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(54) Title: ANTIBODY DIRECTED AGAINST S. *AUREUS* CLUMPING FACTOR A (CLFA)

(57) Abstract: The present disclosure is directed to a monoclonal antibody, or antigen-binding fragment thereof, that specifically binds to a *Staphylococcusaureus* clumping factor A protein (ClfA), as well as compositions comprising the monoclonal antibody. The disclosure also is directed to methods of treating a *Staphylococcusaureus* infection by administering the anti-ClfA monoclonal antibody alone, or in combination with a monoclonal antibody that specifically binds to S. *aureus* alpha toxin (AT) protein to a subject. Bispecific monoclonal antibodies that specifically bind to both ClfA and AT and methods of using the same also are provided.

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ANTIBODY DIRECTED AGAINST *S. AUREUS* CLUMPING FACTOR A (CLFA)

BACKGROUND OF THE INVENTION

[0001] Infections caused by antimicrobial resistant (AMR) bacterial pathogens are an increasing threat to public health. The ongoing AMR epidemic has been fueled, in part, by empiric broad spectrum antibiotic therapy. This has led to the exploration of pathogen specific methods, including monoclonal antibodies (mAbs), to prevent or treat serious bacterial infections. Numerous monoclonal antibodies are currently in development for the prevention or treatment of antibiotic resistant bacterial infections (see, e.g., DiGiandomenico, A., and B.R. Sellman, *Curr. Opin. Microbiol.*, *27*: 78-85 (2015)). Such passive immunization strategies provide an immediate and potent immunoglobulin response against the target pathogen. Ideally, the monoclonal antibody or monoclonal antibody cocktail provides multiple mechanisms of action to neutralize key bacterial virulence mechanisms and augment the host innate immune response, thus providing the greatest opportunity for clinical success.

[0002] *Staphylococcus aureus* is a bacterial pathogen that causes a wide array of diseases including skin and soft tissue infections, endocarditis, osteomyelitis, pneumonia, and bacteremia (Lowy, F.D., *N. Engl. J. Med.*, *339*(8): 520-32 (1998)). Preclinical studies indicate monoclonal antibody-based approaches hold promise for prophylaxis and adjunctive therapy against *S. aureus* infections (see, e.g., Hazenbos et al., *PLoS Pathog.*, *9*(10):e1003653. doi: 10.1371/journal.ppat.10036532013 (2013); Rouha, H., *MAbs*, *7*(1): 243-254 (2015); Foletti et al., *J. Mol. Biol.*, *425*(10): 1641-1654 (2013); Karauzum et al., *J Biol Chem.*, *287*(30): 25203-15 (2012); and Hua et al., *Antimicrob Agents Chemother.*, *58*(2): 1108-17 (2014)). A multi-mechanistic monoclonal antibody combination targeting *S. aureus* alpha toxin (AT) and clumping factor A (ClfA) was shown to enhance protection and improve strain coverage relative to each individual monoclonal antibody in a *S. aureus* lethal bacteremia model (Tkaczyk *et al.*, *MBio.*, *7*(3). pii: e00528-16 (2016)); however, the tested ClfA monoclonal antibody exhibits reduced binding affinity and functional activity against the ClfA founder sequence ClfA002 relative to two other founder sequences (ClfA001 and ClfA004).

[0003] Thus, there remains a need for compositions and methods for treating *Staphylococcus aureus* infections, particularly infections that are resistant to currently-available antibiotics. The present disclosure provides such compositions and methods.

BRIEF SUMMARY OF THE INVENTION

[0004] Provided herein are antibodies or antigen-binding fragments that bind to *Staphylococcus aureus* (*S. aureus*) clumping factor A (ClfA) protein. In certain instances, an antibody or antigen-binding fragment thereof that specifically binds to a *S. aureus* ClfA protein, comprises a variable heavy chain (VH) complementarity determining region (CDR) 1 comprising the amino acid sequence of SEQ ID NO: 1, a VH CDR2 comprising the amino acid sequence of SEQ ID NO: 2, a VH CDR3 comprising the amino acid sequence of SEQ ID NO: 3, a variable light chain (VL) CDR1 comprising the amino acid sequence of SEQ ID NO: 4, a VL CDR2 comprising the amino acid sequence of SEQ ID NO: 5, and a VL CDR3 comprising the amino acid sequence of SEQ ID NO: 6, and the antibody or antigen-binding fragment comprises a heavy chain constant domain comprising the amino acid sequence of CSYHLC (SEQ ID NO: 21). In certain instances, the antibody or antigen-binding fragment thereof comprises a VH comprising the amino acid sequence of SEQ ID NO: 13. In certain instances, the antibody or antigen-binding fragment thereof comprises a VL comprising the amino acid sequence of SEQ ID NO: 14.

[0005] In certain instances, an antibody or antigen-binding fragment thereof that specifically binds to a *S. aureus* ClfA protein comprises a VH, a VL, and a heavy chain constant domain comprising the amino acid sequence of CSYHLC (SEQ ID NO: 21), wherein the VH comprises the amino acid sequence of SEQ ID NO: 13.

[0006] In certain instances, an antibody or antigen-binding fragment thereof that specifically binds to a *S. aureus* ClfA protein comprises a VH, a VL, and a heavy chain constant domain comprising the amino acid sequence of CSYHLC (SEQ ID NO: 21), wherein the VL comprises the amino acid sequence of SEQ ID NO: 14.

[0007] In certain instances, an antibody or antigen-binding fragment thereof that specifically binds to a *S. aureus* ClfA protein comprises the VH CDR1, VH CDR2, VH CDR3, VL CDR1, VL CDR2, and VL CDR3 of SAR114. In certain instances, the CDRs are the Kabat-defined CDRs, the Chothia-defined CDRs, or the AbM-defined CDRs. In

certain instances, the antibody or antigen-binding fragment comprises a heavy chain constant domain comprising the amino acid sequence of CSYHLC (SEQ ID NO: 21).

[0008] In certain instances, the heavy chain constant domain comprises the amino acid sequence of MHEACSYHLCQKSLSLS (SEQ ID NO: 23). In certain instances, the heavy chain constant domain comprises the amino acid sequence of SEQ ID NO: 24. In certain instances, the antibody or antigen-binding fragment thereof comprises a heavy chain comprising the amino acid sequence of SEQ ID NO: 50. In certain instances, the antibody or antigen-binding fragment thereof comprises a light chain comprising the amino acid sequence of SEQ ID NO: 26.

[0009] In certain instances, the IC50's of the antibody or antigen-binding fragment thereof for ClfA001, ClfA002, and ClfA004 in a fibrinogen binding inhibition assay are within 2 μg/ml of each other. In certain instances, the IC_{50}'s of the antibody or antigen-binding fragment thereof for ClfA001, ClfA002, and ClfA004 in a fibrinogen binding inhibition assay are all between 1 μg/ml and 5 μg/ml. In certain instances, the binding affinities (K_D) of the antibody or antigen-binding fragment thereof for ClfA001, ClfA002, and ClfA004 are all between 200 and 350 pM.

[0010] In certain instances, the antibody or antigen-binding fragment thereof has a monomer purity that decreases by no more than 5% after exposure of the antibody or antigen-binding fragment to conventional white light at 2kLux/hr at 23^0C for 14 days. In certain instances, the antibody or antigen-binding fragment comprises a mutation that extends half-life relative to the same antibody without the mutation in human FcRn mice. In certain instances, the antibody or antigen-binding fragment comprises a mutation that extends half-life relative to the same antibody without the mutation, and wherein the mutation does not inhibit OPK activity relative to the same antibody or antigen-binding fragment the mutation.

[0011] Provided herein are also bispecific antibodies and antigen-binding fragments thereof that specifically bind to *S. aureus* ClfA protein and *S. aureus* alpha toxin (AT) protein. In certain instances, a bispecific antibody or antigen-binding fragment thereof that specifically binds to a *S. aureus* ClfA protein and a *S. aureus* alpha toxin (AT) protein comprises a VH CDR1 comprising the amino acid sequence of SEQ ID NO: 1, a VH CDR2 comprising the amino acid sequence of SEQ ID NO: 2, a VH CDR3 comprising the amino acid sequence of SEQ ID NO: 3, a VL CDR1 comprising the amino

acid sequence of SEQ ID NO: 4, a VL CDR2 comprising the amino acid sequence of SEQ ID NO: 5, and a VL CDR3 comprising the amino acid sequence of SEQ ID NO: 6. In certain instances, the antibody or antigen binding fragment thereof comprises a VH comprising the amino acid sequence of SEQ ID NO: 13. In certain instances, the antibody or antigen-binding fragment thereof comprises a VL comprising the amino acid sequence of SEQ ID NO: 14. In certain instances, the antibody or antigen-binding fragment thereof further comprises a VH CDR1 comprising the amino acid sequence of SEQ ID NO: 7, a VH CDR2 comprising the amino acid sequence of SEQ ID NO: 8, a VH CDR3 comprising the amino acid sequence of SEQ ID NO: 9, a VL CDR1 comprising the amino acid sequence of SEQ ID NO: 10, a VL CDR2 comprising the amino acid sequence of SEQ ID NO: 11, and a VL CDR3 comprising the amino acid sequence of SEQ ID NO: 12. In certain instances, the antibody or antigen-binding fragment comprises a VH comprising the amino acid sequence of SEQ ID NO: 15. In certain instances, the antibody or antigen-binding fragment comprises a VL comprising the amino acid sequence of SEQ ID NO: 16.

[0012] In certain instances, an antibody or antigen-binding fragment thereof that specifically binds to a *S. aureus* ClfA protein, comprises the VH CDR1, VH CDR2, VH CDR3, VL CDR1, VL CDR2, and VL CDR3 of SAR72, SAR80, SAR113, SAR132, SAR352, SAR372, SAR510, SAR547, SAS1, SAS19, or SAS203. In certain instances, the CDRs are the Kabat-defined CDRs, the Chothia-defined CDRs, or the AbM-defined CDRs. In certain instances, the antibody or antigen-binding fragment comprises variable heavy chain and variable light chain sequences comprising the amino acid sequences set forth in (a) SEQ ID NOs: 17 and 18, respectively (b) SEQ ID NOs: 30 and 31, respectively, (c) SEQ ID NOs: 32 and 33, respectively, (d) SEQ ID NOs: 34 and 35, respectively, (e) SEQ ID NOs: 36 and 37, respectively, (f) SEQ ID NOs: 38 and 39, respectively, (g) SEQ ID NOs: 40 and 41, respectively, (h) SEQ ID NOs: 42 and 43 respectively (i) SEQ ID NOs: 44 and 45, respectively, (j) SEQ ID NOs: 46 and 47, respectively, or (k) SEQ ID NOs: 48 and 49, respectively.

[0013] In certain instances, an antibody or antigen-binding fragment thereof that specifically binds to a *S. aureus* ClfA protein, comprises a VH and a VL, wherein the VH comprises the amino acid sequence set forth in SEQ ID NO: 17, 30, 32, 34, 36, 38, 40, 42, 44, 46, or 48.

