disclosed herein may be treated or prevented.

Moreover, the invention also provides that in addition to being administered alone, the vaccine and pharmaceutical compositions of the invention can be co-administered with one or more antibiotics. Antibiotics that can be useful for co-administration can be readily determined by one of skill in the art. Non-limiting examples of antibiotics that can be co-administered include a carbapenem antibiotic such as imipenem, or a second line antibiotic such as polymyxins, tigecycline, or aminoglycosides. See, Bassetti et al. (Future Microbiol., 3(6): 649–60 (December 2008)).

Treatment

The invention features methods of vaccinating a mammal against candidiasis including administering to the animal a vaccine as described herein, thereby vaccinating the mammal against candidiasis. Additionally, the invention features methods of passive immunization of a mammal against candidiasis including administering to the mammal an effective amount of a pharmaceutical composition as described herein, thereby passively immunizing the mammal against candidiasis. Candidiasis may include, e.g., disseminated candidiasis, e.g., hematogenously disseminated candidiasis, or mucosal candidiasis. In some instances, the candidiasis is caused, e.g., by *Candida albicans*, *Candida glabrata*, *Candida krusei*, *Candida parapsilosis*, or *Candida tropicalis*. Other *Candida* species include *Candida lusitaniae* and *Candida stellatoidea*.

Vaccines and antibody-containing pharmaceutical compositions (collectively "compositions") as described herein can be administered prophylactically or therapeutically on their own or in combination with other art-known compositions that induce protective responses against pathogens (e.g., viral, bacterial, fungal, or parasitic pathogens), tumors or cancers, allergens, autoimmune disorders, or graft rejection. For example, the compositions can be administered simultaneously, separately, or sequentially, e.g., with another immunization vaccine, such as a vaccine for, e.g., influenza, malaria, tuberculosis, smallpox, measles, rubella, mumps, or any other vaccines known in the art.

Compositions as described herein can be delivered to a mammalian subject (e.g., a human or other mammal described herein) using a variety of known routes and techniques. For example, a composition can be provided as an injectable solution, suspension, or emulsion, and administered via intramuscular, subcutaneous, intradermal, intracavity, parenteral, epidermal, intraarterial, intraperitoneal, or intravenous injection using a conventional needle and syringe, or using a liquid jet injection system. Compositions can also be administered topically to skin or mucosal tissue, such as nasally, intratracheally, intestinal, rectally or vaginally, or provided as a finely divided spray suitable for respiratory or pulmonary administration. Other modes of administration include oral administration, suppositories, and active or passive transdermal delivery techniques.

The compositions described herein can be administered to a mammalian subject (e.g., a human or other mammal described herein) in an amount that is compatible with the dosage formulation and that will be prophylactically and/or therapeutically effective. An appropriate effective amount will fall in a relatively broad range but can be readily determined by one of skill in the art by routine trials. The "Physicians Desk Reference" and "Goodman and Gilman's The Pharmacological Basis of Therapeutics" are useful for the purpose of determining the amount needed.

Prophylaxis or therapy can be accomplished by a single direct administration at a single time point or by multiple administrations, optionally at multiple time points. Administration can also be delivered to a single or to multiple sites. Those skilled in the art can adjust the dosage and concentration to suit the particular route of delivery. In one embodiment, a single dose is administered on a single occasion. In an alternative embodiment, a number of doses are administered to a subject on the same occasion but, for example, at different sites. In a further embodiment, multiple doses are administered on multiple occasions. Such multiple doses may be administered in batches, i.e. with multiple administrations at different sites on the same occasion, or may be administered individually, with one administration on each of multiple occasions (optionally at multiple sites). Any combination of such administration regimes may be used.

In one embodiment, different compositions of the invention may be administered at different sites or on different occasions as part of the same treatment regime.

Different administrations may be performed on the same occasion, on the same day, one, two, three, four, five or six days apart, or one, two, three, four or more weeks apart. In some instances, administrations are 1 to 5 weeks apart, e.g., 2 to 4 weeks apart, such as 2 weeks, 3 weeks or 4 weeks apart. The schedule and timing of such multiple administrations can be optimised for a particular vaccine or pharmaceutical composition by one of skill in the art by routine trials.

The term "treating" or "treatment," as it is used herein is intended to mean an amelioration of a clinical symptom indicative of a bacterial infection. Amelioration of a clinical symptom includes, for example, a decrease or reduction in at least one symptom of a bacterial infection in a treated individual compared to pretreatment levels or compared to an individual with a bacterial infection. Treating also is intended to include the reduction in severity of a pathological condition, a chronic complication or an opportunistic infection which is associated with a bacterial infection. Pathological conditions, chronic complications and opportunistic infections also can be found described in, for example, Merck Manual, Sixteenth Edition, 1992, and Acinetobacter: Molecular Biology, Ulrike Gerischer (Editor), Caister Academic Press; 1st edition (2008).

The term “preventing” or “prevention,” as it is used herein is intended to mean a forestalling of a clinical symptom indicative of a bacterial infection. Such forestalling includes, for example, the maintenance of normal physiological indicators in an individual at risk of infection by bacteria prior to the development of overt symptoms of the condition or prior to diagnosis of the condition. Therefore, preventing can include the prophylactic treatment of individuals to guard them from the occurrence of a bacterial infection. Preventing a bacterial infection in an individual also is intended to include inhibiting or arresting the development of the infection. Inhibiting or arresting the development of the condition includes, for example, inhibiting or arresting the occurrence of abnormal physiological indicators or clinical symptoms such as redness, heat, swelling and localized pain and/or others well known symptoms. Therefore, effective prevention of a bacterial infection would include maintenance of normal body temperature, weight or preventing other pathological manifestations in an individual predisposed to a bacterial infection. Individuals predisposed to a bacterial infection include an individual who is immunocompromised, for example, but not limited to, an individual with AIDS, azotemia, diabetes mellitus, diabetic ketoacidosis, neutropenia, bronchiectasis, emphysema, TB, lymphoma, leukemia, or burns, or an individual undergoing chemotherapy, bone marrow-, stem cell- and/or solid organ-transplantation or an individual with a history of susceptibility to a bacterial infection. Inhibiting or arresting the development of the condition also includes, for example, inhibiting or arresting the progression of one or more pathological conditions, chronic complications or susceptibility to an opportunistic infection associated with bacteria.

Dosages

An adequate dose of the vaccines or antibody-containing pharmaceutical compositions described herein may vary depending on such factors as preparation method, administration method, age, body weight and sex of the patient, severity of symptoms, administration time, administration route, rate of excretion, and responsivity. A physician of ordinary skill in the art will easily determine and diagnose the administration dose effective for treatment.

Compositions may be prepared into unit-dose or multiple-dose preparations by those skilled in the art using a pharmaceutically acceptable carrier and/or excipient according to a method known in the art.

Vectors

The invention also provides vectors containing the nucleic acids of the invention. Suitable expression vectors are well-known in the art and include vectors capable of expressing a nucleic acid operatively linked to a regulatory sequence or element such as a promoter region or enhancer region that is capable of regulating expression of the nucleic acid. Appropriate expression vectors include vectors that are replicable in eukaryotic cells and/or prokaryotic cells and vectors that remain episomal or integrate into the host cell genome.

The terms “vector”, “cloning vector” and “expression vector” mean the vehicle by which a nucleic acid can be introduced into a host cell. The vector can be used for propagation or harboring a nucleic acid or for polypeptide expression of an encoded sequence. A wide variety of vectors are known in the art and include, for example, plasmids, phages and viruses. Exemplary vectors can be found described in, for example, Sambrook et al., “Molecular Cloning: A Laboratory Manual,” 3rd Edition. Cold Spring Harbor Laboratories, Cold Spring Harbor, N.Y., 2001; and Ausubel et al., “Current Protocols in Molecular Biology,” John Wiley and Sons, Baltimore, MD (1999)).

Promoters or enhancers, depending upon the nature of the regulation, can be constitutive or regulated. The regulatory sequences or regulatory elements are operatively linked to a nucleic acid of the invention such that the physical and functional relationship between the nucleic acid and the regulatory sequence allows transcription of the nucleic acid.

Vectors useful for expression in eukaryotic cells can include, for example, regulatory elements including the SV40 early promoter, the cytomegalovirus (CMV) promoter, the mouse mammary tumor virus (MMTV) steroid-inducible promoter, Moloney murine leukemia virus (MMLV) promoter, and the like. The vectors of the invention are useful for subcloning and amplifying a nucleic acid molecule and for recombinantly expressing a polypeptide as disclosed herein. A vector of the invention can include, for example, viral vectors such as a bacteriophage, a baculovirus or a retrovirus; cosmids or plasmids; and, particularly for cloning large nucleic acid molecules, bacterial artificial chromosome vectors (BACs) and yeast artificial chromosome vectors (YACs). Such vectors are commercially available, and their uses are well known in the art. One skilled in the art will know or can readily determine an appropriate promoter for expression in a particular host cell.

The invention additionally provides recombinant cells containing nucleic acids of the invention. The recombinant cells are generated by introducing into a host cell a vector containing a nucleic acid molecule. The recombinant cells are transducted, transfected or otherwise genetically modified. Exemplary host cells that can be used to express recombinant molecules include mammalian primary cells; established mammalian cell lines, such as COS, CHO, HeLa, NIH3T3, HEK 293 and PC12 cells; amphibian cells, such as *Xenopus* embryos and oocytes; and other vertebrate cells. Exemplary host cells also include insect cells such as *Drosophila*, yeast cells such as *Saccharomyces cerevisiae*, *Saccharomyces pombe*, or *Pichia pastoris*, and prokaryotic cells such as *Escherichia coli*.

Embodiments of the present invention also provide specific HYR1 polypeptides that can act as antigens for generating an immune response to gram negative bacteria including bacteria of the *Acinetobacter* genus, for example, *Acinetobacter baumannii*. In some aspects of the invention, the HYR1 polypeptides of the invention include an amino acid sequence selected from SEQ ID NOS:3-10 as well as from CGPSAPESESDLNTP (SEQ ID NO: 11), CGNRDHFRFEYYPDT (SEQ ID NO: 12), CGYDSKLFRIVNSRG (SEQ ID NO: 13), CKIKGTGCVTADEDT (SEQ ID NO: 14), CLKNAVTYDGPVPNN (SEQ ID NO: 15), NSKSSTSFSNFDIGC (SEQ ID NO: 16), CEPTHNFYLKDSKSS (SEQ ID NO: 17), and TSRIDRGGIQGFHGC (SEQ ID NO: 18). Moreover, in some aspects of the invention, the HYR1 polypeptide can comprise less than 937, 936, 935, 934, 933, 932, 931, 930, 920, 910, 900, 890, 880, 870, 860, 850, 840, 830, 820, 810, 800, 790, 780, 770, 760, 750, 740, 730, 720, 710, 700, 690, 680, 670, 660, 650, 640, 630, 620, 610, 600, 590, 580, 570, 560, 550, 540, 530, 520, 510, 500, 490, 480, 470, 460, 450, 440, 430, 420, 410, 400, 390, 380, 370, 360, 350, 340, 320, 310, 300, 290, 280, 270, 260, 250, 240, 230, 220, 210, 200, 190, 180, 170, 160, 150, 140, 130, 120, 110, 100, 90, 80, 70, 60, 50, 40, 30 or 20 amino acid residues in length and can be immunogenic. In some aspects of the invention, the HYR1 polypeptides of the invention are not the HYR1 polypeptide of SEQ ID NO: 1.

In still other aspects, the invention also provides embodiments wherein the polypeptides include more than one amino sequence set forth in any one of SEQ ID NOS: 3-10 or SEQ ID NOS: 11-18. For example, the polypeptides of the invention can include two amino acid sequences such as SEQ ID NO: 15 in combination with SEQ ID NO: 12, or alternatively SEQ ID NO: 11 in combination with SEQ ID NO: 17, or alternatively SEQ ID NO: 13 in combination with SEQ ID NO: 18. It is understood that the polypeptides of the invention can include two, three, four, five, six, seven or all eight amino acid sequences selected from SEQ ID NOS;3-10 or SEQ ID NOS: 11-18. It is also understood that the amino acid sequence need not be contiguous and can be linked by intervening spacer sequences, which can, for example, allow the polypeptide to present the desired amino acid sequence or epitope for generating an immune response.

In some aspects of the invention, the polypeptides of the invention include substantially the same amino acid sequence set forth in any one of SEQ ID NOS: 3-10 or SEQ ID NOS: 11-18. For example, the amino acid sequence can have at least 65%, 70%, 75%, 80%, 85%, 90%, 95%, 98% or 99% sequence identity to any one of SEQ ID NOS: 11-18, wherein the polypeptide fragment can be bound by an anti-HYR1 antibody disclosed herein. In other aspects, the HYR1 polypeptide of the invention can be immunogenic and capable of eliciting production of an anti-HYR1 antibody or immunogenic response in a subject.