[0014] In certain instances, an antibody or antigen-binding fragment thereof that specifically binds to a *S. aureus* ClfA protein comprises a VH and a VL, wherein the VL comprises the amino acid sequence set forth in SEQ ID NO: 18, 31, 33, 35, 37, 39, 41, 43, 45, 47, or 49.

[0015] In certain instances, the antibody or antigen-binding fragment thereof further comprises a heavy chain constant region. In certain instances, the heavy chain constant region is selected from the group consisting of human immunoglobulin IgG_1, IgG_2, IgG_3, IgG_4, IgA_1, and IgA_2 heavy chain constant regions. In certain instances, the heavy chain constant region is a human IgG_1 constant region. In certain instances, the heavy chain constant region comprises an N3, N3E, or N3F mutation. In certain instances, the heavy chain constant region comprises a YTE mutation.

[0016] In certain instances, the antibody or antigen-binding fragment thereof further comprises a light chain constant region. In certain instances, the light chain constant region is selected from the group consisting of human immunoglobulin IgGκ and IgGλ light chain constant regions. In certain instances, the light chain constant region is a human IgGκ light chain constant region.

[0017] In certain instances, the antibody or antigen-binding fragment is a monoclonal antibody or antigen-binding fragment.

[0018] In certain instances, the antibody or antigen-binding fragment is a full–length antibody. In certain instances, the antibody or antigen-binding fragment is an antigen-binding fragment. In certain instances, the antigen-binding fragment comprises a Fab, Fab', $F(ab')_2$, single chain Fv (scFv), disulfide linked Fv, intrabody, IgGΔCH2, minibody, $F(ab')_3$, tetrabody, triabody, diabody, DVD-Ig, Fcab, mAb^2, $(scFv)_2$, or scFv-Fc.

[0019] In certain instances, an antibody that specifically binds to a *S. aureus* ClfA protein comprises a heavy chain comprising the amino acid sequence set forth in SEQ ID NO: 50 and a light chain comprising the amino acid sequence set forth in SEQ ID NO: 26.

[0020] In certain instances, the antibody or antigen-binding fragment thereof further comprises a detectable label.

[0021] Provided herein are also compositions comprising an antibody provided herein. In certain instances, a composition comprises an antibody provided herein and a pharmaceutically-acceptable carrier.

[0022] In certain instances, a composition comprises an antibody provided herein and an antibody or antigen-binding fragment that specifically binds to a *S. aureus* AT protein, and optionally a pharmaceutically-acceptable carrier. In certain instances, the antibody or antigen-binding fragment that specifically binds to a *S. aureus* AT protein comprises a VH CDR1 comprising the amino acid sequence of SEQ ID NO: 7, a VH CDR2 comprising the amino acid sequence of SEQ ID NO: 8, a VH CDR3 comprising the amino acid sequence of SEQ ID NO: 9, a VL CDR1 comprising the amino acid sequence of SEQ ID NO: 10, a VL CDR2 comprising the amino acid sequence of SEQ ID NO: 11, and a VL CDR3 comprising the amino acid sequence of SEQ ID NO: 12. In certain instances, the antibody or antigen-binding fragment that specifically binds to a *S. aureus* AT protein comprises a VH comprising the amino acid sequence of SEQ ID NO: 15. In certain instances, the antibody or antigen-binding fragment that specifically binds to a *S. aureus* AT protein comprises a VL comprising the amino acid sequence of SEQ ID NO: 16. In certain instances, the antibody or antigen-binding fragment that specifically binds to *S. aureus* AT protein comprises a heavy chain comprising the amino acid sequence of SEQ ID NO: 27. In certain instances, the antibody or antigen-binding fragment that specifically binds to *S. aureus* AT protein comprises a light chain comprising the amino acid sequence of SEQ ID NO: 28.

[0023] Provided herein are also methods of using an antibody provided herein. In certain instances, a method of treating or preventing a *S. aureus* infection in a subject comprises administering to the subject an antibody or antigen-binding fragment provided herein or a composition provided herein.

[0024] In certain instances, a method of treating or preventing a *S. aureus* infection in a subject comprises administering to the subject an antibody or antigen-binding fragment provided herein and an antibody or antigen-binding fragment that specifically binds to a *S. aureus* alpha toxin (AT) protein. In certain instances, the antibody or antigen-binding fragment that specifically binds to a *S. aureus* AT protein comprises a VH CDR1 comprising the amino acid sequence of SEQ ID NO: 7, a VH CDR2 comprising the amino acid sequence of SEQ ID NO: 8, a VH CDR3 comprising the amino acid sequence of SEQ ID NO: 9, a VL CDR1 comprising the amino acid sequence of SEQ ID NO: 10, a VL CDR2 comprising the amino acid sequence of SEQ ID NO: 11, and a VL CDR3 comprising the amino acid sequence of SEQ ID NO: 12. In certain instances, the antibody

or antigen-binding fragment that specifically binds to a *S. aureus* AT protein comprises a VH comprising the amino acid sequence of SEQ ID NO: 15. In certain instances, the antibody or antigen-binding fragment that specifically binds to a *S. aureus* AT protein comprises a VL comprising the amino acid sequence of SEQ ID NO: 16. In certain instances, the antibody or antigen-binding fragment that specifically binds to *S. aureus* AT protein comprises a heavy chain comprising the amino acid sequence of SEQ ID NO: 27. In certain instances, the antibody or antigen-binding fragment that specifically binds to *S. aureus* AT protein comprises a light chain comprising the amino acid sequence of SEQ ID NO: 28. In certain instances, the anti-*S. aureus* ClfA antibody or antigen-binding fragment provided herein and the antibody or antigen-binding fragment that specifically binds to a *S. aureus* AT protein are administered simultaneously. In certain instances, the anti-*S. aureus* ClfA antibody or antigen-binding fragment provided herein and the antibody or antigen-binding fragment that specifically binds to a *S. aureus* AT protein are administered sequentially.

[0025] In certain instances, treating or preventing an *S. aureus* infection in a subject comprises inhibiting *S. aureus*-associated sepsis, inhibiting *S. aureus* agglutination, inhibiting thromboembolic lesion formation, toxin neutralization, inducing opsonophagocytosis, inhibiting *S. aureus* fibrinogen binding, inhibiting *S. aureus* agglutination, or any combination of the foregoing.

[0026] In certain instances, the subject has diabetes. In certain instances, the subject is human.

[0027] Provided herein are also polynucleotides. In certain instances, an isolated polynucleotide comprises a nucleic acid molecule encoding the VH or heavy chain of an antibody or antigen-binding fragment thereof provided herein. In certain instances, the nucleic acid molecule encodes the VH of SEQ ID NO: 13 or the heavy chain of SEQ ID NO: 25, 50, or 52.

[0028] In certain instances, an isolated polynucleotide comprises a nucleic acid molecule encoding the VL or light chain of an antibody or antigen-binding fragment thereof provided herein. In certain instances, the nucleic acid molecule encodes the VL of SEQ ID NO: 14 or the light chain of SEQ ID NO: 26.

[0029] In certain instances, an isolated polynucleotide comprises a nucleic acid molecule encoding the VH or heavy chain of an antibody or antigen-binding fragment thereof

provided herein and the VH or light chain of the antibody or antigen-binding fragment thereof.

[0030] Also provided herein are vectors. In certain instances, an isolated vector comprises a polynucleotide provided herein.

[0031] Also provided herein are host cells. In certain instances, a host cell comprises a polynucleotide provided herein, a vector provided herein, or a first vector a polynucleotide provided herein and a second vector comprising a polynucleotide provided herein. In certain instances, the host cell is selected from the group consisting of CHO, NS0, PER-C6, HEK-293, and HeLa cells. In certain instances, the host cell is isolated.

[0032] Also provided herein are methods of producing antibodies or antigen-binding fragments. In certain instances, a method of producing an antibody or antigen-binding fragment thereof comprises culturing a host cell provided herein so that the antibody or antigen-binding fragment thereof is produced.

[0033] Also provided herein are methods for detecting detecting *S. aureus* or *S. aureus* ClfA. In certain instances, a method for detecting *S. aureus* or *S. aureus* ClfA in a sample comprises contacting the sample with an antibody or antigen-binding fragment thereof provided herein.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING(S)

[0034] Figure 1 is a series of graphs which illustrate inhibition of fibrinogen binding to the three main ClfA genotypes as measured in the presence of serially diluted (from 666 μM to 2.55 μM) anti-ClfA mAb 11H10 (Figure 1A) or SAR114 (Figure 1B). Data are representative of three independent experiments.

[0035] Figure 2 is a graph which illustrates agglutination of *S. aureus* clinical isolates in the presence of human plasma and anti-ClfA mAbs. Figure 2 shows the minimum concentration of the 11H10 and SAR114 mAbs required to inhibit bacterial agglutination. Data are representative of two independent experiments. c-IgG was used as a negative control and did not show any inhibition at 200 μg/ml.

[0036] Figure 3 is a series of graphs which illustrate opsonophagocytic killing (OPK) activity of the anti-ClfA monoclonal antibody SAR114 against the *S. aureus* clinical isolates ARC635(ST5) (Figure 3A), SF8300 (ST8) (Figure 3B), NRS383 (ST346) (Figure 3C), NRS382 (ST5) (Figure 3D), NRS384 (ST8) (Figure 3E), and ARC2081 (ST30)

(Figure 3F). *S. aureus* strains were incubated with human HL-60 cells, human sera, and serial dilutions of SAR114 (squares) or c-IgC (circles). The graphs represent mean values ± standard deviation (SD) of three independent experiments.

[0037] Figure 4 is a graph which illustrates agglutination inhibition of multiple *S. aureus* types by the SAR114 monoclonal antibody. 112 *S. aureus* clinical isolates representing 40 different sequence types (ST) and some not found (NF) were tested as described in Example 1.

[0038] Figure 5 shows graphs illustrating competition of SAR114 and 11H10 for binding to ClfA001 genotype. The graph in Figure 5A shows results of an ELISA competition binding assay as described in Example 1. Data represent the mean values ± standard deviation (SD). The graph in Figure 5B shows results of the OCTECT® binding assay described in Example 1.

[0039] Figure 6 provides graphs showing the effect of YTE and N3 mutations in anti-bacterial antibodies on opsonophagocytic killing (OPK). Cam004 (top panel) is an anti-pseudomonas antibody, and 2F4 (bottom panel) is an anti-*S. aureus* antibody. R347 antibody was used as a negative control. (See Example 2.)

[0040] Figure 7 provides graphs showing that the N3 mutation does not reduce the ability of SAR114 in inhibiting of ClfA001, ClfA002, or ClfA1004 binding to fibrinogen. (See Example 2.)

[0041] Figure 8 provides tables reporting the effects of N3F and N3Y mutations on SAR114 in agglutination and fibrinogen potency assays. (See Example 3.)

[0042] Figure 9 provides graphs showing the effects of the N3 (N3W), N3F, and N3Y mutations on the pharmacokinetic (PK) in mice transgenic for human FcRn (top panel) and OPK (bottom panel) of SAR114. (See Example 3.)