As described herein, the polypeptides of the invention can encompass substantially similar amino acid sequences having at least about 65% identity with respect to the reference amino acid sequence, and retaining comparable functional and biological activity characteristic of the reference amino acid sequence. In one aspect, polypeptides having substantially the same amino acid sequence will have at least 65% identity, at least 70% identity, at least 75% identity, at least 80% identity, at least 85% identity, at least 90% identity, at least 95% identity, at least 98% identity, or at least 99% identity. It is recognized, however, that polypeptides, or encoding nucleic acids, containing less than the described levels of sequence identity arising as splice variants or that are modified by conservative amino acid substitutions, or by substitution of degenerate codons are also encompassed within the scope of the present invention.

EXAMPLES

The following example is to illustrate the invention. It is not meant to limit the invention in any way.

EXAMPLE I

Active and Passive Immunization with rHyr1-N Protects Against Hematogenously Disseminated Candidiasis

HYR1 belongs to the *IFF* gene family of *C. albicans*, which includes 12 members. It encodes a cell surface glycosyl phosphatidylinositol (GPI)-anchored protein that is expressed during hyphal formation. It has previously been shown that Hyr1p mediates *C. albicans* resistance to phagocyte killing in vitro and contributes higher fungal burden in organs rich in phagocytes (e.g. liver and spleen). Native *HYR1* is positively regulated by transcription factor Bcr1p. It was found that autonomous *HYR1* expression reversed the hyper-susceptibility to phagocyte-mediated killing of a *bcr1* null mutant of *C. albicans in vitro*. Further, heterologous expression of *HYR1* in *C. glabrata* rendered the organism more resistant to neutrophil killing. Previous studies also showed that a vaccine based on the recombinant N terminus of Hyr1p (rHyr1p-N) markedly improved survival of immunocompetent mice challenged intravenously with *C. albicans* when mixed with either Freund's or alum as an adjuvant.

The current studies were performed, *inter alia*, to further define the vaccine efficacy of rHyr1p-N vaccine in both immunocompetent and immunocompromised mice using FDA-approved alum as an adjuvant. Further, the breadth of protection induced by rHyr1p-N was evaluated by its efficacy against non-*albicans Candida* species. Finally, we sought to study the potential use of passive immune therapy in disseminated candidiasis using anti-Hyr1 antibodies.

Materials and Methods

Candida strains and growth conditions

C. albicans 15663, *C. glabrata* 31028, *C. parapsilosis* 22019 and *C. tropicalis* 4243 are clinical bloodstream isolates collected from Harbor-UCLA Medical Center. *C. krusei* 91-1159 was generously provided by Michael Rinaldi, San Antonio, TX. *C. albicans* strains CAAH-31 and THE31 were engineered as described in our previous study and doxycycline was used to regulate the *HYR1* expression Luo et al., J. Infect. Dis. 201: 1718-1728 (2010)]. All tested strains were routinely grown in YPD (2% Bacto Peptone, 1% yeast extract, 2% dextrose). Cell densities were determined by counting in a hemacytometer.

rHyr1p-N production

6XHis tagged rHyr1p-N was produced in *E. coli* and purified by Ni-agarose affinity column as previously described [Luo et al., J. Infect. Dis. 201: 1718-1728 (2010)]. Endotoxin was removed from rHyr1p-N using ProteoSpin Endotoxin Removal kit (Norgen Bioteck Corporation, Ontario, Canada), and the endotoxin level was determined with Limulus Amebocyte Lysate endochrome (Charles River Laboratories, Wilmington, MA) per manufacturer's instruction. Using this procedure, endotoxin was reduced to <0.1 EU per dose of the vaccine.

Synthetic peptides and rabbit anti-Hyr1p polyclonal antibodies

Eight peptides derived from rHyr1p-N (Table 1) were commercially synthesized and used to generate anti-Hyr1p antibodies. Peptides were >85% pure as determined by HPLC and mass spectrometry

(GenScript, Piscataway, NJ). They were conjugated to keyhole limpet hemocyanin (KLH) before raising rabbit antiserum individually using a standard immunization protocol (GenScript, Piscataway, NJ). Total IgG from pooled serum was affinity purified using Pierce Protein A plus Agarose (Thermo Scientific, Rockford, IL) per the manufacturer's instruction prior to administering in passive immunization studies.

Immunofluorescence detection of Hyr1p cellular localization

Indirect immunofluorescence was performed using pooled rabbit anti-Hyr1p IgG raised against 8 peptides of r-Hyr1p-N as previously described [Luo et al., J. Infect. Dis. 201: 1718-1728 (2010)]. In brief, *C. albicans* blastospores (1x 10^7) were pre-germinated in RPMI 1640 for 90 min at 37°C and transferred into a 4-well chamber slide (Nalge Nunc International). After incubation at 4°C for 30 min, the cells were blocked with 300 µl of 1.5% mouse serum, then stained with 1:500 dilution of either 1) pooled anti-Hyr1 IgGs, 2) pooled anti-Hyr1p IgG absorbed with *C. albicans* hyphae (by incubating the pooled IgG repeatedly for 4 times with 1 x 10^7 *C. albicans* hyphae for 30 min each time on ice), or 3) control rabbit IgG. The cells were counterstained with fluorescein isothiocyanate (FITC)-labeled goat anti-rabbit IgG at 1:100 dilution prior to imaging with Zeiss *Axioskop* fluorescence microscopy.

Immunization protocol and animal studies

All active vaccinations were conducted as previously described [Luo et al., J. Infect. Dis. 201: 1718-1728 (2010)]. In brief, juvenile (10-12 week) Balb/C mice were vaccinated subcutaneously with 30 µg of rHyr1p-N mixed with alum (2% Alhydrogel; Brenntag Biosector, Frederikssund, Denmark) as an adjuvant in phosphate buffered saline (PBS) on day 0, boosted with the same dose on day 21, then infected via the tail vein on day 35 [Ibrahim et al., Infect. Immun. 73:999-1005 (2005)]. Control mice were vaccinated with alum alone.

To test the efficacy of the vaccine in immunocompromised mice, mice were vaccinated as above prior to inducing neutropenia by intraperitoneal injection of 200 mg/kg of cyclophosphamide on day –2 followed by another dose of 100 mg/kg on day +7 relative to infection. This regimen results in approximately 10 days of leucopenia with reduction in neutrophil, lymphocyte and monocyte counts, as described previously [Spellberg et al., Infect. Immun. 73:6191-6193 (2005); Fu et al., Eukaryot. Cell. 7:483-492 (2008); Sheppard et al., Antimicrob. Agents Chemother. 48:1908-1911 (2004)]. For both immunocompetent and neutropenic mice differences in survival between vaccinated and adjuvant vaccinated mice were compared by the Log Rank test.

For passive immunization, immune IgG was administered intraperitoneally to naïve mice 2 h before infecting i.v. with *C. albicans*. Control mice were given isotype matching IgG (Innovative Research, USA). IgG doses were repeated 3 days after infection, and survival of mice was monitored twice daily.

Quantitative culturing of kidneys from vaccinated or control mice infected with different species of *Candida* was performed as previously described [Ibrahim et al., Infect. Immun. 74:3039-3041 (2006)]. In brief, mice were infected through tail veins. Kidneys were harvested 3 day post infection, homogenized, serially diluted in 0.85% saline, and quantitatively cultured on YPD that contained 50 μg/mL chloramphenicol. Colonies were counted after incubation of the plates at 37°C for 24 to 48 h, and results were expressed as log CFU per gram of infected organ.

Concomitant with the fungal burden experiment, kidneys were removed aseptically from two mice per group for histopathological examination. Kidneys were immersed in zinc formalin fixative until examination. Fixed organs were dehydrated in graded alcohol solutions, embedded in paraffin, and cut into 6-μm-thick sections. Mounted sections were stained with Gomori methenamine silver and examined by light microscopy [Davis et al., Infect. Immun. 68:5953-5959 (2000)].

Enzyme-linked immunosorbent assay (ELISA)

To test if the rHyr1p-N vaccine induced an immune response, antibody titers of serum samples collected from vaccinated and control mice were determined by ELISA in 96-well plates as previously described [Ibrahim et al., Infect. Immun. 73:999-1005 (2005)]. Wells were coated at 100 μl per well with rHyr1p-N at 5 μg/ml in PBS. Mouse sera were incubated for 1 h at room temperature following a blocking step with Tris-buffered saline (TBS; 0.01 M Tris HCl [pH 7.4], 0.15 M NaCl) containing 3% bovine serum albumin. The wells were washed three times with TBS containing 0.05% Tween 20, followed by another three washes with TBS. Goat anti-mouse secondary antibody conjugated with horseradish peroxidase (Sigma) was added at a final dilution of 1:5000, and the plate was further incubated for 1 h at room temperature. Wells were washed with TBS and incubated with substrate containing 0.1 M citrate buffer (pH 5.0), 50 mg of *o*-phenylenediamine (Sigma), and 10 μl of 30% H_2O_2. The color was allowed to develop for 30 min, after which the reaction was terminated by addition of 10% H_2SO_4 and the optical density (OD) at 490 nm was determined in a microtiter plate reader. Negative control wells received only diluent, and background absorbance was subtracted from the test wells to obtain final OD readings. The ELISA titer was taken as the reciprocal of the last serum dilution that gave a positive OD reading (i.e., more than the mean OD of negative control samples plus 2 standard deviations).

F(ab')$_2$ *blocking assay*

To study the mechanism of protection mediated by anti-Hyr1p antibodies in phagocyte-mediated killing of *C. albicans,* HL-60 cells that have been differentiated to neutrophil-like phenotype were used [Luo et al., J. Infect. Dis. 201: 1718-1728 (2010)]. Killing assay was conducted in the presence of anti-Hyr1p IgG or F(ab')$_2$ fragments as described before [Luo et al., J. Infect. Dis. 201: 1718-1728 (2010)]. In brief, HL-60 cells were induced with 2.5 μM of retinoic acid and 1.3% DMSO for three days at 37°C with 5%CO_2. Immune anti-Hyr1 peptides (Table 1) sera were pooled and total IgG was isolated using protein A agarose (Thermo Scientific). Serum collected from the same rabbits prior to immunization with the peptides served as control serum. The F(ab')$_2$ fragments from immune or control IgG were purified with Pierce F(ab')$_2$ Preparation Kit according to the manufacturer's instruction. SDS-PAGE analysis indicated >95% of Fc fragment was digested by this kit (data not shown). Next, *C. albicans* cells overexpressing or suppressing Hyr1p [Luo et al., J. Infect. Dis. 201: 1718-1728 (2010)] were incubated with 50 μg/ml of vaccinated or control F(ab')$_2$ fragments on ice for 45 min. *C. albicans* cocultured with the $F(ab')_2$ fragments were incubated with HL-60 derived neutrophils for 1 h at 37°C with 5% CO_2 prior to sonication and quantitative culturing on YPD plates. % killing was calculated by dividing the number of CFU after coculturing with HL-60 derived neutrophils by the number of CFU from *C. albicans* incubated with media without neutrophil-like cells.

Statistical analysis

The nonparametric log rank test was used to determine differences in the survival times of the mice. Neutrophil killing assay, titers of antibody, and tissue fungal burden were compared by the Mann-Whitney U test for unpaired comparisons. Correlations were calculated with the Spearman rank sum test. P values of <0.05 were considered significant.

All procedures involving mice were approved by the Los Angeles Biomedical Research Institute animal use and care committee for the project 11672-05 specifically to this vaccine study, following the National Institutes of Health guidelines for animal housing and care. The institute has a US Public Health Service approved animal welfare assurance number A3330-01.

Results

The rHyr1p-N vaccine significantly improved survival and decreased fungal burden in immunocompetent mice challenged i.v. with C. albicans.

To determine the most effective dose of the rHyr1p-N immunogen, a 3-fold dose range was evaluated (1 to 30 µg per mouse). Female juvenile BALB/c mice were immunized with rHyr1p-N plus alum (2% Alhydrogel; Brenntag Biosector) or with alum alone. These mice were subsequently infected with a lethal inoculum of *C. albicans* (7×10^5 blastospores). Vaccinated mice had significant improvements in survival compared to adjuvant control mice (Figure 1A). All tested doses, except 1 µg, prolonged or improved survival compared to mice receiving adjuvant alone, and a dose response was found with 10 and 30 µg having the greatest efficacy (Figure 1A). The experiment was terminated on day 28, with all remaining mice appearing healthy.

To determine the impact of vaccination on fungal burden, juvenile mice were vaccinated and infected as above. On day 3 post-infection (one day before the control mice were predicted to die based on the previous experiment), mice were euthanized and kidneys, being the primary target organ, were harvested to determine tissue fungal burden. Vaccination reduced the tissue fungal burden by approximately 16-fold compared to control mice ($p < 0.01$) (Figure 1B).

Consistent with the survival and fungal burden data, histopathological examination of kidneys harvested from rHyr1p-N vaccinated mice demonstrated very few abscesses with minimal fungal residues mainly present in the blastospore formation (Figure 2B). In contrast, numerous abscesses full of fungal cells showing mostly yeast forms with some hyphae and pseudohyphae were detected in kidneys taken from mice vaccinated with alum alone (Figure 2A). Semi-quantitative evaluation of the severity of infection showed a significant reduction of abscesses per field as well as reduced *Candida* cells per abscess in vaccinated mice compared to that in controls (Fig. 2C, $P < 0.0001$ by Wilcoxon rank sum test).

The rHyr1p-N effectively protected immunocompromised mice against candidiasis

It is known that a significant fraction of immunocompromised patients do respond to a variety of vaccines [Dockrell et al., Vaccine 17:2779-2785 (1999); Chokephaibulkit et al., Vaccine 22:2018-2022 (2004); dos Santos et al., AIDS Res. Hum. Retroviruses 20:493-496 (2004); King et al., Pediatrc. Infect. Dis. 15:192-196 (1996)]. We sought to define the potential usage of the rHyr1p-N vaccine to protect neutropenic mice from disseminated candidiasis. Immunized mice were bled twelve days following the boost with 30 mg of rHyr1p-N. Vaccination significantly increased the mouse immune response as determined by detection of increased anti-rHyr1p-N antibody titers (Figure 3A). One day after the bleeding, mice were made neutropenic. Vaccination resulted in significant improvements in survival (P = 0.007 by log rank test versus control) (Figure 3B).

We also evaluated the kidney fungal burden on day 10 post infection. Concordant with our survival result, we found that mice vaccinated with 30 µg of rHyr1p-N had 1.50 log fold decrease in fungal burden compared to kidneys harvested from control mice (Figure 3C, P=0.0021 by Wilcoxon rank-sum test).

Passive immunization with anti-Hyr1 IgG prolonged the survival of mice infected with C. albicans

Since some patients might not respond to an active vaccine strategy, we evaluated the possibility of using passive immunotherapy targeting Hyr1p. We generated polyclonal antibodies by vaccinating rabbits with 8 hydrophilic, highly antigenic 14-mer peptides located within rHyr1p-N region (Table 1). Purified IgG targeting these 8-hydrophilic peptides were pooled and used to treat naïve mice infected with a lethal dose of *C. albicans*. Mice receiving anti-Hyr1p IgGs at either 1 or 3 mg (but not when administered at 0.3 mg) were protected substantially from infection when compared to mice receiving non-specific, control IgG from commercial source (Figure 4A, B and C).

To determine if the generated anti-Hyr1p antibodies enhanced phagocyte function by increasing opsonophagocytosis or by neutralizing the Hyr1p virulence function, we isolated and prepared $F(ab')_2$ fragments from pooled IgG raised against the 8 peptides of Hyr1p or from isotype-matching control IgG. These fragments were used in HL-60 derived neutrophil killing assay against *C. albicans* conditionally overexpressing or suppressing Hyr1p rather than wild-type *C. albicans* to demonstrate specificity of these fragments to Hyr1p and not to other members of Iff family [d'Enfer et al., Nucleic Acids Res. 33:D353-357 (2005)]. Consistent with our previous mouse IgG data [Luo et al., J. Infect. Dis. 201: 1718-1728 (2010)], we found that $F(ab')_2$ fragments prepared from anti-Hyr1p antibodies but not those prepared from control antibodies were able to restore HL-60 derived neutrophil killing of the *HYR1* conditional expressing strain to levels equivalent to that of the suppressing strain (Figure 4D).

To verify that the protection elicited by antibodies was indeed due to anti-Hyr1p antibodies and not due to non-specific protection caused by antibodies reacting to unrelated immunogen (e.g. antibodies against KLH), the purified IgG targeting the 8 hydrophilic rHyr1p-N peptides was absorbed with *C. albicans* hyphae prior to testing for their protective activity against hematogenously disseminated candidiasis. The absorbed IgG did not stain *C. albicans* hyphae (Figure 5A), indicating the anti-Hyr1p IgG were eliminated. Furthermore, similar to control IgG (i.e. non-specific IgG from commercial source), the absorbed IgG did not protect mice from *C. albicans* infection, whereas the unabsorbed purified IgG did (Figure 5B, p=0.002). These results confirm the specificity of the anti-rHyr1p antibodies in protecting against hematogenously disseminated candidiasis.

The rHyr1p-N vaccine substantially reduced tissue fungal burden in BALB/c mice challenged with several non- albicans species of Candida.

A vaccine that elicits protection against *C. albicans* and other non-*albicans* species is highly desirable because a significant number of *Candida* infections are caused by non-*albicans* species. For example, *C. glabrata* represents the second most common cause of candidiasis and *C. krusei* is resistant to azole therapy. Using blast searches we were able to detect Hyr1p-N orthologs in several *Candida* species with amino acid similarity ranging between 47-72% in certain area. Thus, we vaccinated mice with rHyr1p-N plus alum as above, then challenged with *C. albicans, C. glabrata, C. krusei, C. parapsilosis,* or *C. tropicalis.* Three days post infection mice were sacrificed and the kidneys harvested for determination of tissue fungal burden through colony counts. Mice vaccinated with rHyr1p-N had 0.65-1.69 log decrease in kidney fungal burden compared to mice vaccinated with alum alone (Figure 6).

We have identified properties of the recombinant N-terminus of Hyr1p (rHyr1p-N) [Luo et al., J. Infect. Dis. 201: 1718-1728 (2010)] that make it useful as both active and passive immunotherapy target. Rabbit polyclonal IgG raised against 8 different 14-mer peptides from regions of rHyr1p-N substantially protects mice from experimental disseminated candidiasis. Furthermore, the rHyr1p-N maintained its efficacy in the neutropenic mouse model.

Tissue fungal burden and histopathological examination of kidneys harvested from mice vaccinated with rHyr1p-N or alum alone further confirmed the efficacy of the rHyr1p-N vaccine. However, the histopathology difference between control (Figure 2A) and rHyr1p-N vaccinated mice (Figure 2B) was far more prominent than that of tissue fungal burden of the same organs. In this regard, it has been previously reported that colony counting can underestimate the tissue fungal burden in the presence of hyphae and pseudohyphae [Spellberg et al., J. Leukoc. Biol. 78:338-344 (2005), Spellberg et al., J. Infect. Dis. 194:256-260 (2006)], likely because tissue homogenization kills fungal filaments. We found that control mice had significantly more filamentous fungi in kidneys than vaccinated mice which had less abscesses mainly consisting of yeast form fungal elements. Therefore, tissue homogenization likely artificially lowers the colony counts for kidneys harvested from control mice but not from rHyr1p-N-vaccinated mice, making the difference less prominent.

Our results also show a dose response of anti-Hyr1p IgG in protecting mice from disseminated candidiasis. We also confirmed that the protection elicited by anti-Hyr1p IgG was specific to Hyr1p since absorbed IgG with *C. albicans* hyphae lost its ability to protect mice against hematogenously disseminated candidiasis (Figure 5B). These results suggest that the mechanism of protection rendered by rHyr1p-N appears to be attributed, at least in part, to protective antibody response.

In this study, we show that pooled IgG raised against 8 Hyr1 peptides directly neutralize the function of Hyr1p in resisting phagocyte killing rather than enhance opsonophagocytosis. This is evident by the ability of $F(ab')_2$ fragments' (prepared from anti-rHyr1p-N antibodies) to restore phagocyte killing of *C. albicans* overexpressing Hyr1p to levels equivalent to that of the suppressing strain (Figure 4D). However, the rHyr1p-N vaccine maintained its efficacy in neutropenic mice. This can be explained by the fact that cyclophosphamide induces leukopenia in mice with minimal effect on tissue phagocytes.

In summary, the rHyr1p-N vaccine is efficacious in both immunocompetent and immunocompromised mice, when mixed with alum as an adjuvant, against multiple clinical isolated strains of *C. albicans*, and against several non-*albicans Candida* species.

EXAMPLE II

HYRl Protein Fragments Prevent Infections by *Acinetobacter baumannii*

Candida albicans is a diploid fungus that grows both as yeast and filamentous cells. *C. albicans* causes approximately 60,000 cases of disseminated candidiasis per year in the United States. The *C. albicans* HYR1 protein is a cell surface protein that confers phagocyte resistance to fungal cells by white blood cells during fungal infections. Vaccination with a recombinant HYR1 protein has been shown to protect mice against *Candidia* infection. Moreover, passive immunization with anti-HYR1 protein antibodies protects against hematogenously disseminated candidiasis.

Through predictive structure homology modeling, the *C. albicans* HYR1 protein was discovered to have considerable homology to several proteins from gram negative bacteria, including *Acinetobacter baumannii*. Consequently, the feasibility of using active and passive immunization targeting HYR1 protein in protecting against *Acinetobacter baumannii* was examined.

Three-dimensional structure homology studies were conducted using convergent methods of structural homology modeling. These include multiple sequence aligment, threading to structural homologes based on sequence identity and similarity, and three dimensional structural modeling. This analysis revealed that the full length *Candidal* HYRl polypeptide has significant homology to proteins from several gram negative bacteria including *Haernophilus, Bordetella, Salmonella, Bordetella, Yersina, Escherichia and Acinetobacter* species (Table 3).

Table 3:

Homology Modeling of Hyr1 Vaccine Primary and Secondary Structure

PDB Code (Link)	Identity	e Value	Precision	Superfamily	Specific Homologue	Original Source Pathogen
2odL	12%	0.0016	95%	Chain A adhesin	HMW1 virulence factor	*Haemophilus influenzae* (G-)
1daB	11%	0.06	95%	Pectin-Lyase	Virulence p69 pertactin	*Bordetella pertussis* (G-)
1wlG	7%	0.11	90%	Flagellar body	Flagellar hook (flgE)	*Salmonella typhimurium* (G-)
1rwR	9%	0.26	90%	Pectin-Lyase	FH secretion domain (fhaB)	*Bordetella pertussis* (G-)
1cwV	8%	0.37	85%	Invasin	Integrin binding protein	*Yersina pseudotuber.* (G-)
1dbO	8%	0.86	75%	Chondroitinase	Chondroitinase B	*Escherichia coli* (G-)
1qiU	14%	0.93	75%	Fiber protein	Adenovirus fiber shaft	*Adenovirus* (viral)
1rwI	11%	1	75%	6-bladed Propeller	Kinase sensor domain	*Mycobact. tuberculosis* (G+)
1ofL	9%	1.2	70%	Pectin-Lyase	Chondroitinase B	*Pedobacter heparinus* (G-)
2z2O	7%	1.4	65%	Lyase	Virginiamycin B lyase	*Staphylococcus aureus* (G+)

Based on the structural analysis studies, rHYR1-N (SEQ ID NO: 2) was produced in *E. coli* and was used to actively vaccinate mice. Mice were immunized with aluminum hydroxide alone (n=10) or rHYR1p-N (30 mg) mixed with aluminum hydroxide (n=9) on day 0, and boosted on day 21. The vaccinated mice were subsequently infected with *A. baumannii* on day 35. The vaccinated mice had a 67% survival compared to 10% survival in the control arm (p <0.05 by Log Rand test) (Figure 7). Additionally, the bacterial burden in the tissue of mice vaccinated and infected similarly was examined. The bacterial burden as measured by the number of colony forming units per gram of tissue showed that tissue isolates from kidney, lung and spleen had a lower bacterial burden as compared to control tissue samples (Figure 8).

Polyclonal antibodies were next raised in rabbits against eight specific polypeptide regions chosen from the HYRl protein. These regions were structurally mapped to be exposed hydrophilic regions when expressed by *C. albicans* and predicted to be highly antigenic. The eight specific polypeptide regions consisted of 14 amino acid residues plus an additional cysteine residue on either the N-terminus or the C-terminus of the polypeptide (Table 2). The terminal cysteine residues provided for attachment to the carrier protein, Keyhole limpet hemocyanin (KLH), which was used for production of the polyclonal antibodies.

Overall passive immunization against *Acinetobacter baumannii* infection was assayed in diabetic mice. Purified IgG from the eight different polyclonal antibodies generated above were pooled and given to diabetic mice (n=20) 2 hours prior to infection. Commercially available unrelated rabbit IgG was given to diabetic control mice (n=18). The mice were then infected with a lethal dose of *Acinetobacter* *baumannii* via tail vein injection. Mice receiving a single dose of the anti-Hyrlp IgG survived significantly longer than mice receiving the control IgG (i.e. - 80% survival in the anti-Hyrlp IgG vs. 0 % in the control arm, p<0.0001 by Log Rank test) (Figure 9).