[0043] Figures 10A-M are a series of graphs which illustrate that the combination of SAR114 and MEDI4893* monoclonal antibodies provides strain coverage in a lethal bacteremia mouse model as described in Example 4. The different *S. aureus* clinical isolates from diverse sequence types (ST), and ClfA genotypes tested included: NRS123 (ST1, ClfA012), NRS387 (ST5, ClfA002), ARC635 (ST5, ClfA002), 3049043 (ST5, ClfA002), 3049057 (ST8, ClfA001), SF8300 (ST8, Clf A001), 3049088 (ST30, ClfA004), 3049114 (ST30, ClfA004), ARC2784 (ST188, ClfA019), 9043, 9057, 9157, and 2784. The data shown are representative of three independent experiments. Dashed

lines with a circle at the end represent mice treated with an IgG control antibody. Lines with a square at the end represent mice treated with SAR114 (15 mpk). Lines with an upward triangle at the end represent mice treated with MEDI4893* (15 mpk). Lines with a downward triangle at the end represent mice treated with SAR114 and MEDI4893* (7.5 mpk each). (See Example 4.)

[0044] Figure 11 is a series of graphs illustrating that the combination of SAR114 and MEDI4893* monoclonal antibodies protects against CA-MRSA SF8300-induced IV lethal bacteremia in BKS.Cg-Dock7^{m} +/+ Lepr^{db}/J diabetic mice (db/db). The horizontal bars in the bottom two panels represent the geometric mean CFU. The data are representative of three independent experiments. (See Example 5.)

[0045] Figure 12 provides images demonstrating the effects of the combination of SAR114 and MEDI4893* monoclonal antibodies on liver damage in db/db mice exposed to CA-MRSA SF8300-induced IV lethal bacteremia, either by gross pathology (left) or after hematoxylin and eosin staining of section (right). (See Example 7.)

[0046] Figure 13 is a series of graphs which illustrate that the combination of SAR114 and MEDI4893* monoclonal antibodies provides strain coverage for protection in a lethal bacteremia diabetic db/db mouse model. (See Example 8.)

[0047] Figure 14 provides schematic representations of bispecific constructs using anti-ClfA mAb as a scaffold (Figure 14A) or scFv of anti-AT mAb MEDI4893* linked via a 10-amino acid linker (GGGGx2) to the ClfA monoclonal antibody heavy chain N terminus (Figure 14B) or heavy chain C terminus (Figure 14C). (See Example 9.)

[0048] Figure 15 is a series of graphs illustrating *in vitro* characterization of anti-ClfA SAR114 or 11H10 / MEDI4893* BiSAbs, as described in Example 9. Figures 15A and 15D illustrate BiS_2 and BiS_3 activities compared to MEDI4893* in an AT-mediated rabbit RBC hemolytic assay. Serial dilutions of BiSAbs and MEDI4893* were incubated with AT alone (Figure 15A) or 10M excess of ClfA001 (Figure 15D) and RBC. Percent hemolysis inhibition was calculated as follows: $100*(100-(OD_{AT+mAb}) / (OD_{AT\ alone}))$. Data are representative of three independent experiments. Figures 15B and 15C illustrate the results of the immobilized fribrinogen binding assay described in Example 9. Serial dilutions of BiSAbs, SAR114 or 11H10 were incubated with ClfA alone (Figure 15B) or with 10M excess of AT (Figure 15C). Data represent the mean values standard deviation

of three separate experiments. Percent inhibition binding was calculated as 100*(100-($OD_{ClfA+mAb}$) / ($OD_{ClfA\ alone}$)).

[0049] Figure 16 is a series of graphs illustrating inhibition of fibrinogen binding to the three main ClfA genotypes as described in Example 9. Inhibition of fibrinogen binding was measured in the presence of serial dilutions of the monoclonal antibodies 11H10 (Figure 16A), SAR114 (Figure 16B), or respective bispecific antibodies (Figure 16C). A similar assay was conducted by saturating AT scFv in the presence of a 10M excess of AT (6.6 mM) (Figures 16D-F).

[0050] Figure 17 is a series of graphs illustrating opsonophagocytic killing (OPK) activity of anti-ClfA/AT bispecific antibodies (BiS). *S. aureus* Newman isolate was incubated with human HL-60 cells, human sera, and serial dilutions of 11H10 parental monoclonal antibodies or 11H10-BiS molecules (Figure 17A), or serial dilutions of SAR114 parental monoclonal antibodies or SAR114-BiS molecules (Figure 17B). The graphs represent mean values ± SD of two independent experiments. (See Example 9)

[0051] Figure 18 is a series of graphs illustrating the efficacy of anti-ClfA mAb/MEDI4893* bispecific antibodies in a bacteremia mouse model. Balb/c mice (n=10) were passively immunized IP with SAR114/MEDI4893* BiS_2, BiS_3 or a combination of SAR114+MEDI4893* at the indicated concentrations, and IV infected 24 hours later with an LD_{90} of *S. aureus* isolates SF8300 ($6e^7$ cfu) (Figure 18A) or 3049057 ($5e^7$ cfu) (Figure 18B). Protective efficacy for 11H10/MEDI4893* BiS_2, BiS_3 or 11H10+MEDI4893* mAbs was evaluated against SF8300 (Figure 18C) or 30419057 (Figure 18D) challenge. Survival was monitored for 2 weeks. Results were analyzed with a Log Rank (Mantel Cox) test. Statistical analysis versus c-IgG were considered statistically different if $p<0.05$, and indicated with an asterisk (*). Data are representative of three independent experiments. (See Example 10.)

[0052] Figure 19 is a series of graphs illustrating that ClfA sequesters SAR114/MEDI4893* BiSAb in a lethal pneumonia mouse model. C57/B6 mice (n=10) were passively immunized IP with BiS_2, BiS_3, MEDI4893* or the SAR114+MEDI4893* mAb combination at the indicated concentrations, and intranasally (IN) infected 24 hours later with $1.5e^6$ cfu of *S. aureus* isolates SF8300 (Figure 19A) or SF8300 Δ*clfA* isogenic mutant (Figure 19B). Survival was monitored for 6 days. Results were analyzed with a Log Rank (Mantel Cox) test. Statistical analysis versus c-IgG were considered

statistically different if $p<0.05$. Data are representative of three independent experiments. (See Example 11.)

[0053] Figure 20 shows the levels of SAR114, SAR114 N3F, and SAR114 N3Y is cynomolgus monkeys over a period of 60 days after administration of 5 mg/kg of the antibodies.

[0054] Figure 21 is a graph illustrating the immunogenicity of wild-type and N3Y Fc regions using an *ex vivo* PBMC stimulation assay.

DETAILED DESCRIPTION OF THE INVENTION

[0055] The present disclosure provides antibodies and antigen-binding fragments thereof (e.g., monoclonal antibodies and antigen-binding fragments thereof) that bind to *Staphylococcus aureus* (*S. aureus*) clumping factor A (ClfA) protein (and optionally also to *S. aureus* alpha toxin (AT) protein. The present disclosure also provides compositions comprising such antibodies or fragments thereof, as well as methods of using such antibodies, fragments thereof, or compositions.

[0056] The term "antibody" means an immunoglobulin molecule that recognizes and specifically binds to a target, such as a protein, polypeptide, peptide, carbohydrate, polynucleotide, lipid, or combinations of the foregoing through at least one antigen recognition site within the variable region of the immunoglobulin molecule. As used herein, the term "antibody" encompasses intact polyclonal antibodies, intact monoclonal antibodies, chimeric antibodies, humanized antibodies, human antibodies, fusion proteins comprising an antibody, and any other modified immunoglobulin molecule so long as the antibodies exhibit the desired biological activity. An antibody can be of any the five major classes of immunoglobulins: IgA, IgD, IgE, IgG, and IgM, or subclasses (isotypes) thereof (e.g. IgG1, IgG2, IgG3, IgG4, IgA1 and IgA2), based on the identity of their heavy-chain constant domains referred to as alpha, delta, epsilon, gamma, and mu, respectively. The different classes of immunoglobulins have different and well known subunit structures and three-dimensional configurations. Antibodies can be naked or conjugated to other molecules such as toxins, radioisotopes, etc.

[0057] The term "monoclonal antibodies," as used herein, refers to antibodies that are produced by a single clone of B-cells and bind to the same epitope. In contrast, the term

"polyclonal antibodies" refers to a population of antibodies that are produced by different B-cells and bind to different epitopes of the same antigen.

[0058] The term "antibody fragment" refers to a portion of an intact antibody. An "antigen-binding fragment," "antigen-binding domain," or "antigen-binding region," refers to a portion of an intact antibody that binds to an antigen. An antigen-binding fragment can contain the antigenic determining regions of an intact antibody (e.g., the complementarity determining regions (CDR)). Examples of antigen-binding fragments of antibodies include, but are not limited to Fab, Fab', F(ab')2, and Fv fragments, linear antibodies, and single chain antibodies. An antigen-binding fragment of an antibody can be derived from any animal species, such as rodents (*e.g.*, mouse, rat, or hamster) and humans or can be artificially produced.

[0059] A whole antibody typically consists of four polypeptides: two identical copies of a heavy (H) chain polypeptide and two identical copies of a light (L) chain polypeptide. Each of the heavy chains contains one N-terminal variable (VH) region and three C-terminal constant (CHI , CH2 and CH3) regions, and each light chain contains one N-terminal variable (VL) region and one C-terminal constant (CL) region. The variable regions of each pair of light and heavy chains form the antigen binding site of an antibody. The VH and VL regions have the same general structure, with each region comprising four framework regions, whose sequences are relatively conserved. The term "framework region," as used herein, refers to the relatively conserved amino acid sequences within the variable region which are located between the hypervariable or complementary determining regions (CDRs). There are four framework regions in each variable domain, which are designated FR1, FR2, FR3, and FR4. The framework regions form the β sheets that provide the structural framework of the variable region (see, e.g., C.A. Janeway et al. (eds.), *Immunobiology*, 5th Ed., Garland Publishing, New York, NY (2001)). The three CDRs, known as CDR1, CDR2, and CDR3, form the "hypervariable region" of an antibody, which is responsible for antigen binding.

[0060] The term "Kabat numbering" and like terms are recognized in the art and refer to a system of numbering amino acid residues in the heavy and light chain variable regions of an antibody or an antigen-binding fragment thereof. In certain aspects, CDRs can be determined according to the Kabat numbering system (see, *e.g.*, Kabat EA & Wu TT (1971) Ann NY Acad Sci 190: 382-391 and Kabat EA *et al.*, (1991) Sequences of

Proteins of Immunological Interest, Fifth Edition, U.S. Department of Health and Human Services, NIH Publication No. 91-3242). Using the Kabat numbering system, CDRs within an antibody heavy chain molecule are typically present at amino acid positions 31 to 35, which optionally can include one or two additional amino acids, following 35 (referred to in the Kabat numbering scheme as 35A and 35B) (CDR1), amino acid positions 50 to 65 (CDR2), and amino acid positions 95 to 102 (CDR3). Using the Kabat numbering system, CDRs within an antibody light chain molecule are typically present at amino acid positions 24 to 34 (CDR1), amino acid positions 50 to 56 (CDR2), and amino acid positions 89 to 97 (CDR3). In a specific embodiment, the CDRs of the antibodies described herein have been determined according to the Kabat numbering scheme.