Passive immunization with polyclonal antibodies against individual amino acid sequences were also assayed in diabetic mice infected by *Acinetobacter baumannii.* Two hours prior to infection, diabetic mice were treated with 1 mg of rabbit control IgG (n=18) or polyclonal anti-HYR1 polypeptide IgG raised individually against one of eight different synthetic HYR1 peptides (Table 2). Additionally, two separate combination pools of antibodies were assayed. Combination 1 included antibody Nos. 2, 3, 5 and 8 and combination 2 included antibody Nos. 2, 5 and 8. Antibodies raised against peptide #5 (SEQ ID NO: 15) protected mice from *Acinetobacter baumannii* infection to a degree similar to the pool of antibodies (i.e. 86% survival with anti-peptide 5 Ab vs. 80% survival with the pooled IgG). The results of these experiments are shown in Figure 10.

EXAMPLE III

Anti-HYR1 Antibody Binds Specific Proteins Expressed by *Acinetobacter baumannii*

Cell wall extracts from *Acinetobacter baumannii* were run on a two-dimensional gel and assayed by western blot using rabbit IgG raised against CLKNAVTYDGPVPNN (SEQ ID NO: 15). The blots were compared to pre-immune serum as a control. The anti-HYRl IgG recognized unique bands from cell wall extracts (Figure 11). Select spots were extracted and sequenced. Sequencing analysis showed that the anti-HYRl antibody cross reacted with several proteins including an outer membrane protein 1 of *Acinetobacter baumannii* (GI No.|126642014| GenBank ref|YP_001084998.1|) (SEQ ID NO: 19), an outer membrane protein 2 of *Acinetobacter baumannii* (GI No.|126640296| GenBank ref|YP_001083280.1|) (SEQ ID NO: 20), an ferric siderophore receptor protein of *Acinetobacter baumannii* (including GI No.|126641700| GenBank ref|YP_001084684.1| (SEQ ID NO: 21) ; GI No.|126640547| GenBank ref|YP_001083531.1| (SEQ ID NO: 22) ; GI No.|126643331| GenBank ref|YP_001086315.1|) (SEQ ID NO: 23), an Dnak heat shock protein of *Acinetobacter baumannii* (GI No.|126642981| GenBank ref|YP_001085965.1|) (SEQ ID NO: 24), elongation factor G of *Acinetobacter baumannii* (GI No.|126640918| GenBank ref|YP_001083902.1|) (SEQ ID NO: 25), organic solvent tolerance protein precursor of *Acinetobacter baumannii* (GI No.|126641591| GenBank ref|YP_001084575.1|) (SEQ ID NO: 26), putative lipoprotein precursor (VacJ) transmembrane of *Acinetobacter baumannii* (GI No.|126640689| GenBank ref|YP_001083673.1|) (SEQ ID NO: 27), putative glucose-sensitive porin (OprB-like) of *Acinetobacter baumannii* (GI No.|126642873| GenBank ref|YP_001085857.1|) (SEQ ID NO: 28), AdeA membrane fusion protein of *Acinetobacter baumannii* (GI No.|126641797| GenBank ref|YP_001084781.1|) (SEQ ID NO: 29), cell division protein of *Acinetobacter baumannii* (GI No.|126643339| GenBank ref|YP_001086323.1|) (SEQ ID NO: 30), and cell division protein FtsZ of *Acinetobacter baumannii* (GI No.|126643338| GenBank ref|YP_001086322.1|) (SEQ ID NO: 31).

Other Embodiments

All publications including GenBank and GI number publications, patents, and patent applications mentioned in the above specification are hereby incorporated by reference. Various modifications and variations of the described methods of the invention will be apparent to those skilled in the art without departing from the scope and spirit of the invention. Although the invention has been described in connection with specific embodiments, it should be understood that the invention as claimed should not be unduly limited to such specific embodiments. Indeed, various modifications of the described modes for carrying out the invention that are obvious to those skilled in the art are intended to be within the scope of the invention.

Other embodiments are in the claims.

CLAIMS

1. A vaccine comprising an isolated *Candida* Hyr1 protein (SEQ ID NO: 1), or an immunogenic fragment thereof, for use in a method of treatment or prevention of an Acinetobacter infection in a mammal.

2. The vaccine for use according to claim 1, wherein said *Candida* Hyr1 protein or fragment thereof is derived from *Candida albicans*, *Candida krusei*, *Candida tropicalis*, *Candida glabrata* or *Candida parapsilosis*.

3. The vaccine for use according to claims 1 or 2, wherein said infection results from *Acinetobacter baummani*.

4. The vaccine for use according to any of the aforementioned claims, wherein the immunogenic fragment is an N-terminal region fragment of said *Candida* Hyr1 protein.

5. The vaccine for use according to any of the aforementioned claims, wherein the immunogenic fragment comprises an amino acid sequence shown in SEQ ID NO: 2 or an Hyr1p fragment shown in Table 1 or 2.

6. The vaccine for use according to any of the aforementioned claims, wherein the immunogenic fragment is one of more of the Hyr1p fragments shown in Table 1 or 2 or an immunogenic fragment thereof.

7. The vaccine for use according to any of the aforementioned claims, wherein said vaccine is administered subcutaneously; as a booster dose; or comprises an immunostimulating adjuvant (such as alum).

8. The vaccine for use according to any of the aforementioned claims, wherein said Hyr1p, or immunogenic fragment thereof, is recombinantly produced (such as in *Saccharomyces cerevisiae*) or is chemically synthesized..

9. An isolated polypeptide comprising the amino acid sequence of any one of SEQ ID NOs: 3-10, or a variant sequence thereof having up to three substitutions, deletions, or additions to said amino acid sequence of any one of SEQ ID NOs: 3-10, wherein said polypeptide does not comprise more than 20 contiguous amino acids of SEQ ID NO: 2.

10. The polypeptide of claim 9, comprising the amino acid sequence of any one of SEQ ID NOs: 3-10.

11. The polypeptide of claim 9 or 10, wherein the amino acid sequence of said polypeptide consists of between 14 and 20 amino acids.

12. The polypeptide of any one of claims 9-12, wherein the N-terminal amino acid residue or C-terminal amino acid residue of said polypeptide is cysteine; wherein the amino acid sequence of said polypeptide comprises the amino acid sequence of any one of SEQ ID NOs: 11-18; or wherein the amino acid sequence of said polypeptide consists of the amino acid sequence of any one of SEQ ID NOs: 11-18.

13. An isolated conjugate comprising the polypeptide of any one of claims 9-12 conjugated to a carrier.

14. The conjugate of claim 14, wherein said carrier is keyhole limpet hemocyanin (KLH), CRM197, or tetanus toxoid.

15. The conjugate of claim 14, wherein said carrier is a phage, a yeast, a virus, virosome, or a recombinant virus-like particle, or wherein said conjugate is a recombinant fusion protein.

16. A vaccine comprising an immunogenic amount of the polypeptide of any one of claims 9-12 or the conjugate of any one of claims 13-15, and a pharmaceutically acceptable excipient.

17. The vaccine of claim 16, comprising a mixture of distinct polypeptides of any one of claims 9-12 or conjugates of any one of claims 13-15.

18. The vaccine of any one of claims 16-17; or wherein said polypeptide or conjugate is produced synthetically; or wherein said polypeptide or conjugate is produced recombinantly.

19. The vaccine of any one of claims 16-18 for use in the vaccination of a mammal (e.g. a human) against candidiasis or for use in the vaccinations of a mammal (e.g. a human) against Acinetobacter.

20. The vaccine of claim 19, wherein said vaccine is to be administered by intramuscular, subcutaneous, or intradermal administration.

21. A method of vaccinating a mammal against candidiasis comprising administering to said mammal the vaccine of any one of claims 16-20, thereby vaccinating said mammal (e.g. human) against

candidiasis.

22. A method of vaccinating a mammal against Acinetobacter comprising administering to said mammal the vaccine of any one of claims 16-20, thereby vaccinating said mammal (e.g. a human) against an Acinetobacter infection.

23. A method of producing a chimeric vaccine comprising the steps of:

(a) providing a phage, yeast, or virus;

(b) inserting into said phage, yeast, or virus a nucleic acid molecule that encodes the polypeptide of any one of claims 9-12 or 13-15;

(c) allowing expression of said polypeptide in said phage, yeast, or virus;

(d) isolating said phage, yeast, or virus of step (c) comprising said expressed polypeptide; and

(e) adding a pharmaceutically acceptable excipient to said isolated phage, yeast, or virus of step (d).

24. The method of claim 23, wherein said polypeptide is displayed on the surface of said phage, yeast, or virus following step (c).

25. An isolated monoclonal antibody that binds to the polypeptide of any one of claims 9-12 or the conjugate of any one of claims 13-15.

26. A diagnostic composition comprising the antibody of claim 25.

27. A pharmaceutical composition comprising the antibody of claim 25.

28. A pharmaceutical composition comprising polyclonal antibodies that bind to the polypeptide of any one of claims 9-12 or the conjugate of any one of claims 13-15, or that bind to a mixture of distinct polypeptides of any one of claims 9-12 or conjugates of any one of claims 13-15.

29. The pharmaceutical composition of claims 27 or 28 for use in the passive immunization of a mammal against candidiasis.

30. The pharmaceutical composition of claims 27 or 28 for use in the passive immunization of a mammal against Acinetorbacter.

31. A method of passive immunization of a mammal against candidiasis comprising administering to said mammal an effective amount of the pharmaceutical composition of any one of claims 27 or 28, thereby passively immunizing said mammal against said candidiasis.

32. The method of claim 31, wherein said mammal is a human.

33. The method of claim 31 or 32, wherein said pharmaceutical composition is administered by intramuscular, subcutaneous, or intradermal administration.

34. A method of passive immunization of a mammal against Acinetobacter comprising administering to said mammal an effective amount of the pharmaceutical composition of any one of claims 27 or 28, thereby passively immunizing said mammal against said Acinetobacter.

35. The method of claim 34, wherein said mammal is a human.

36. The method of claim 34 or 35, wherein said pharmaceutical composition is administered by intramuscular, subcutaneous, or intradermal administration.

37. An isolated nucleic acid encoding a HYR1 polypeptide comprising an amino acid sequence selected from CGPSAPESESDLNTP (SEQ ID NO: 11), CGNRDHFRFEYYPDT (SEQ ID NO:12), CGYDSKLFRIVNSRG (SEQ ID NO: 13), CKIKGTGCVTADEDT (SEQ ID NO: 14), CLKNAVTYDGPVPNN (SEQ ID NO: 15), NSKSSTSFSNFDIGC (SEQ ID NO: 16), CEPTHNFYLKDSKSS (SEQ ID NO: 17), and TSRIDRGGIQGFHGC (SEQ ID NO: 18), wherein said polypeptide comprises less than 930 amino acid residues in length.

38. The isolated nucleic acid of claim 37, wherein said amino acid sequence consists of the amino acid sequence set forth in any one of SEQ ID NOS: 11-18.

39. The isolated nucleic acid of claim 37, wherein said polypeptide comprises less than 900, 800, 700, 600, 500, 400, 300, 200, 100, 90, 80, 70, 60, 50, 40, 30 or 20 amino acid residues in length.

40. A vector containing the nucleic acid of claim 37.

41. A recombinant cell containing the nucleic acid of claim 37.

42. A kit for detecting the presence of *Acinetobacter* in a sample comprising at least one oligonucleotide comprising between 15 to 300 contiguous nucleotides that encode an outer membrane

protein 1 of *Acinetobacter baumannii*, an outer membrane protein 2 of *Acinetobacter baumannii*, an ferric siderophore receptor protein of *Acinetobacter baumannii*, an Dnak heat shock protein of *Acinetobacter baumannii*, an elongation factor G of *Acinetobacter baumannii*, an organic solvent tolerance protein precursor of *Acinetobacter baumannii*, a putative lipoprotein precursor (VacJ) transmembrane of *Acinetobacter baumannii*, a putative glucose-sensitive porin (OprB-like) of *Acinetobacter baumannii*, an AdeA membrane fusion protein of *Acinetobacter baumannii*, a cell division protein of *Acinetobacter baumannii*, or a cell division protein FtsZ of *Acinetobacter baumannii*.

43. An isolated HYR1 polypeptide comprising an amino acid sequence selected from CGPSAPESESDLNTP (SEQ ID NO: 11), CGNRDHFRFEYYPDT (SEQ ID NO: 12), CGYDSKLFRIVNSRG (SEQ ID NO: 13), CKIKGTGCVTADEDT (SEQ ID NO: 14), CLKNAVTYDGPVPNN (SEQ ID NO: 15), NSKSSTSFSNFDIGC (SEQ ID NO: 16), CEPTHNFYLKDSKSS (SEQ ID NO: 17), and TSRIDRGGIQGFHGC (SEQ ID NO: 18), wherein said polypeptide comprises less than 930 amino acid residues in length.