[0061] Chothia refers instead to the location of the structural loops (Chothia and Lesk, J. Mol. Biol. 196:901-917 (1987)). The end of the Chothia CDR-H1 loop when numbered using the Kabat numbering convention varies between H32 and H34 depending on the length of the loop (this is because the Kabat numbering scheme places the insertions at H35A and H35B; if neither 35A nor 35B is present, the loop ends at 32; if only 35A is present, the loop ends at 33; if both 35A and 35B are present, the loop ends at 34). The AbM hypervariable regions represent a compromise between the Kabat CDRs and Chothia structural loops, and are used by Oxford Molecular's AbM antibody modeling software.

Loop	Kabat	AbM	Chothia
L1	L24-L34	L24-L34	L24-L34
L2	L50-L56	L50-L56	L50-L56
L3	L89-L97	L89-L97	L89-L97
H1	H31-H35B	H26-H35B (Kabat Numbering)	H26-H32..34
H1	H31-H35	H26-H35 (Chothia Numbering)	H26-H32
H2	H50-H65	H50-H58	H52-H56
H3	H95-H102	H95-H102	H95-H102

[0062] In one embodiment, the composition comprises a first antibody or antigen-binding fragment thereof (e.g. a monoclonal antibody or fragment) that specifically binds to a

Staphylococcus aureus clumping factor A protein (ClfA) and a second antibody or antigen-binding fragment thereof (e.g. a monoclonal antibody or fragment) that specifically binds to a *S. aureus* alpha toxin (AT) protein. Among the many *S. aureus* surface adhesins, clumping factor A (ClfA) has been demonstrated to play an important role in serious bloodstream infections (Foster et al., *Nat. Rev. Microbiol.*, *12*: 49-62 (2014); and Murphy et al., *Hum. Vaccin.*, *7*(Suppl): 51-59 (2011)). ClfA binds fibrinogen and facilitates both bacterial adherence to fibrinogen and bacterial clumping, both of which are key attributes in the development of an *S. aureus* bloodstream infection (Vaudaux et al., *Infect. Immun.*, *63*: 585-590 (1995); McDevitt et al., *Mol. Microbiol.*, *11*: 237-248 (1994); and McDevitt et al., *Eur. J. Biochem.*, *247*: 416-424 (1997)). ClfA bound to fibrin or fibrinogen at a site of injury or coated on an indwelling device can facilitate bacterial colonization (Foster et al., *supra*) and bacterial clumping, which is thought to enhance bacterial invasiveness (McDevitt et al., *Eur. J. Biochem.*, *247*: 416-424 (1997); McAdow et al., *PLoS Pathog.*, *7*:e1002307 (2011); Flick et al., *Blood*, *121*: 1783-1794 (2013); and Rothfork et al., *J. Immunol.*, *171*: 5389-5395 (2003)). ClfA also has been reported to impair complement deposition required for opsonophagocytic bacterial killing (OPK) (Hair et al., *Infect. Immun.*, *78*: 1717-1727 (2010)). Consistent with these observations, isogenic ΔclfA mutants exhibited reduced virulence in infection models (McAdow et al., *supra*; Josefsson et al., *PLoS One*, *3*: e2206 (2008); and Josefsson et al., *J Infect. Dis.*, *184*: 1572-1580 (2001)). In addition, passive immunization with human anti-ClfA-enriched intravenous (i.v.) immunoglobulin (Ig) (INH-A21 or Veronate) or a monoclonal antibody (tefibazumab or Aurexis) improved disease outcomes for patients with *S. aureus* bloodstream infections (Vernachio et al., *Antimcirob. Agents Chemother.*, *47*: 3400-3406 (2003); and Vernachio et al., *Antimicrob. Agents Chemother.*, *50*: 511-518 (2006)). However, these antibody preparations failed to improve outcomes in clinical studies of prophylaxis or adjunctive therapy with vancomycin to prevent or treat *S. aureus* bacteremia in very-low-birth-weight infants (DeJonge et al., *J. Pediatr.*, *151*: 260-265 (2007); Capparelli et al., Antimicrob. Agents Chemother., 49: 4121-4127 (2005); and Bloom et al., *Pediatr. Infect. Dis.*, *24*: 858-866 (2005)). ClfA structure and function is described in detail in, for example, McDevitt et al., *Mol. Microbiol.*, *11*: 237-248 (1994)).

[0063] Alpha toxin (AT) is a key virulence factor in several *S. aureus* diseases, including pneumonia, skin and soft tissue infections (SSTI), and bacteremia (Bubeck Wardenburg,

J. and O. Schneewind, *J. Exp. Med.*, *205*: 287-294 (2008); Inoshima et al., *J. Invest. Dermatol.*, *132*: 1513-1516 (2012); and Foletti et al., *supra*). Passive immunization with anti-AT monoclonal antibodies reduced disease severity in pneumonia and dermonecrosis models (Hua et al., *Antimicrob. Agents Chemother.*, *58*: 1108-1117 (2014); Tkaczyk et al., *Clin. Vaccine Immunol.*, *19*: 377-385 (2012); and Ragle, B.E. and J. Wardenburg Bubeck, *Infect. Immun.*, *77*: 2712-2718 (2009)), and vaccination with an AT toxoid containing an H35L mutation (ATH35L) protected against death in mouse lethal bacteremia and pneumonia models (Bubeck Wardenburg, *supra*, Foletti et al., *supra*, Hua et al., *supra*, Ragle, *supra*, Menzies, B.E. and D.S Kernodle, *Infect. Immun.*, *77*: 2712-2718 (2009); and Adhikari et al., *PLoS One*, *7*: e38567 (2012)). AT contributes to multiple aspects of *S. aureus* pathogenesis during bacteremia and sepsis, including stimulating a hyperinflammatory response characteristic of sepsis and activating ADAM10-mediated cleavage of endothelial tight junctions, leading to a loss in vascular integrity (Powers et al., *J Infect. Dis.*, *206*: 352-356 (2012); Wilke, G.A. and J. Bubeck Wardenburg, *Proc. Natl. Acad. Sci. USA*, *107*: 13473-13478 (2010); and Becker et al., *J Innate Immun.*, *6*: 619-631 (2014)). AT also has been demonstrated to target platelets, which prevents repair of the injured endothelial barrier and promotes organ dysfunction through platelet-neutrophil aggregate formation (Powers et al., *Cell Host Microbe*, *17*: 775-787 (2015)). Alpha toxin structure and function is described in detail in, for example, Bhakdi, S. and J. Tranum-Jensen, *Microbiol. Mol. Biol. Rev.*, *55*(4): 733-751 (1991).

[0064] Monoclonal and polyclonal antibodies which bind ClfA are known in the art (see, e.g., U.S. Patent 7,364,738; Hall et al., *Infect. Immun.*, *71*(12): 6864-6870 (2003); and Vernachio et al., *Antimicrob. Agents Chemother.*, *47*(11): 3400-3406 (2003)) and are commercially available from sources such as, for example, Creative Biolabs (Shirley, NY). As discussed above, while some anti-ClfA monoclonal antibodies (e.g., the 11H10 monoclonal antibody described in Tkaczyk et al., MBio., 7(3). pii: e00528-16 (2016)) have shown efficacy against *S. aureus* infections in bacteremia models, such antibodies have been found to exhibit reduced affinity for ClfA and impaired inhibition of fibrinogen binding to ClfA founder sequence (ClfA002) expressed by certain strains of methicillin-resistant *Staphylococcus aureus* (MRSA). As such, the present disclosure provides an antibody or antigen-binding fragment thereof (e.g., a monoclonal antibody or fragment) that specifically binds to ClfA with greater than 100-fold increased affinity for three

prominent ClfA variants, including ClfA002, and potent inhibition of bacterial agglutination by 112 diverse clinical isolates. In this regard, in one embodiment the first antibody or antigen-binding fragment thereof (e.g., monoclonal antibody or fragment) of the composition described herein specifically binds to ClfA and comprises, consists essentially of, or consists of (i) a heavy chain polypeptide comprising a complementarity determining region 1 (CDR) amino acid sequence of SEQ ID NO: 1, a CDR2 amino acid sequence of SEQ ID NO: 2, and a CDR3 amino acid sequence of SEQ ID NO: 3, and (ii) a light chain polypeptide comprising a CDR1 amino acid sequence of SEQ ID NO: 4, a CDR2 amino acid sequence of SEQ ID NO: 5, and a CDR3 amino acid sequence of SEQ ID NO: 6. In another embodiment, the heavy chain polypeptide of the first antibody or antigen-binding fragment comprises (e.g., monoclonal antibody or fragment), consists essentially of, or consists of a variable region amino acid sequence of SEQ ID NO: 13 and the light chain polypeptide of the first antibody or antigen-binding fragment comprises, consists essentially of, or consists of, a variable region amino acid sequence of SEQ ID NO: 14. In certain instances, the antibody or antigen-binding fragment (e.g., monoclonal antibody or fragment) comprises a heavy chain constant domain comprising the amino acid sequence of CSYHLC (SEQ ID NO: 21), MHEACSYHLCQKSLSLS (SEQ ID NO: 23), or SEQ ID NO:24.

[0065] Monoclonal and polyclonal antibodies which bind AT also are known in the art (see, e.g., Hua et al., *Antimicrob. Agents Chemother.*, *58*(2): 1108-1117 (2014); and Oganesyan et al., *J. Biol. Chem.*, *289*: 29874-29880 (2014)) and are commercially available from sources such as, for example, Sigma Aldrich (St. Louis, MO) and AbCam (Cambridge, MA). In one embodiment, the second antibody or antigen-binding fragment (e.g., monoclonal antibody or fragment) of the composition described herein specifically binds to *S. aureus* alpha toxin (AT) protein and comprises, consists essentially of, or consists of (i) a heavy chain polypeptide comprising a CDR1 amino acid sequence of SEQ ID NO: 7, a CDR2 amino acid sequence of SEQ ID NO: 8, and a CDR3 amino acid sequence of SEQ ID NO: 9, and (ii) a light chain polypeptide comprising a CDR1 amino acid sequence of SEQ ID NO: 10, a CDR2 amino acid sequence of SEQ ID NO: 11, and a CDR3 amino acid sequence of SEQ ID NO: 12. In another embodiment, the heavy chain polypeptide of the second antibody or antigen-binding fragment (e.g., monoclonal antibody or fragment) comprises, consists essentially of, or consists of a variable region

amino acid sequence of SEQ ID NO: 15 and/or the light chain polypeptide of the second monoclonal antibody comprises, consists essentially of, or consists of a variable region amino acid sequence of SEQ ID NO: 16.

[0066] Sequences of exemplary anti-ClfA and anti-AT antibodies are provided below. In certain instances, an antibody or antigen-binding fragment thereof described herein binds to ClfA and/or AT and comprises the six CDRs of an antibody listed in the two tables below (i.e., the three VH CDRs of the antibody listed in the first table and the three VL CDRs of the same antibody listed in the second table). The anti-AT antibody MEDI4893 is the half-life extended (YTE) version of "LC10" described previously in International Patent Application Publications WO 2012/109285 and WO 2014/074540 (both of which are herein incorporated by reference in their entireties). MEDI4893* does not contain the YTE mutation.

VH CDR Amino Acid Sequences

Antibody	**VH CDR1 (SEQ ID NO:)**	**VH CDR2 (SEQ ID NO:)**	**VH CDR3 (SEQ ID NO:)**
SAR114	NSYWS (SEQ ID NO: 1)	YLYSSGRTNYTPSLKS (SEQ ID NO: 2)	THLGGFHYGGGFWFDP (SEQ ID NO: 3)
MEDI4893 and MEDI4893*	SHDMH (SEQ ID NO: 7)	GIGTAGDTYYPDSVKG (SEQ ID NO: 8)	DRYSPTGHYYGMDV (SEQ ID NO: 9)

VL CDR Amino Acid Sequences

Antibody	**VL CDR1 (SEQ ID NO:)**	**VL CDR2 (SEQ ID NO:)**	**VL CDR3 (SEQ ID NO:)**
SAR114	RASQSITSYLN (SEQ ID NO: 4)	ASSSLQS (SEQ ID NO: 5)	QESYSTPPT (SEQ ID NO: 6)
MEDI4893 and MEDI4893*	RASQSISSWLA (SEQ ID NO: 10)	KASSLES (SEQ ID NO: 11)	KQYADYWT (SEQ ID NO: 12)

[0067] In certain instances, an antibody or antigen-binding fragment thereof described herein binds to ClfA and/or AT and comprises the VH of an antibody listed in the following table, e.g., in combination with a VL.

Variable Heavy Chain (VH) Amino Acid Sequence

Antibody	**VH Amino Acid Sequence (SEQ ID NO)**
SAR114	QVQLQESGPGLVKPSETLSLTCTVSGGSIQNSYWSWIRQPPGKGLEWI GYLYSSGRTNYTPSLKSRVTISVDTSKNQFSLKLSSVTAADTAVYYCA

	RTHLGGFHYGGGFWFDPWGQGTLVTVSS (SEQ ID NO: 13)
MEDI4893 and MEDI4893*	EVQLVESGGGLVQPGGSLRLSCAASGFTFSSHDMHWVRQATGKGLE WVSGIGTAGDTYYPDSVKGRFTISRENAKNSLYLQMNSLRAGDTAV YYCARDRYSPTGHYYGMDVWGQGTTVTVSS (SEQ ID NO: 15)
SAR72	EVQLVESGGGLVKPGGSLRVSCAASGFSFRNALMSWVRQAPGKGLE WVGRSKTDGGTTDYAAPVKGRFTISRDDSKNTLYLQMNSLKTEDTA VYYCTTGPGGGPPGDYYYDGMDVWGQGTTVTVSS (SEQ ID NO: 17)
SAR80	EVQLVESGGDLVKPGGSLRLSCAASGFTFSDAWMTWVRQAPGKGLE WVGRIRSKTAGGTTDYAAPVKGRFTISRDDSKNTLYLQMTSLKIEDT ALYYCMTDGLGLLNFGDSDPHHYWGQGTRVTVSS (SEQ ID NO: 30)
SAR113	EVQLVQSGAEVKKPGESLKISCKAXGYXFTSYWIGWVRQVPGKGLE WMGIIYPGDSDTRHSPSFQGQVTISVDKSISTAYLQWSSLKASDSAMY YCARHQSGSHGFDAFEIWGQGTMVTVSS (SEQ ID NO: 32)
SAR132	EVQLVQSGAEVKKPGESLKISCKGSGYNFTNYWIAWVRQMPGKGLE WMGIIYSGDSDTRYSPSFLGQVSISVDKSFTTAYLQWRSLKASDTAM YYCARRPGGQKPYDYWGQGTLVTVSS (SEQ ID NO: 34)
SAR352	EVQLVESGGGLVKPGGSLRLSCAASGFTFNNAWMSWVRQAPGKGLE WVGRIKSETAGGTTDYAAPVKGRFSISRDDSRNTLYLEMNSLKTEDT AVYYCTTDSYTPLEEPCPNGVCYTYYYYGMDVWGQGTTVTVSS (SEQ ID NO: 36)
SAR372	EVQLVESGGGLVQPGGSLRLSCAASGFIFNRYSMNWVRQAPGKGLE WVSYISSSSSPIYYADSVKGRFTISRDNAKNSLYLQMNSLRDEDTAVY YCASRVTLGLEFDFWGQGTLVTVSS (SEQ ID NO: 38)
SAR510	QVTLRESGPALVKPTQTLTLTCTFSGFSLSTSGMCVGWIRQPPGKALE WLALIEWDDDKYYNTSLKTRLSISKDTSKNQVVLTMTNMDPVDTGT YYCARHSSSSRGFDYWGQGALVTVSS (SEQ ID NO: 40)
SAR547	EVQLVQSGAEVKKPGESLKISCKGSGYSFTTYWIAWVRQMPGKGLE WMGIIYPGDSDTRYSPSFQGQVTISADKSTATAYLQWSSLNASDSAM YYCARQGGSHGYDAFHMWGQGTMVTVSS (SEQ ID NO: 42)
SAS1	EVQLLESGGGLVQPGGSLRLSCTASGFTFSTYALNWVRQAPGKGLE WVAGINGTGYNTYYADSVRGRFTISRDNSKNTVTLEMNSLRVEDTA TYYCHKVPWWGQGTLVSVSS (SEQ ID NO: 44)
SAS19	QVQLQESGPRLVKPSETLSLTCFVSGGSINNSYWTWIRQPPGQGLEWI GFVFSSGRTNYSPSLKSRVTISVDTSKNLFSLRLTSVTAADTAVYFCA RQVHYDFWSGYSLTKTNWFDPWGQGTLVTVSS (SEQ ID NO: 46)
SAS203	QVQLQESGPGLVKPSETLSLTCVVSGGSINNSYWTWIRQPPGQGLEWI GFVYSSGRTYYSPSLKSRVTISVDTSKNFFSLRLNSVTAADTAVYFCA RQVHYDLWSGYSLTKTNWFDPWGQGTLVTVSS (SEQ ID NO: 48)

[0068] In certain instances, an antibody or antigen-binding fragment thereof described herein binds to ClfA and/or AT and comprises the VL of an antibody listed in the following table, e.g., in combination with a VH, optionally the VH of the same antibody listed in the preceding table.

Variable Light Chain (VL) Amino Acid Sequence

Antibody	**VL Amino Acid Sequence (SEQ ID NO)**
SAR114	DIQMTQSPSSLSASVGDRVTITCRASQSITSYLNWYQQKPGKAPKLLI

	YASSSLQSGVPSRFSGSGSGTDFTLTISSLQPEDFATYYCQESYSTPPTF GQGTKVEIK (SEQ ID NO: 14)
MEDI4893 and MEDI4893*	DIQMTQSPSTLSASVGDRVTITCRASQSISSWLAWYQQKPGKAPKLLI YKASSLESGVPSRFSGSGSGTEFTLTISSLQPDDFATYYCKQYADYWT FGQGTKVEIK (SEQ ID NO: 16)
SAR72	SYELTQPPSVSVSPGQTARITCSGDAVPKKYAYWYQQKSGQAPVLVI YEDKKRPSGIPERFSGSSSGTMATLTISGAQVEDEADYYCYSTDSSEG VFGGGTKLTVL (SEQ ID NO: 18)
SAR80	SYELTQPPSVSVSPGQTARITCSGDALPKKYAYWYQQKSGQAPVLVI HEDTKRPSGIPERFSGSSSGTMATLTISGAQVEDEADYHCYSTDSSGV VFGGGTKLTVL (SEQ ID NO: 31)
SAR113	DIVLTQSPDSLAVSLGERATINCKSSQGVLSRSNNKNYLAWYQQKPG QPPKLLIYWASTRESGVPDRFSGSGSGTDFTLTISSLQAEDVAVYYCQ QYYNNLRTFGQGTKVEIR (SEQ ID NO: 33)
SAR132	DIQMTQSPSTLSASVGDRVTITCRASQRISNWLAWYQKKPGKAPKLLI YKASTLESEVPSRFSGSGSGTEFTLTISSLQPDDLATYYCHQYISYYTF GQGTKLEIK (SEQ ID NO: 35)
SAR352	QSVLTQPPSVSAAPGEKVTISCSGSSSNIGANSVSWYQQFPGTAPKLLI YDNDKRPSGVPDRFSGSKSGTSATLGITGLQTGDEADYYCGTWVGIL SAGWVFGGGTKLTVL (SEQ ID NO: 37)
SAR372	EIVLTQSPATLSLSPGERATLSCRASQSVSSNLAWYQQKPGQAPRLLI YDASNRATGIPDRFSGSGSGTDFTLTISSLKPEDFAVYYCQLRSNWAY TFGQGTKLEIK (SEQ ID NO: 39)
SAR510	SYGLTQPPSVSVSPGQTARITCSGDALAKQYVYWYQQKPGQAPVLVI DKDRERPSGIPERFSGSSSGTTVTLTISGVQAEDEADYYCQSADSSRT YVFGTGTKVTVL (SEQ ID NO: 41)
SAR547	DVVMTQSPLSLPVTLGQPASISCRSSQSLVHSDGNTYLNWFQQRPGQ SPRRLIYKVSNRDSGVPDRFSGSGSGTDFTLKISRVEAEDVGVYYCM QGTHLTWTFGQGTKVEIK (SEQ ID NO: 43)
SAS1	DIVLTQSPESLAVSLGERATISCKSSQSLFFKSNNKNYLAWYQQKPGQ PPKVIIYWASTRESGVPARFSGSGSGTDFTLTISSLQAEDVAVYFCHQ YYSTQYSFGQGTKLEIK (SEQ ID NO: 45)
SAS19	DIQMTQSPSSLSASVGDTVTITCRTSQSISNFLNWYQQKPGKAPKLLIY AASSLQSGVPSRVNGSTSGTEFTLTLSSLQPEDFATYYCQQSYSTPWT FGQGTKVEIK (SEQ ID NO: 47)
SAS203	DIQMTQSPSSLSASVGDTVTITCRTSQSISNFLNWYQQKPGKAPKLLIY AASSLQSGVPSRFNGSTSGTDFTLTLSSLQPEDFATYYCQQSYSTPWT FGQGTKVEIK (SEQ ID NO: 49)

[0069] In certain instances, an antibody or antigen-binding fragment thereof described herein binds to ClfA and/or AT and comprises the heavy chain of an antibody listed in the following table, e.g., in combination with a light chain.