44. The isolated HYR1 polypeptide of claim 43 wherein said polypeptide fragment comprises less than 900, 800, 700, 600, 500, 400, 300, 200, 100, 90, 80, 70, 60, 50, 40, 30 or 20 amino acid residues in length.

45. The isolated HYR1 polypeptide of claim 43, wherein said polypeptide can be bound by an anti-HYR1 antibody.

46. The isolated HYR1 polypeptide of claim 43, wherein said polypeptide is immunogenic.

47. The isolated HYR1 polypeptide of claim 46, wherein said immunogenic polypeptide is capable of eliciting production of an anti-HYR1 antibody in a subject.

48. A fusion protein comprising a polypeptide fused to a carrier protein, an affinity tag or a linker sequence, wherein said polypeptide comprises the HYR1 polypeptide of any one of claims 43-47.

49. An isolated anti-*Acinetobacter* protein antibody having specific reactivity to an HYR1 polypeptide according to any one of claims 43-47, an outer membrane protein 1 of *Acinetobacter baumannii*, an outer membrane protein 2 of *Acinetobacter baumannii*, an ferric siderophore receptor protein of *Acinetobacter baumannii*, an Dnak heat shock protein of *Acinetobacter baumannii*, an elongation factor G of *Acinetobacter baumannii*, an organic solvent tolerance protein precursor of *Acinetobacter baumannii*, a putative lipoprotein precursor (VacJ) transmembrane of *Acinetobacter* baumannii, a putative glucose-sensitive porin (OprB-like) of *Acinetobacter baumannii*, an AdeA

membrane fusion protein of *Acinetobacter baumannii*, a cell division protein of *Acinetobacter baumannii*, or a cell division protein FtsZ of *Acinetobacter baumannii*.

50. The antibody according to claim 49, wherein said antibody is a monoclonal antibody.

51. The antibody according to claim 49, wherein said antibody is a polyclonal antibody.

52. A cell line producing the monoclonal antibody of claim 50.

53. A kit for detecting the presence of *Acinetobacter* in a sample comprising an isolated anti-*Acinetobacter* protein antibody according to claim 43-47.

54. A method of detecting *Acinetobacter* nucleic acid molecule in a sample, comprising contacting said sample with two or more oligonucleotides comprising between 15 to 300 contiguous nucleotides that encode a portion of an outer membrane protein 1 of *Acinetobacter baumannii*, an outer membrane protein 2 of *Acinetobacter baumannii*, an ferric siderophore receptor protein of *Acinetobacter baumannii*, an Dnak heat shock protein of *Acinetobacter baumannii*, an elongation factor G of *Acinetobacter baumannii*, an organic solvent tolerance protein precursor of *Acinetobacter baumannii*, a putative lipoprotein precursor (VacJ) transmembrane of *Acinetobacter baumannii*, a putative glucose-sensitive porin (OprB-like) of *Acinetobacter baumannii*, an AdeA membrane fusion protein of *Acinetobacter baumannii*, a cell division protein of *Acinetobacter baumannii*, or a cell division protein FtsZ of *Acinetobacter baumannii*, amplifying a nucleic acid molecule, and detecting said amplification.

55. The method of claim 54, wherein said amplification is performed using polymerase chain reaction.

56. A method for detecting the presence of *Acinetobacter* in a sample, comprising contacting a sample with an anti-*Acinetobacter* protein antibody according to claim 49, and detecting the presence of specific binding of said antibody to said sample, thereby detecting the presence of *Acinetobacter* in said sample.

57. A pharmaceutical composition comprising a pharmaceutically acceptable carrier and the anti-*Acinetobacter* protein antibody according to any one of claims 49-51 or an anti-HYR1 protein antibody having specific reactivity to an HYR1 protein (SEQ ID NO: 9) or a fragment thereof.

58. A vaccine composition for immunization of a subject against *Acinetobacter* infection, comprising a pharmaceutically acceptable carrier and an immunogenic amount of the HYR1 polypeptide of any one

of claims 43-47, a fusion protein of claim 48, an HYR1 protein (SEQ ID NO: 9) or a fragment thereof, an outer membrane protein 1 of *Acinetobacter baumannii* or a fragment thereof, an outer membrane protein 2 of *Acinetobacter baumannii* or a fragment thereof, an ferric siderophore receptor protein of *Acinetobacter baumannii* or a fragment thereof, an Dnak heat shock protein of *Acinetobacter baumannii* or a fragment thereof, an elongation factor G of *Acinetobacter baumannii* or a fragment thereof, an organic solvent tolerance protein precursor of *Acinetobacter baumannii* or a fragment thereof, a putative lipoprotein precursor (VacJ) transmembrane of *Acinetobacter baumannii* or a fragment thereof, a putative glucose-sensitive porin (OprB-like) of *Acinetobacter baumannii* or a fragment thereof, an AdeA membrane fusion protein of *Acinetobacter baumannii* or a fragment thereof, a cell division protein of *Acinetobacter baumannii* or a fragment thereof, or a cell division protein FtsZ of *Acinetobacter baumannii* or a fragment thereof .

59. The vaccine composition of claim 58, further comprising an adjuvant.

60. A method of treating or preventing *Acinetobacter* infection in a subject in need thereof comprising administering a therapeutically effective amount of a pharmaceutical composition of claim 28 or a vaccine composition of claim 57.

61. The method of claim 60, further comprising co-administration of an antibiotic.

62. A method of diagnosing *Acinetobacter* infection in a subject, comprising the steps of:

(a) providing a test sample from the subject;

(b) contacting said sample with an agent that can bind an isolated nucleic acid encoding an outer membrane protein 1 of *Acinetobacter baumannii*, an outer membrane protein 2 of *Acinetobacter baumannii*, an ferric siderophore receptor protein of *Acinetobacter baumannii*, an Dnak heat shock protein of *Acinetobacter baumannii*, an elongation factor G of *Acinetobacter baumannii*, an organic solvent tolerance protein precursor of *Acinetobacter baumannii*, a putative lipoprotein precursor (VacJ) transmembrane of *Acinetobacter baumannii*, a putative glucose-sensitive porin (OprB-like) of *Acinetobacter baumannii*, an AdeA membrane fusion protein of *Acinetobacter baumannii*, a cell division protein of *Acinetobacter baumannii*, a cell division protein FtsZ of *Acinetobacter baumannii.* or said HYR1 polypeptide of claim 41 under suitable conditions, wherein said conditions allow specific binding of said agent to said nucleic acid or polypeptide; and

(c) comparing the amount of said specific binding in said test sample with the amount of specific binding in a control sample, wherein an increased or decreased amount of said specific binding in said test sample as compared to said control sample is diagnostic of *Acinetobacter* infection.

63. The method of claim 62, wherein said agent is the anti-*Acinetobacter* protein antibody of claim 48 or an oligonucleotide comprising between 15 to 300 contiguous nucleotides that encode a portion of an outer membrane protein 1 of *Acinetobacter baumannii*, an outer membrane protein 2 of *Acinetobacter baumannii*, an ferric siderophore receptor protein of *Acinetobacter baumannii*, an Dnak heat shock protein of *Acinetobacter baumannii*, an elongation factor G of *Acinetobacter baumannii*, an organic solvent tolerance protein precursor of *Acinetobacter baumannii*, a putative lipoprotein precursor (VacJ) transmembrane of *Acinetobacter baumannii*, a putative glucose-sensitive porin (OprB-like) of *Acinetobacter baumannii*, an AdeA membrane fusion protein of *Acinetobacter baumannii*, a cell division protein of *Acinetobacter baumannii*, or a cell division protein FtsZ of *Acinetobacter baumannii*.

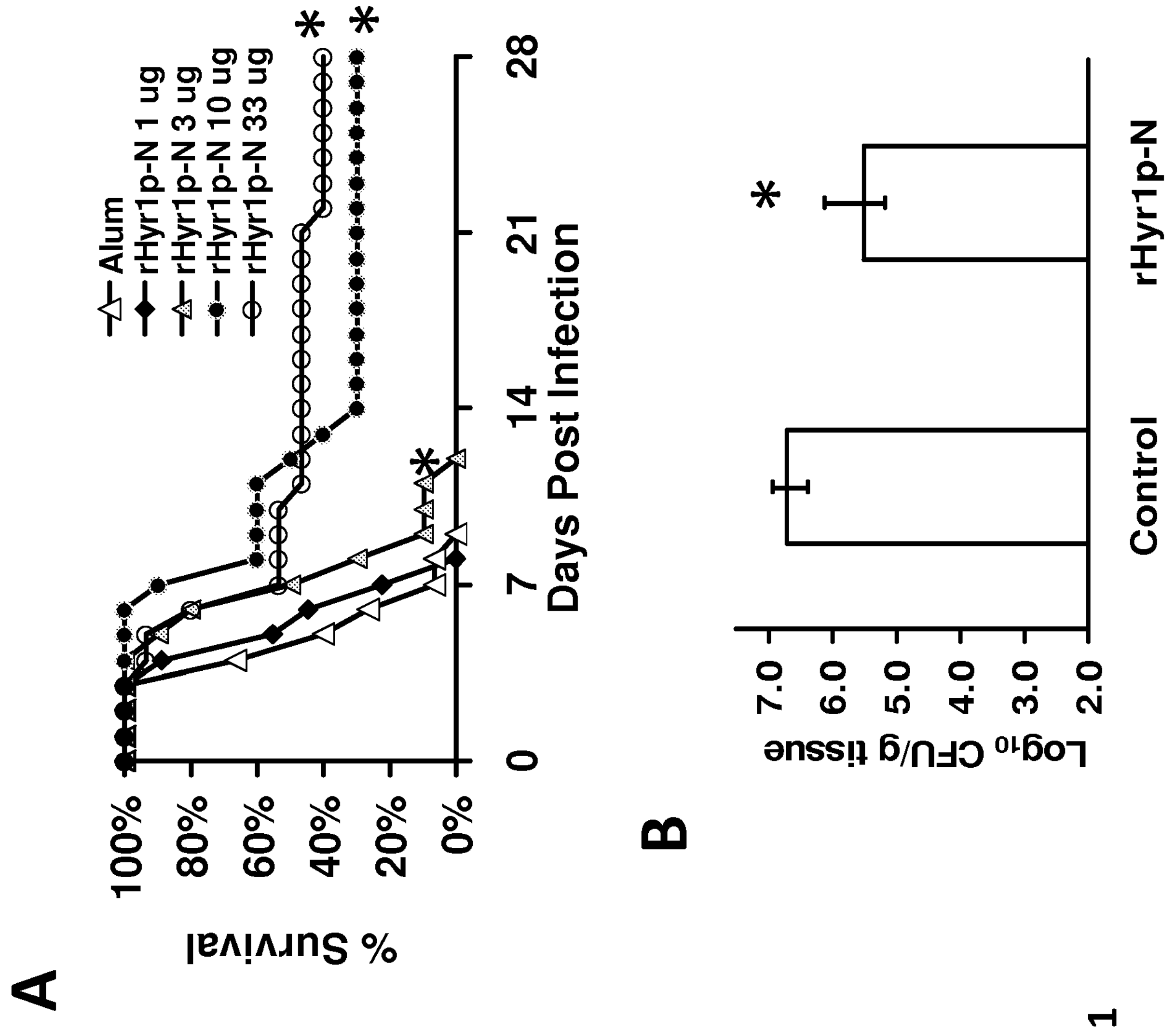
A
% Survival
100%
80%
60%
40%
20%
0%
0
7
14
21
28
Days Post Infection
Alum
rHyr1p-N 1 ug
rHyr1p-N 3 ug
rHyr1p-N 10 ug
rHyr1p-N 33 ug
*
B
Log10 CFU/g tissue
7.0
6.0
5.0
4.0
3.0
2.0
Control
rHyr1p-N
*

Figure 1

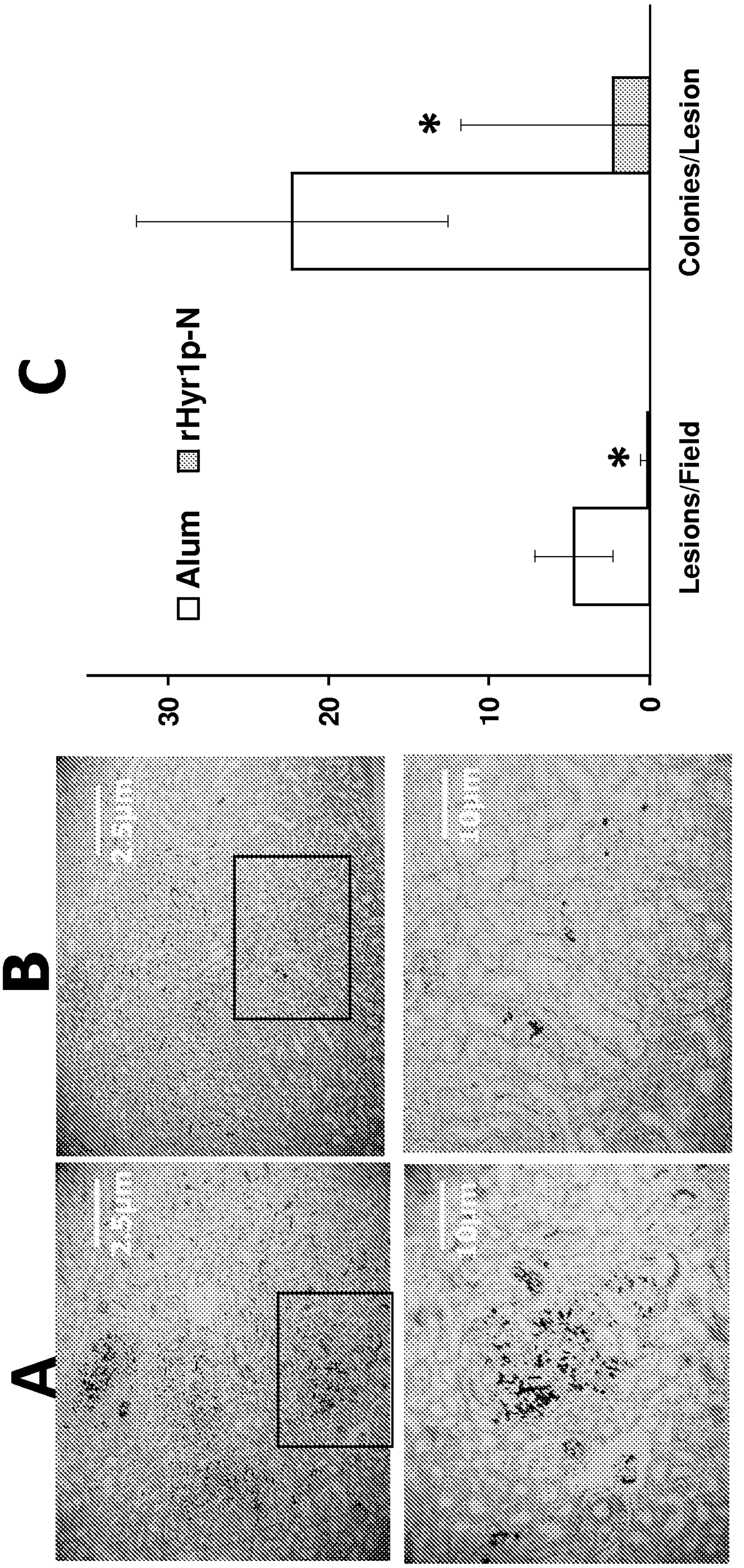
A
B
C
2.5µm
10µm
□ Alum
▩ rHyr1p-N
0
10
20
30
Lesions/Field
Colonies/Lesion
*

Figure 2

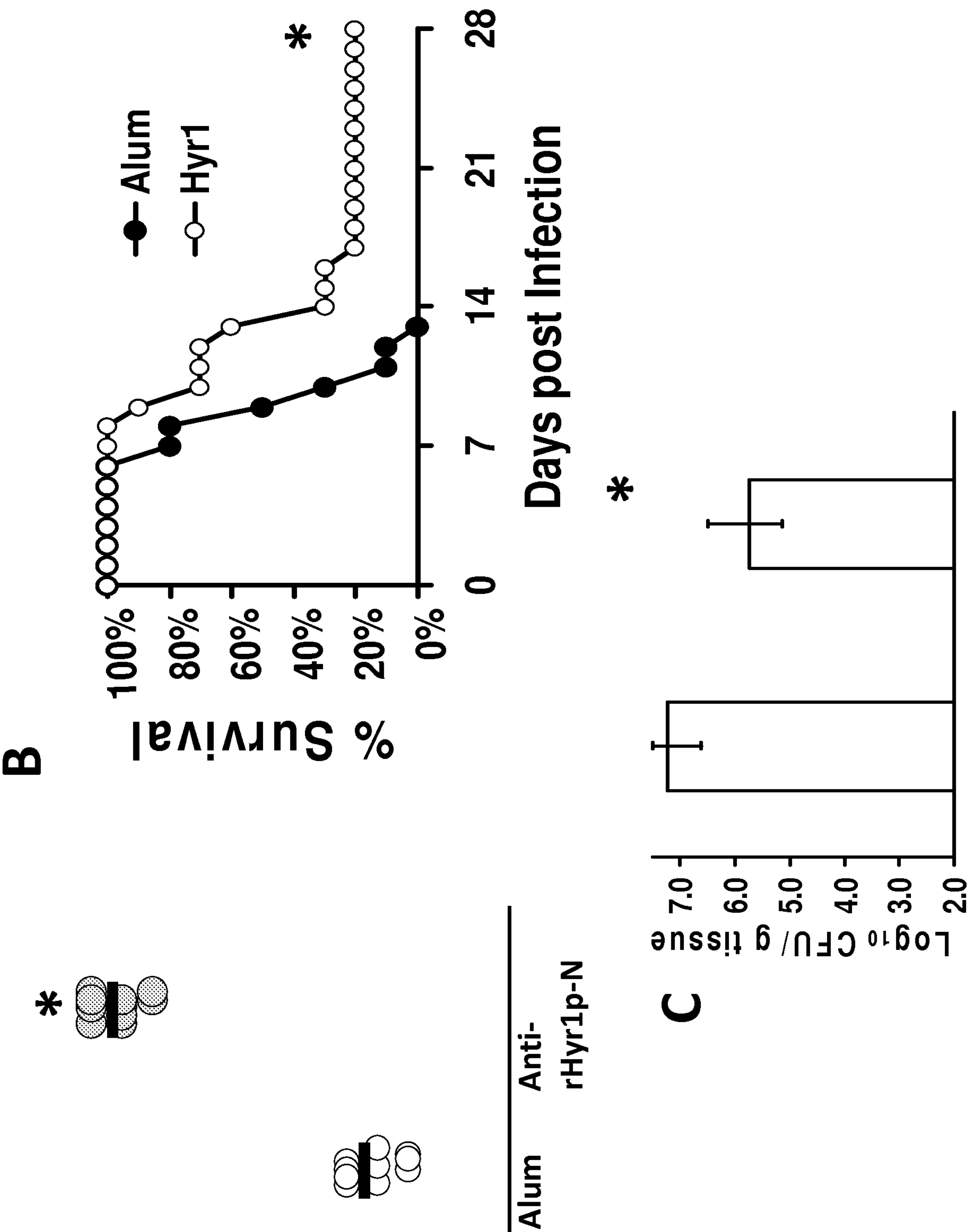
A
Log 10 Anti-rHyr1p-N Titer
1
2
3
4
5
Alum
Anti-rHyr1p-N
*
B
% Survival
100%
80%
60%
40%
20%
0%
0
7
14
21
28
Days post Infection
Alum
Hyr1
*
C
Log 10 CFU/ g tissue
2.0
3.0
4.0
5.0
6.0
7.0
Control
rHyr1p-N
*

Figure 3

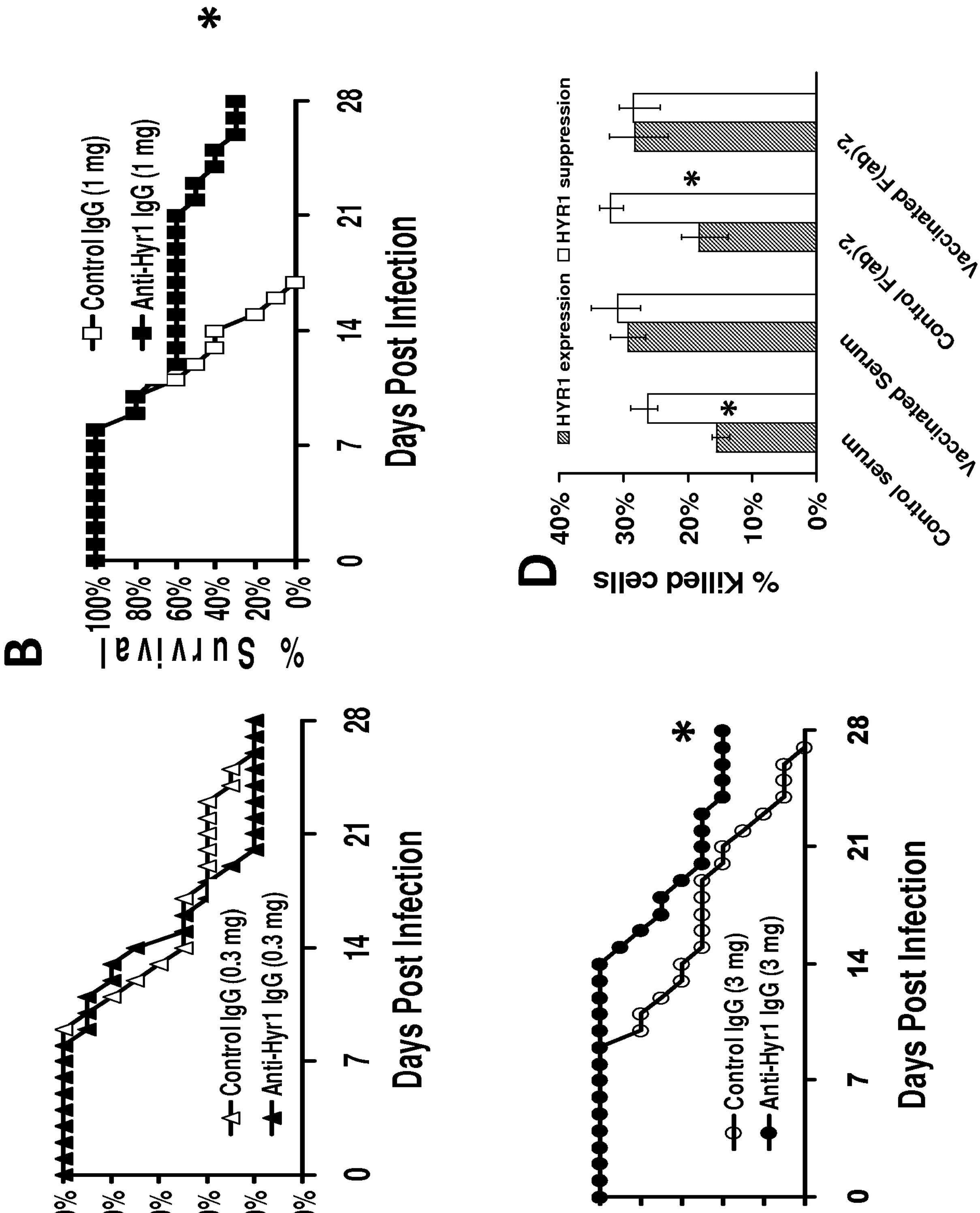
A
% Survival
100%
80%
60%
40%
20%
0%
Control IgG (0.3 mg)
Anti-Hyr1 IgG (0.3 mg)
0
7
14
21
28
Days Post Infection
B
% Survival
Control IgG (1 mg)
Anti-Hyr1 IgG (1 mg)
*
Days Post Infection
C
% Survival
Control IgG (3 mg)
Anti-Hyr1 IgG (3 mg)
*
Days Post Infection
D
% Killed cells
40%
30%
20%
10%
0%
HYR1 expression
HYR1 suppression
*
*
Control serum
Vaccinated Serum
Control F(ab)'2
Vaccinated F(ab)'2