Full-length heavy chain amino acid sequences

Antibody	**Full-Length Heavy Chain Amino Acid Sequence (SEQ ID NO)**
SAR114	QVQLQESGPGLVKPSETLSLTCTVSGGSIQNSYWSWIRQPPGKGLEW IGYLYSSGRTNYTPSLKSRVTISVDTSKNQFSLKLSSVTAADTAVYYC

	ARTHLGGFHYGGGFWFDPWGQGTLVTVSSASTKGPSVFPLAPSSKS TSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLY SLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKRVEPKSCDKTHTCP PCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKF NWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEY KCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLT CLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVD KSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK (SEQ ID NO: 25)
SAR114 N3	QVQLQESGPGLVKPSETLSLTCTVSGGSIQNSYWSWIRQPPGKGLEW IGYLYSSGRTNYTPSLKSRVTISVDTSKNQFSLKLSSVTAADTAVYYC ARTHLGGFHYGGGFWFDPWGQGTLVTVSSASTKGPSVFPLAPSSKS TSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLY SLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKRVEPKSCDKTHTCP PCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKF NWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEY KCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLT CLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVD KSRWQQGNVFSCSVMHEACSWHLCQKSLSLSPGK (SEQ ID NO: 52)
SAR114 N3Y	QVQLQESGPGLVKPSETLSLTCTVSGGSIQNSYWSWIRQPPGKGLEW IGYLYSSGRTNYTPSLKSRVTISVDTSKNQFSLKLSSVTAADTAVYYC ARTHLGGFHYGGGFWFDPWGQGTLVTVSSASTKGPSVFPLAPSSKS TSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLY SLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKRVEPKSCDKTHTCP PCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKF NWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEY KCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLT CLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVD KSRWQQGNVFSCSVMHEACSYHLCQKSLSLSPGK (SEQ ID NO: 50)
MEDI4893	EVQLVESGGGLVQPGGSLRLSCAASGFTFSSHDMHWVRQATGKGL EWVSGIGTAGDTYYPDSVKGRFTISRENAKNSLYLQMNSLRAGDTA VYYCARDRYSPTGHYYGMDVWGQGTTVTVSSASTKGPSVFPLAPSS KSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSG LYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKRVEPKSCDKTHT CPPCPAPELLGGPSVFLFPPKPKDTLYITREPEVTCVVVDVSHEDPEV KFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGK EYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVS LTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLT VDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK (SEQ ID NO: 27)
MEDI4893*	EVQLVESGGGLVQPGGSLRLSCAASGFTFSSHDMHWVRQATGKGL EWVSGIGTAGDTYYPDSVKGRFTISRENAKNSLYLQMNSLRAGDTA VYYCARDRYSPTGHYYGMDVWGQGTTVTVSSASTKGPSVFPLAPSS KSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSG LYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKRVEPKSCDKTHT CPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEV KFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGK EYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVS LTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLT

	VDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK (SEQ ID NO: 51)

[0070] In certain instances, an antibody or antigen-binding fragment thereof described herein binds to ClfA and/or AT and comprises the light chain of an antibody listed in the following table, e.g., in combination with a heavy chain, optionally the heavy chain of the same antibody listed in the preceding table.

Full-length light chain amino acid sequences

Antibody	Full-Length Light Chain Amino Acid Sequence (SEQ ID NO)
SAR114	DIQMTQSPSSLSASVGDRVTITCRASQSITSYLNWYQQKPGKAPKLLI YASSSLQSGVPSRFSGSGSGTDFTLTISSLQPEDFATYYCQESYSTPPT FGQGTKVEIKRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAK VQWKVDNALQSGNSQESVTEQDSKDSTYSLSSTLTLSKADYEKHKV YACEVTHQGLSSPVTKSFNRGEC (SEQ ID NO: 26)
MEDI4893 and MEDI4893*	DIQMTQSPSTLSASVGDRVTITCRASQSISSWLAWYQQKPGKAPKLL IYKASSLESGVPSRFSGSGSGTEFTLTISSLQPDDFATYYCKQYADYW TFGQGTKVEIKRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREA KVQWKVDNALQSGNSQESVTEQDSKDSTYSLSSTLTLSKADYEKHK VYACEVTHQGLSSPVTKSFNRGE (SEQ ID NO: 28)

[0071] In certain aspects, the CDRs of an antibody or antigen-binding fragment thereof can be determined according to the Chothia numbering scheme, which refers to the location of immunoglobulin structural loops (*see*, *e.g.*, Chothia C & Lesk AM, (1987), J Mol Biol 196: 901-917; Al-Lazikani B *et al.*, (1997) J Mol Biol 273: 927-948; Chothia C *et al.*, (1992) J Mol Biol 227: 799-817; Tramontano A *et al.*, (1990) J Mol Biol 215(1): 175-82; and U.S. Patent No. 7,709,226). Typically, when using the Kabat numbering convention, the Chothia CDR-H1 loop is present at heavy chain amino acids 26 to 32, 33, or 34, the Chothia CDR-H2 loop is present at heavy chain amino acids 52 to 56, and the Chothia CDR-H3 loop is present at heavy chain amino acids 95 to 102, while the Chothia CDR-L1 loop is present at light chain amino acids 24 to 34, the Chothia CDR-L2 loop is present at light chain amino acids 50 to 56, and the Chothia CDR-L3 loop is present at light chain amino acids 89 to 97. The end of the Chothia CDR-H1 loop when numbered using the Kabat numbering convention varies between H32 and H34 depending on the length of the loop (this is because the Kabat numbering scheme places the insertions at H35A and H35B; if neither 35A nor 35B is present, the loop ends at 32; if only 35A is present, the loop ends at 33; if both 35A and 35B are present, the loop ends at 34).

[0072] In certain aspects, provided herein are antibodies and antigen-binding fragments thereof that comprise the Chothia VH and VL CDRs of the SAR114 and/or MEDI4893*

antibodies. In certain embodiments, antibodies or antigen-binding fragments thereof comprise one or more CDRs, in which the Chothia and Kabat CDRs have the same amino acid sequence. In certain embodiments, provided herein are antibodies and antigen-binding fragments thereof comprise combinations of Kabat CDRs and Chothia CDRs.

[0073] In certain aspects, the CDRs of an antibody or antigen-binding fragment thereof can be determined according to the IMGT numbering system as described in Lefranc M-P, (1999) The Immunologist 7: 132-136 and Lefranc M-P *et al.*, (1999) Nucleic Acids Res 27: 209-212. According to the IMGT numbering scheme, VH-CDR1 is at positions 26 to 35, VH-CDR2 is at positions 51 to 57, VH-CDR3 is at positions 93 to 102, VL-CDR1 is at positions 27 to 32, VL-CDR2 is at positions 50 to 52, and VL-CDR3 is at positions 89 to 97. In a particular embodiment, provided herein are antibodies and antigen-binding fragments thereof that comprise the IMGT VH and VL CDRs of the SAR114 and/or MEDI4893* antibodies, for example, as described in Lefranc M-P (1999) *supra* and Lefranc M-P *et al.*, (1999) *supra*).

[0074] In certain aspects, the CDRs of an antibody or antigen-binding fragment thereof can be determined according to MacCallum RM *et al.*, (1996) J Mol Biol 262: 732-745. *See also*, *e.g.*, Martin A. "Protein Sequence and Structure Analysis of Antibody Variable Domains," in *Antibody Engineering*, Kontermann and Dübel, eds., Chapter 31, pp. 422-439, Springer-Verlag, Berlin (2001). In a particular embodiment, provided herein are antibodies or antigen-binding fragments thereof comprise the VH and VL CDRs of the SAR114 and/or MEDI4893* antibodies determined by the method in MacCallum RM *et al.*

[0075] In certain aspects, the CDRs of an antibody or antigen-binding fragment thereof can be determined according to the AbM numbering scheme, which refers AbM hypervariable regions which represent a compromise between the Kabat CDRs and Chothia structural loops, and are used by Oxford Molecular's AbM antibody modeling software (Oxford Molecular Group, Inc.). In a particular embodiment, provided herein are antibodies or antigen-binding fragments that and comprise VH and VL CDRs of the SAR114 and/or MEDI4893* antibodies as determined by the AbM numbering scheme.

[0076] In another embodiment, the antibody or antigen-binding fragment thereof (e.g., monoclonal antibody or fragment) described herein may comprise a constant region (Fc) of any suitable class (IgG, IgA, IgD, IgM, and IgE) that has been modified in order to

improve effector functions (e.g., opsonophagocytic bacterial killing (OPK)) or the half-life of the first and/or second antibody or antigen-binding fragment (e.g., monoclonal antibody or fragment) present in the composition. For example, the antibody or antigen-binding fragment thereof (e.g., monoclonal antibody or fragment) described herein may comprise an Fc that comprises a mutation that extends half-life relative to the same antibody without the mutation, and wherein the mutation does not inhibit OPK activity relative to the same antibody or antigen-binding fragment the mutation. Fc region engineering is widely used in the art to extend the half-life of therapeutic antibodies and protect from degradation *in vivo*. In some embodiments, the Fc region of an IgG antibody or antigen-binding fragment may be modified in order to increase the affinity of the IgG molecule for the Fc Receptor-neonate (FcRn), which mediates IgG catabolism and protects IgG molecules from degradation. The Fc region of any of the antibodies or antigen-binding fragments (e.g., monoclonal antibodies or fragments) described herein may comprise one or more amino acid substitutions or modifications which improve or extend antibody half-life or effector function, such as by increasing the affinity of an IgG molecule for the FcRn. Suitable Fc region amino acid substitutions or modifications are known in the art and include, for example, the triple substitution M252Y/S254T/T256E (referred to as "YTE") (see, e.g., U.S. Patent 7,658,921; U.S. Patent Application Publication 2014/0302058; and Yu et al., *Antimicrob. Agents Chemother.*, *61*(1): e01020-16 (2017)). In another embodiment, the Fc region may be derived from the high affinity FcRn-binding Fc variant N3E-YTE (see, e.g., Borrok et al., *J. Biol. Chem.*, *290*(7): 4282-4290 (2015)), which comprises the YTE mutation in C_H2 and cysteine residues at positions 432 and 437. For example, the N3E-YTE variant may lack the YTE mutation (referred to as "N3E"), or may be substituted at Fc residue 432 (using Kabat numbering) with, for example, the sequence CSWHLC (referred to as "N3"; SEQ ID NO:19), CSFHLC (referred to as "N3F"; SEQ ID NO:20), or CSYHLC (referred to as "N3Y"; SEQ ID NO:21). The N3, N3F, and N3Y Fc variants, in particular, exhibit enhanced pharmacokinetic (PK) properties (e.g., serum persistence) and effector functions (e.g., opsonophagocytic bacterial killing (OPK)) as compared to the YTE variants.

[0077] Sequences of exemplary Fc variants are provided below.