Figure 4

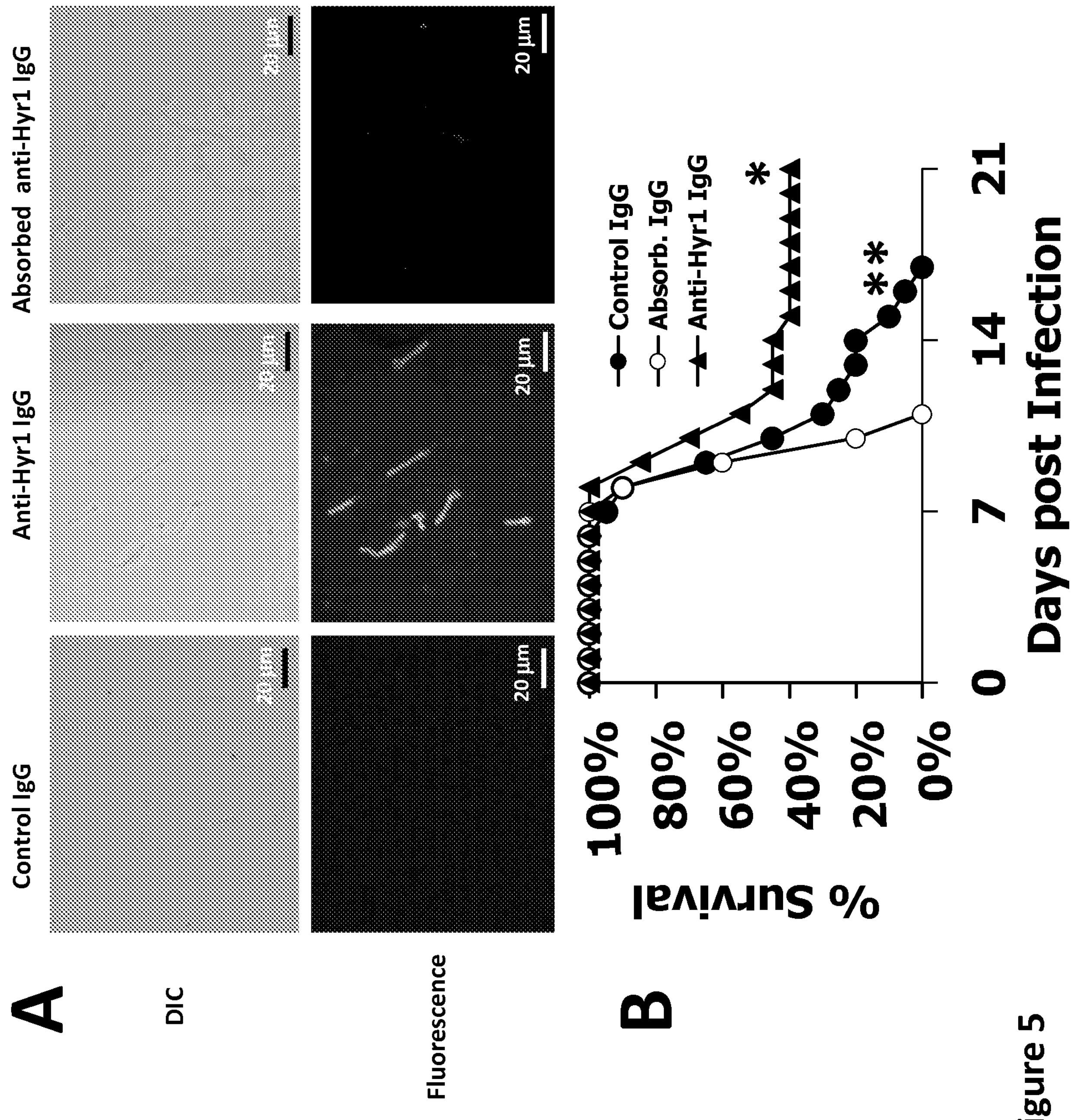
A
DIC
Fluorescence
Control IgG
Anti-Hyr1 IgG
Absorbed anti-Hyr1 IgG
20 µm
B
% Survival
100%
80%
60%
40%
20%
0%
0
7
14
21
Days post Infection
Control IgG
Absorb. IgG
Anti-Hyr1 IgG
*
**

Figure 5

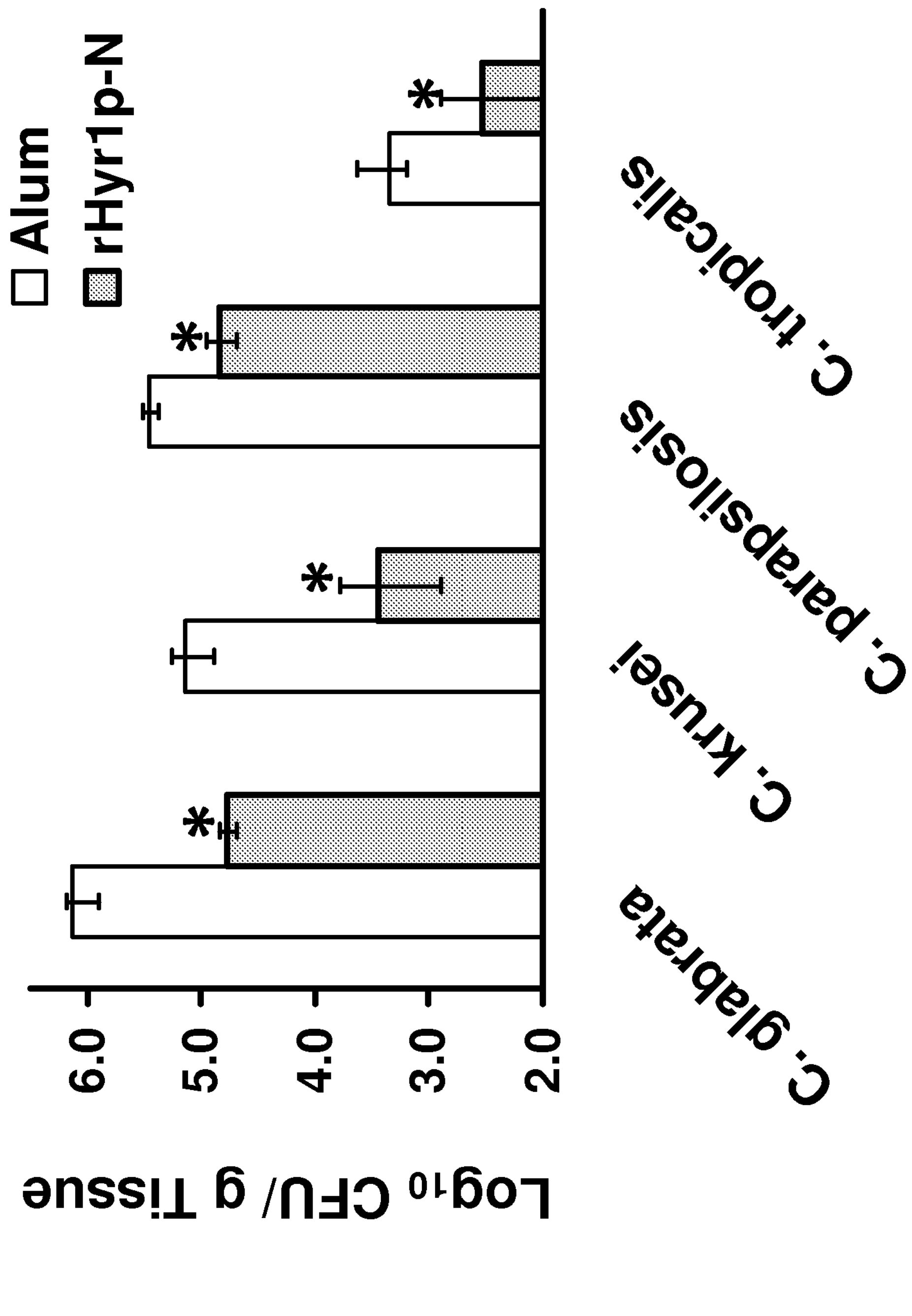
Alum
rHyr1p-N
Log10 CFU/ g Tissue
6.0
5.0
4.0
3.0
2.0
*
C. glabrata
C. krusei
C. parapsilosis
C. tropicalis

Figure 6

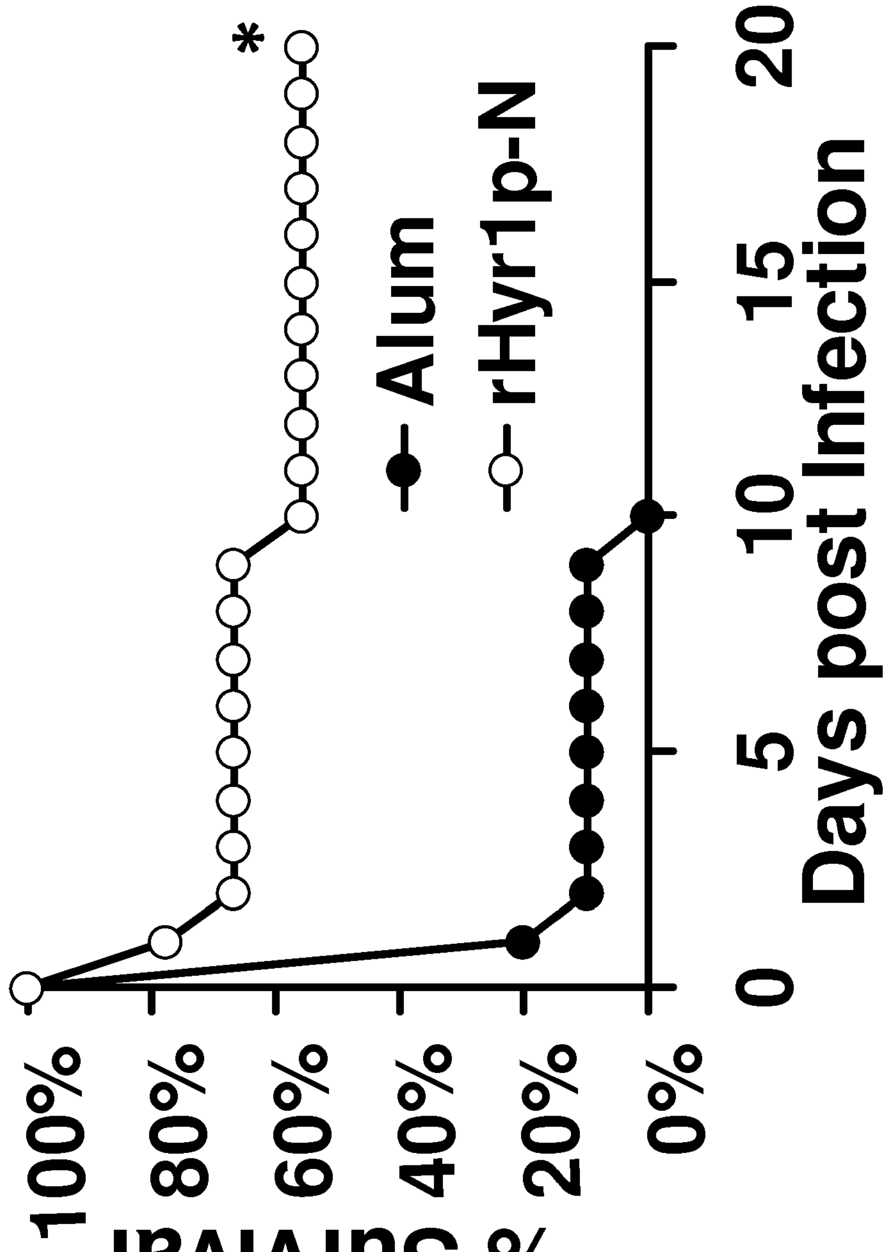
% Survival
100%
80%
60%
40%
20%
0%
0
5
10
15
20
Days post Infection
Alum
rHyr1p-N
*