Fc Variant	Sequence (SEQ ID NO)
N3 (also referred to	CSWHLC (SEQ ID NO:19)

as N3W)	
N3F	CSFHLC (SEQ ID NO:20)
N3Y	CSYHLC (SEQ ID NO:21)
N3 Fc starting from hinge	CPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEV KFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGK EYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVS LTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLT VDKSRWQQGNVFSCSVMHEACSWHLCQKSLSLSPGK (SEQ ID NO: 29)
N3Y Fc starting from hinge	CPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEV KFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGK EYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVS LTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLT VDKSRWQQGNVFSCSVMHEACSYHLCQKSLSLSPGK (SEQ ID NO: 24)

[0078] The present disclosure provides antibodies and antigen-binding fragments thereof that bind to ClfA (e.g., antibodies and antigen-binding fragments comprising the CDR, VH and/or VL, heavy and or light, or Fc variant sequences listed in the tables above) and have IC50's for ClfA001, ClfA002, and ClfA004 in a fibrinogen binding inhibition assay that are within 2 μg/ml of each other. For example, the IC_{50}'s of the antibody or antigen-binding fragment thereof for ClfA001, ClfA002, and ClfA004 can all be between 1 μg/ml and 5 μg/ml. The binding affinities (K_D) of the antibody or antigen-binding fragment thereof for ClfA001, ClfA002, and ClfA004 can all be all between 200 and 350 pM.

[0079] The present disclosure provides antibodies and antigen-binding fragments thereof that bind to ClfA (e.g., antibodies and antigen-binding fragments comprising the CDR, VH and/or VL, heavy and or light, or Fc variant sequences listed in the tables above) and have a monomeric purity that decreases by no more than 5% after exposure to conventional white light at 2kLux/hr at 23°C for 14 days.

[0080] The present disclosure is not limited to a composition comprising both the ClfA-binding antibody or antigen-binding fragment and the AT-binding antibody or antigen-binding fragment described above. Indeed, the present disclosure also separately provides a antibody or antigen-binding fragment thereof (e.g., a monoclonal antibody or fragment) comprising: (a) a heavy chain polypeptide comprising a CDR1 amino acid sequence of SEQ ID NO: 1, a CDR2 amino acid sequence of SEQ ID NO: 2, and a CDR3 amino acid sequence of SEQ ID NO: 3, and (b) a light chain polypeptide comprising a CDR1 amino acid sequence of SEQ ID NO: 4, a CDR2 amino acid sequence of SEQ ID NO: 5, and a CDR3 amino acid sequence of SEQ ID NO: 6.

[0081] The disclosure also provides a bispecific antibody or antigen-binding fragment that binds (e.g., simultaneously) both ClfA and AT. The term "bispecific monoclonal antibody" (also referred to as a "dual-specific" monoclonal antibody) refers to a monoclonal antibody that comprises two different antigen-recognition domains and therefore can simultaneously bind two different epitopes. Monoclonal antibodies that recognize and bind to more than two different epitopes are referred to in the art as "multi-specific monoclonal antibodies." The first bispecific antibodies were generated by somatic hybridization of two antibody-secreting cells, but produced poor yields due to random assembly of parental heavy and light chains (Milstein, C. and A.C. Cuello, *Immunol. Today*, *5*: 299-304 (1984)). The discovery of single chain variable fragments (scFvs) and advances in antibody engineering have resulted in new methodologies for the development of bispecific antibodies (Orcutt et al., *Protein Eng. Des. Sel.*, *23*: 221-228 (2010); and Coloma, M.J. and S.L. Morrison, *Nat. Biotechnol.*, *15*: 159-163 (1997)). There are now at least 50 different bispecific antibody formats based on scFv numbers and fusion positions on the IgG scaffold (Kontermann, R.E., *MAbs*, *4*: 182-197 (2012)). Bispecific and multispecific antibodies may be manufactured in several different structural formats, including, but not limited to, tandem scFv, diabodies, tandem diabodies, dual variable domain antibodies and heterodimerization using a motif such as CH1/Ck domain or the Dock and Lock motif (see, e.g., Chames, P. and D. Baty, *Curr. Opin. Drug. Discov. Devel.*, *12*: 276-283 (2009)). In one embodiment, the disclosure provides an antibody or antigen-binding fragment thereof (e.g., a monoclonal antibody or fragment) which specifically binds to a *Staphylococcus aureus* ClfA protein and a *Staphylococcus aureus* alpha toxin (AT) protein (i.e., a bispecific antibody), which comprises: (a) a first heavy chain polypeptide comprising a CDR1 amino acid sequence of SEQ ID NO: 1, a CDR2 amino acid sequence of SEQ ID NO: 2, and a CDR3 amino acid sequence of SEQ ID NO: 3, (b) a first light chain polypeptide comprising a CDR1 amino acid sequence of SEQ ID NO: 4, a CDR2 amino acid sequence of SEQ ID NO: 5, and a CDR3 amino acid sequence of SEQ ID NO: 6, (c) a second heavy chain polypeptide comprising a CDR1 amino acid sequence of SEQ ID NO: 7, a CDR2 amino acid sequence of SEQ ID NO: 8, and a CDR3 amino acid sequence of SEQ ID NO: 9, and (d) a second light chain polypeptide comprising a CDR1 amino acid sequence of SEQ ID NO: 10, a CDR2 amino acid sequence of SEQ ID NO: 11, and a CDR3 amino acid

sequence of SEQ ID NO: 12. In another embodiment, the first heavy chain polypeptide and the first light chain polypeptide of the aforementioned bispecific antibody or antigen-binding fragment thereof (e.g., monoclonal antibody or fragment) comprises variable region amino acid sequences of SEQ ID NO: 13 and SEQ ID NO: 14, respectively, and the second heavy chain polypeptide and the second light chain polypeptide of the aforementioned bispecific antibody or antigen-binding fragment thereof (e.g., monoclonal antibody or fragment) comprises variable region amino acid sequences of SEQ ID NO: 15 and SEQ ID NO: 16, respectively. Such bispecific (optionally monoclonal) antibodies (antibodies comprising SAR114 and MEDI4893 or MEDI4893* sequences) can have decreased AT-neutralization activity as compared to the AT-neutralization activity of MEDI4893 or MEDI4893* e.g., as a result of SAR114's strong binding to ClfA. This is in contrast to other bispecific (optionally monoclonal) antibodies that bind to *Staphylococcus aureus* ClfA and AT proteins (e.g., antibodies comprising 11H10 and MEDI4893 or MEDI4893* sequences) that do not have significantly decreased AT-neutralization activity as compared to the AT-neutralization activity of MEDI4893 or MEDI4893*. Methods for generating bispecific or multi-specific (optionally monoclonal) antibodies are known in the art and described in, for example, Holliger et al., *Proc. Natl. Acad. Sci. USA*, *90*(14): 6444-6448 (1993); Brinkmann, U. and R.E. Kontermann, *MAbs*, *9*(2): 182-212 (2017); and Segal, D. M. and Bast, B. J. 2001. Production of Bispecific Antibodies. *Current Protocols in Immunology*. 14:IV:2.13:2.13.1–2.13.16)

[0082] The antibody or antigen-binding fragment (e.g. monoclonal antibody or fragment) described herein may be, or may be obtained from, a human antibody, a humanized antibody, a non-human antibody, or a chimeric antibody. A "chimeric" antibody refers to an antibody or fragment thereof comprising both human and non-human regions. A "humanized" antibody is a antibody comprising a human antibody scaffold and at least one CDR obtained or derived from a non-human antibody. Non-human antibodies include antibodies isolated from any non-human animal, such as, for example, a rodent (e.g., a mouse or rat). A humanized antibody can comprise, one, two, or three CDRs obtained or derived from a non-human antibody. A fully human antibody does not contain any amino acid residues obtained or derived from a non-human animal. It will be appreciated that fully human and humanized antibodies carry a lower risk for inducing immune responses in humans than mouse or chimeric antibodies (see, e.g., Harding et al., *mAbs*, *2*(3): 256-

26 (2010)). In one embodiment, the antibody described herein, or antigen-binding fragment thereof, is a fully human antibody.

[0083] A human antibody, a non-human antibody, a chimeric antibody, or a humanized antibody can be obtained by any means, including via *in vitro* sources (e.g., a hybridoma or a cell line producing an antibody recombinantly) and *in vivo* sources (e.g., rodents, human tonsils). Methods for generating antibodies are known in the art and are described in, for example, Köhler and Milstein, *Eur. J. Immunol.*, *5*: 511-519 (1976); Harlow and Lane (eds.), *Antibodies: A Laboratory Manual*, CSH Press (1988); and Janeway et al. (eds.), *Immunobiology, 5th Ed.*, Garland Publishing, New York, N.Y. (2001)). In certain embodiments, a human antibody or a chimeric antibody can be generated using a transgenic animal (e.g., a mouse) wherein one or more endogenous immunoglobulin genes are replaced with one or more human immunoglobulin genes. Examples of transgenic mice wherein endogenous antibody genes are effectively replaced with human antibody genes include, but are not limited to, the Medarex HUMAB-MOUSE™, the Kirin TC MOUSE™, and the Kyowa Kirin KM-MOUSE™ (see, e.g., Lonberg, *Nat. Biotechnol.*, *23*(9): 1117-25 (2005), and Lonberg, *Handb. Exp. Pharmacol.*, *181*: 69-97 (2008)). A humanized antibody can be generated using any suitable method known in the art (see, e.g., An, Z. (ed.), *Therapeutic Monoclonal Antibodies: From Bench to Clinic*, John Wiley & Sons, Inc., Hoboken, N.J. (2009)), including, e.g., grafting of non-human CDRs onto a human antibody scaffold (see, e.g., Kashmiri et al., *Methods*, *36*(1): 25-34 (2005); and Hou et al., *J. Biochem.*, *144*(1): 115-120 (2008)). In one embodiment, a humanized antibody can be produced using the methods described in, e.g., U.S. Patent Application Publication 2011/0287485 A1.

[0084] The disclosure also provides one or more isolated nucleic acid sequences that encode the ClfA-binding antibody, the AT-binding antibody, or the antibody that binds both ClfA and AT as described herein, or an antigen-binding fragment thereof (optionally wherein the antibody or fragment is monoclonal). The term "nucleic acid sequence" is intended to encompass a polymer of DNA or RNA, i.e., a polynucleotide, which can be single-stranded or double-stranded and which can contain non-natural or altered nucleotides. The terms "nucleic acid" and "polynucleotide" as used herein refer to a polymeric form of nucleotides of any length, either ribonucleotides (RNA) or deoxyribonucleotides (DNA). These terms refer to the primary structure of the molecule,

and thus include double- and single-stranded DNA, and double- and single-stranded RNA. The terms include, as equivalents, analogs of either RNA or DNA made from nucleotide analogs and modified polynucleotides such as, though not limited to, methylated and/or capped polynucleotides. Nucleic acids are typically linked via phosphate bonds to form nucleic acid sequences or polynucleotides, though many other linkages are known in the art (e.g., phosphorothioates, boranophosphates, and the like).