Figure 7

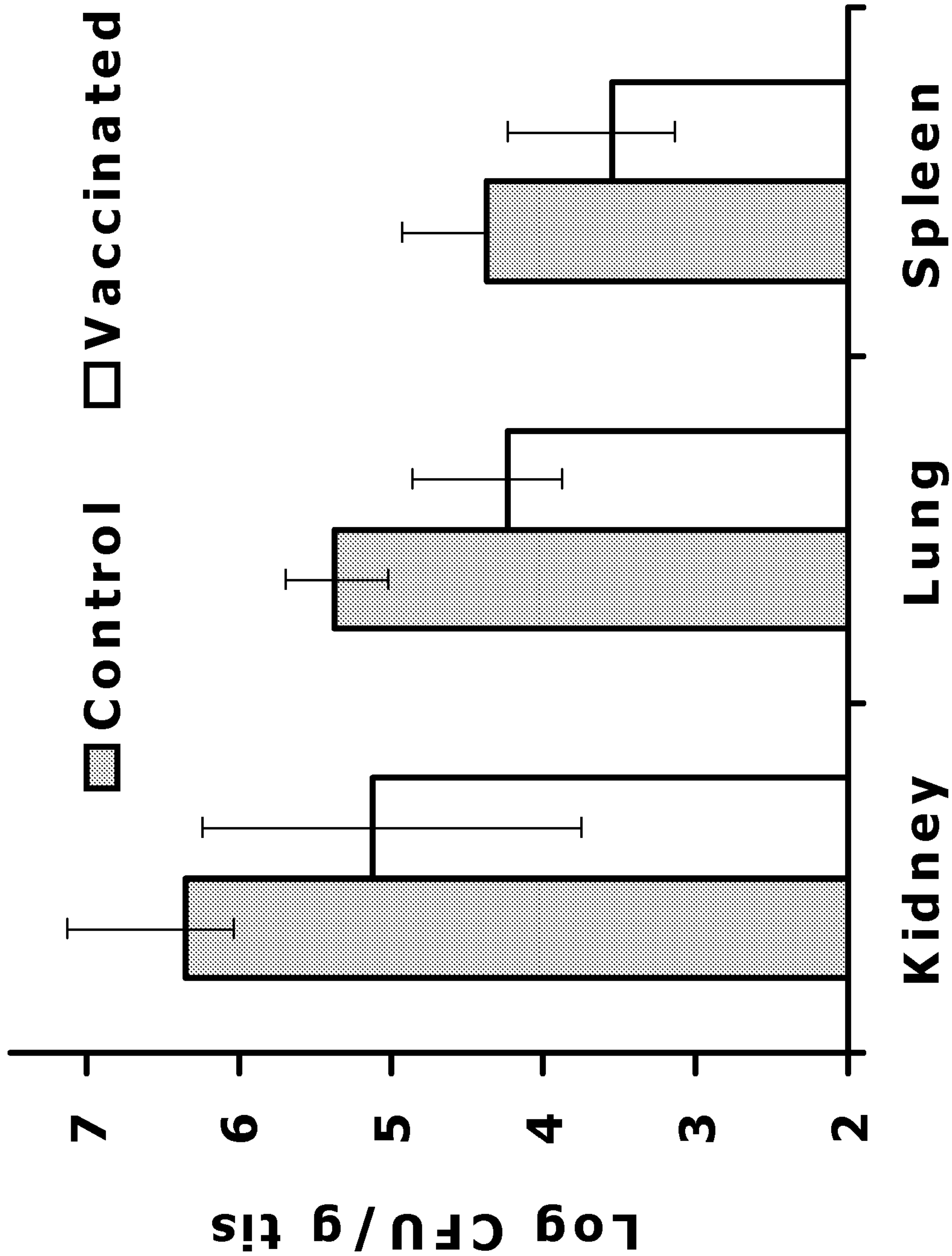

Figure 8

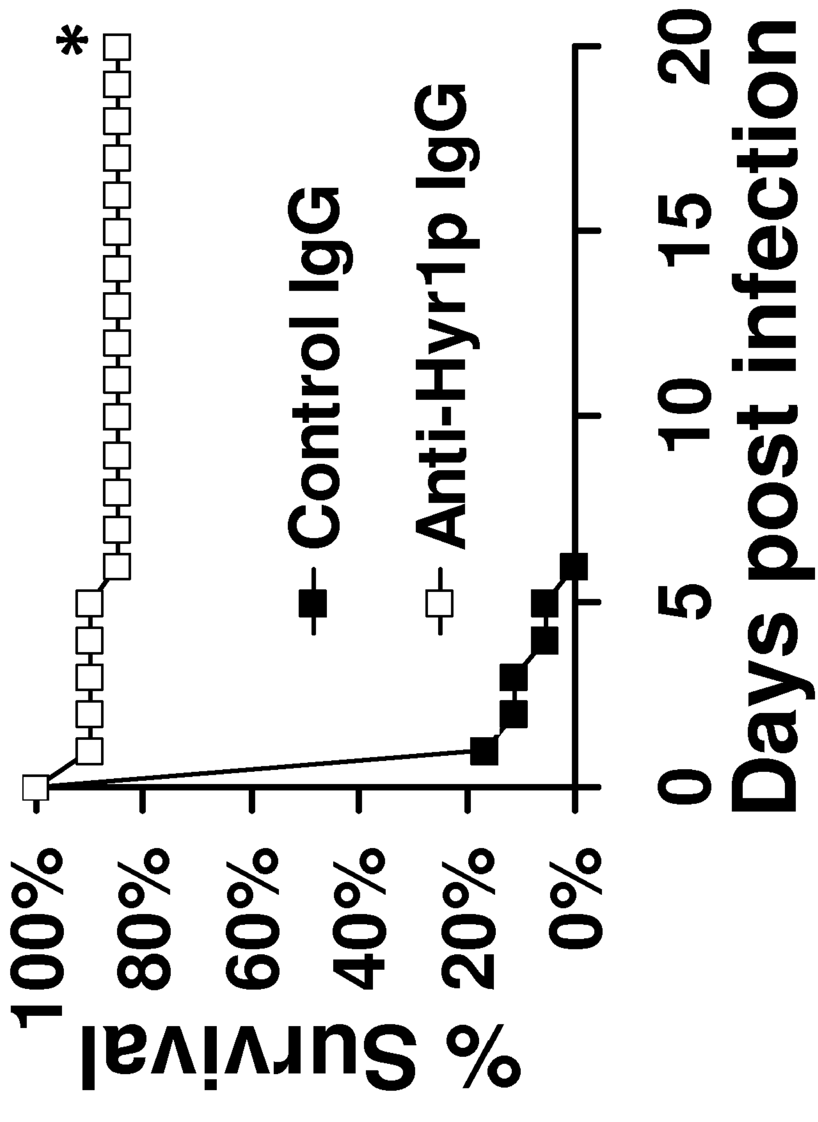
% Survival
100%
80%
60%
40%
20%
0%
0
5
10
15
20
Days post infection
Control IgG
Anti-Hyr1p IgG
*

Figure 9

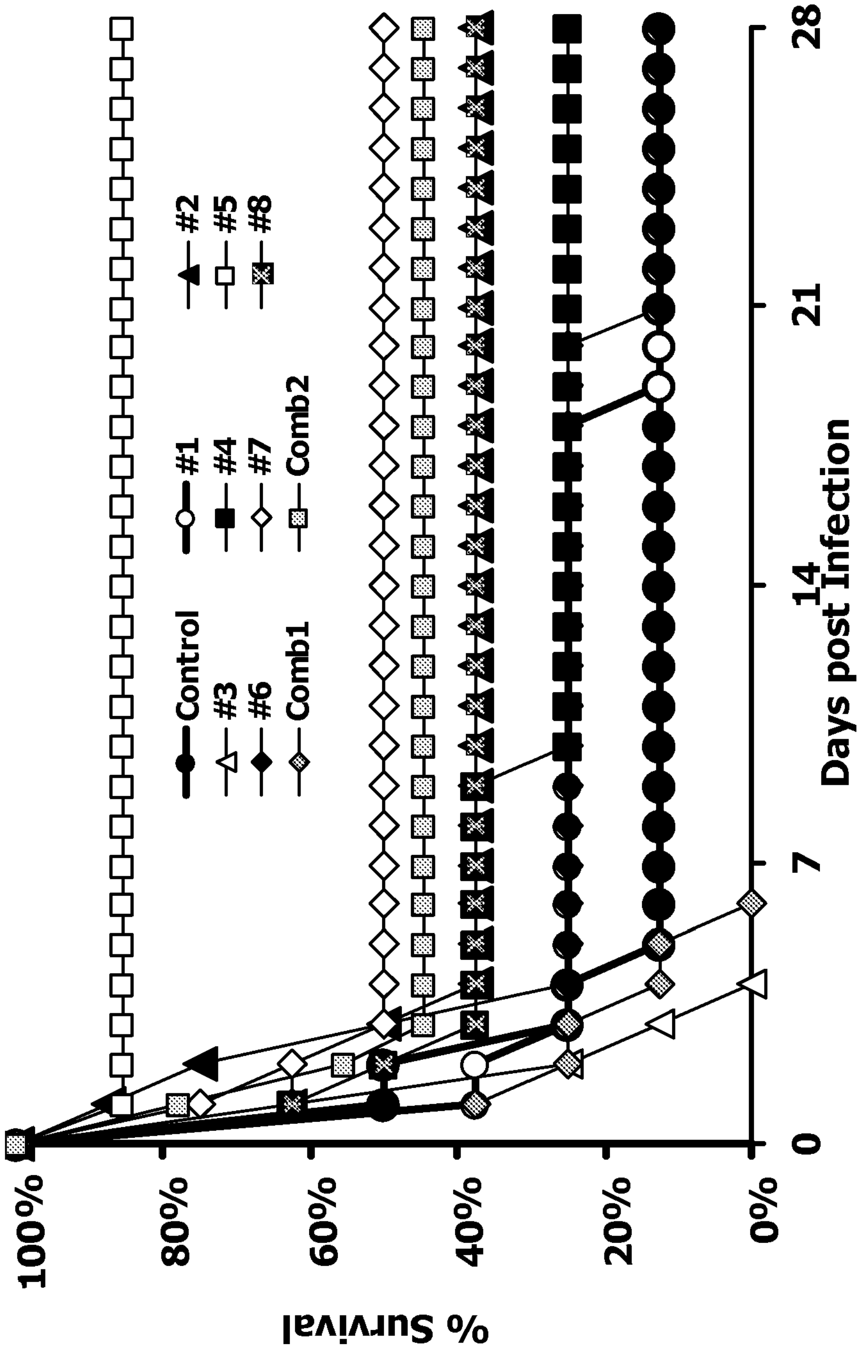
% Survival
100%
80%
60%
40%
20%
0%
0
7
14
21
28
Days post Infection
Control
#1
#2
#3
#4
#5
#6
#7
#8
Comb1
Comb2

Figure 10

Rabbit IgG raised against peptide 5

Pre-immune serum

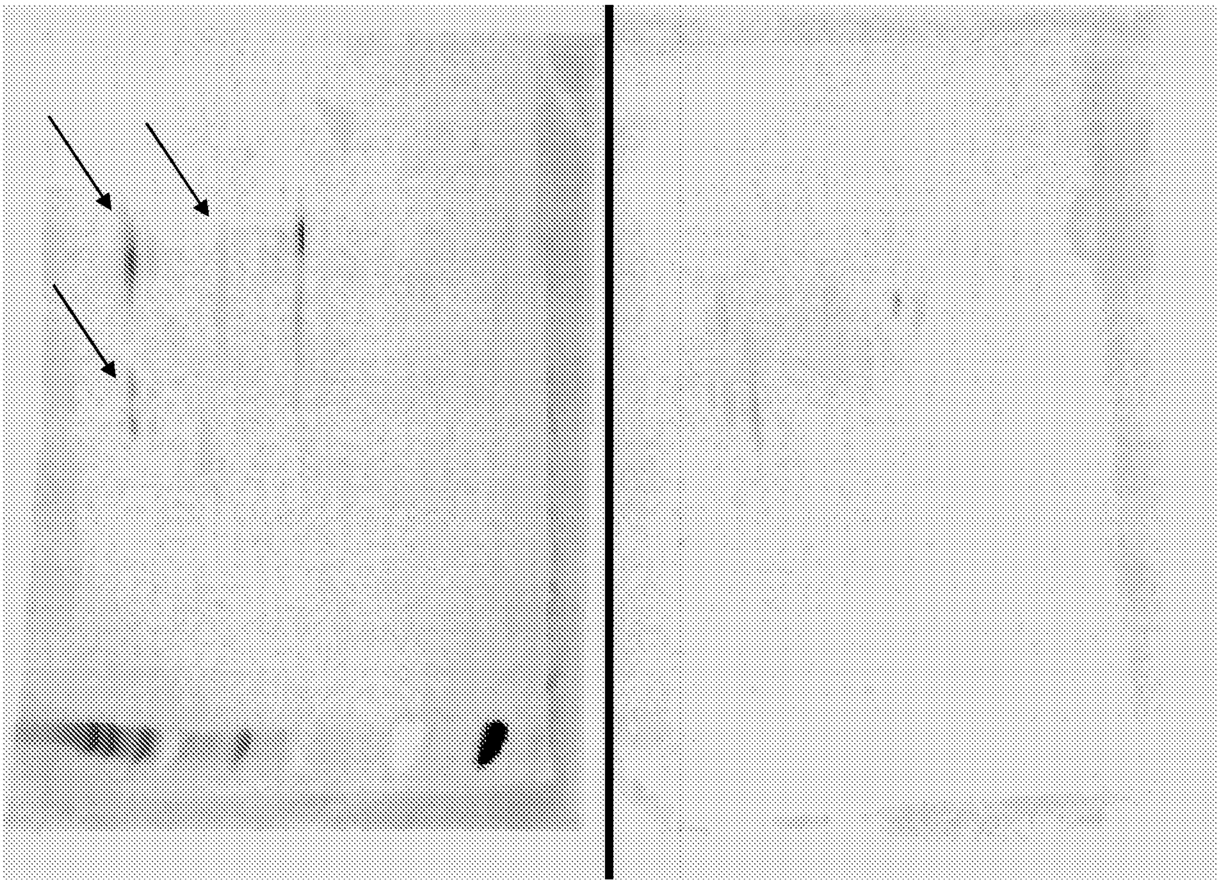

Figure 11