[0085] The disclosure further provides one or more vectors comprising one or more nucleic acid sequences encoding the ClfA-binding antibody, the AT-binding antibody, or the antibody that binds both ClfA and AT as described herein, or an antigen-binding fragment thereof (optionally wherein the antibody or fragment is monoclonal). The vector can be, for example, a plasmid, episome, cosmid, viral vector (e.g., retroviral or adenoviral), or phage. Suitable vectors and methods of vector preparation are well known in the art (see, e.g., Sambrook et al., *Molecular Cloning, a Laboratory Manual, 3rd edition*, Cold Spring Harbor Press, Cold Spring Harbor, N.Y. (2001), and Ausubel et al., *Current Protocols in Molecular Biology*, Greene Publishing Associates and John Wiley & Sons, New York, N.Y. (1994)).

[0086] In addition to the nucleic acid sequence encoding the ClfA-binding antibody or antigen-binding fragment, the AT-binding antibody or antigen-binding fragment, or the antibody or antigen-binding fragment that binds both ClfA and AT as described herein (optionally wherein the antibody or fragment is monoclonal), the vector desirably comprises expression control sequences, such as promoters, enhancers, polyadenylation signals, transcription terminators, internal ribosome entry sites (IRES), and the like, that provide for the expression of the coding sequence in a host cell. Exemplary expression control sequences are known in the art and described in, for example, Goeddel, *Gene Expression Technology: Methods in Enzymology*, Vol. 185, Academic Press, San Diego, Calif. (1990).

[0087] The vector(s) comprising the nucleic acid(s) encoding the amino acid sequence(s) of the antibodies or antigen-binding fragments described herein (e.g., an amino acid sequence encoding the heavy chain and/or the light chain of a ClfA-binding antibody) (optionally a monoclonal antibody or fragment) can be introduced into a host cell that is capable of expressing the polypeptides encoded thereby, including any suitable prokaryotic or eukaryotic cell. As such, the present disclosure provides an isolated cell

comprising the vector. Host cells that may be used include those that can be easily and reliably grown, have reasonably fast growth rates, have well characterized expression systems, and can be transformed or transfected easily and efficiently. Examples of suitable prokaryotic cells include, but are not limited to, cells from the genera *Bacillus* (such as *Bacillus subtilis* and *Bacillus brevis*), *Escherichia* (such as *E. coli*), *Pseudomonas*, *Streptomyces*, *Salmonella*, and *Erwinia*. Particularly useful prokaryotic cells include the various strains of *Escherichia coli* (e.g., K12, HB101 (ATCC No. 33694), DH5a, DH10, MC1061 (ATCC No. 53338), and CC102). Suitable eukaryotic cells are known in the art and include, for example, yeast cells, insect cells, and mammalian cells. In one embodiment, the vector is expressed in mammalian cells. A number of suitable mammalian host cells are known in the art, and many are available from the American Type Culture Collection (ATCC, Manassas, VA). Examples of suitable mammalian cells include, but are not limited to, Chinese hamster ovary cells (CHO) (ATCC No. CCL61), CHO DHFR- cells (Urlaub et al, *Proc. Natl. Acad. Sci. USA*, *97*: 4216-4220 (1980)), human embryonic kidney (HEK) 293 or 293T cells (ATCC No. CRL1573), and 3T3 cells (ATCC No. CCL92). Other suitable mammalian cell lines are the monkey COS-1 (ATCC No. CRL1650) and COS-7 cell lines (ATCC No. CRL1651), as well as the CV-1 cell line (ATCC No. CCL70). The mammalian cell desirably is a human cell. For example, the mammalian cell can be a human lymphoid or lymphoid derived cell line, such as a cell line of pre-B lymphocyte origin, a PER.C6® cell line (Crucell Holland B.V., The Netherlands), or human embryonic kidney (HEK) 293 or 293T cells (ATCC No. CRL1573).

[0088] A nucleic acid sequence encoding amino acids of any of the antibodies or antigen-binding fragments (optionally monoclonal antibodies or fragments) described herein may be introduced into a cell by "transfection," "transformation," or "transduction." "Transfection," "transformation," or "transduction," as used herein, refer to the introduction of one or more exogenous polynucleotides into a host cell by using physical or chemical methods. Many transfection techniques are known in the art and include, for example, calcium phosphate DNA co-precipitation (see, e.g., Murray E.J. (ed.), *Methods in Molecular Biology, Vol. 7, Gene Transfer and Expression Protocols*, Humana Press (1991)); DEAE-dextran; electroporation; cationic liposome-mediated transfection; tungsten particle-facilitated microparticle bombardment (Johnston, *Nature*, *346*: 776-777

(1990)); and strontium phosphate DNA co-precipitation (Brash et al, *Mol. Cell Biol.*, *7*: 2031-2034 (1987)). Phage or viral vectors can be introduced into host cells, after growth of infectious particles in suitable packaging cells, many of which are commercially available.

[0089] The present disclosure provides a composition comprising an effective amount of any one or combination of the antibodies or antigen-binding fragments thereof described herein and a pharmaceutically acceptable carrier. In one embodiment, for example, the composition may comprise a first antibody or antigen-binding fragment thereof (optionally monoclonal) that specifically binds to *S. aureus* ClfA protein, as described above, and a second antibody or antigen-binding fragment thereof (optionally monoclonal) that specifically binds to *S. aureus* AT protein, as described above, and a pharmaceutically acceptable carrier. Alternatively, the composition may comprise either a antibody or antigen-binding fragment thereof that specifically binds to *S. aureus* ClfA protein, or a antibody or antigen-binding fragment thereof that specifically binds to *S. aureus* AT protein and a pharmaceutically acceptable carrier. In yet another embodiment, the composition may comprise the nucleic acid sequences encoding the ClfA-binding antibody or antigen-binding fragment, the AT-binding antibody or antigen-binding fragment, and/or the anti-ClfA/AT bispecific antibody or antigen-binding fragment, or one or more vectors comprising such nucleic acid sequences. In one embodiment, the composition is a pharmaceutically acceptable (e.g., physiologically acceptable) composition, which comprises a carrier, such as a pharmaceutically acceptable (e.g., physiologically acceptable) carrier, and the ClfA-binding antibody or antigen-binding fragment, the AT-binding antibody or antigen-binding fragment, the anti-ClfA/AT bispecific antibody or antigen-binding fragment, nucleic acid sequence(s), or vector(s). Any suitable carrier can be used within the context of the disclosure, and such carriers are well known in the art. The choice of carrier will be determined, in part, by the particular site to which the composition may be administered and the particular method used to administer the composition. The composition optionally can be sterile. The composition can be frozen or lyophilized for storage and reconstituted in a suitable sterile carrier prior to use. The compositions can be generated in accordance with conventional techniques described in, e.g., *Remington: The Science and Practice of Pharmacy*, 21st Edition, Lippincott Williams & Wilkins, Philadelphia, PA (2001).

[0090] The composition desirably comprises the ClfA-binding antibody and/or the AT-binding antibody, and/or the anti-ClfA/AT bispecific antibody, or antigen-binding fragments thereof (e.g., monoclonal antibody or fragment), in an amount that is effective to treat or prevent a *S. aureus* infection. Thus, the disclosure provides a method of treating or preventing a *Staphylococcus aureus* (*S. aureus*) infection in a subject (e.g., a human), which comprises administering the composition comprising any one or combination of the antibodies or antigen-binding fragments thereof (e.g. monoclonal antibodies or fragments) described herein to a subject in need thereof, whereupon the *S. aureus* infection is treated or prevented in the subject. The disclosure also provides use of the ClfA-binding antibody or antigen-binding fragment, the AT-binding antibody or antigen-binding fragment, and/or the anti-ClfA/AT bispecific antibody or antigen-binding fragment described herein, or the composition comprising any one or combination of the antibodies or fragments thereof described herein, in the manufacture of a medicament for treating or preventing a *S. aureus* infection. As discussed herein, *Staphylococcus aureus* is a major human pathogen that causes a wide range of clinical infections. *S. aureus* is a leading cause of bacteremia and infective endocarditis as well as osteoarticular, skin and soft tissue, pleuropulmonary, and device-related infections. Approximately 30% of the human population is colonized with *S. aureus* (Wertheim et al., *Lancet Infect. Dis.*, *5*: 751-762 (2005)). The symptoms of *S. aureus* skin infections include, for example, boils, cellulits, and impetigo. *S. aureus* also may cause food poisoning, blood poisoning (also known as bacteremia), toxic shock syndrome, and septic arthritis. The epidemiology, pathophysiology, and clinical manifestations of *S. aureus* infections are described in detail in, e.g., Tong et al., *Clin. Microbiol. Rev.*, *28*(3): 603-661 (2015), and the genomes of several different S. aureus strains have been sequenced (see, e.g., GenBank/EMBL Accession Nos. BX571856, BX571857, BX571858, FN433596, FN433597, FN433598, HE681097, FR821777, FR821778, FR821779, and FR821780). As discussed herein, the subject (e.g., human subject) can have diabetes.

[0091] As used herein, the terms "treatment," "treating," and the like, refer to obtaining a desired pharmacologic and/or physiologic effect. In one embodiment, the effect is therapeutic, i.e., the effect partially or completely cures a disease and/or adverse symptom attributable to the disease. To this end, the disclosed method comprises administering a "therapeutically effective amount" of the ClfA-binding antibody, the AT-binding

antibody, and/or the anti-ClfA/AT bispecific antibody, or antigen-binding fragments thereof, or the composition comprising any one or combination of the aforementioned antibodies or fragments (including monoclonal antibodies or fragments). A "therapeutically effective amount" refers to an amount effective, at dosages and for periods of time necessary, to achieve a desired therapeutic result. The therapeutically effective amount may vary according to factors such as the disease state, age, sex, and weight of the individual, and the ability of the antibody or antigen-binding fragment to elicit a desired response in the individual. For example, a therapeutically effective amount of a ClfA-binding antibody or antigen-binding fragment thereof, an AT-binding antibody or antigen-binding fragment thereof, or a ClfA/AT bispecific antibody or antigen-binding fragment thereof is an amount which inhibits *S. aureus*-associated sepsis, inhibits *S. aureus* agglutination, inhibits thromboembolic lesion formation, neutralizes alpha toxin, induces opsonophagocytosis, inhibits *S. aureus* fibrinogen binding, inhibits *S. aureus* agglutination, or any combination of the foregoing, in a human.

[0092] Alternatively, the pharmacologic and/or physiologic effect may be prophylactic, i.e., the effect completely or partially prevents a disease or symptom thereof. In this respect, the disclosed method comprises administering a "prophylactically effective amount" of the ClfA-binding antibody, the AT-binding antibody, and/or the anti-ClfA/AT bispecific antibody, or antigen-binding fragments thereof (including monoclonal antibodies or fragments). A "prophylactically effective amount" refers to an amount effective, at dosages and for periods of time necessary, to achieve a desired prophylactic result (e.g., prevention of *S. aureus* infection or disease onset).

[0093] Therapeutic or prophylactic efficacy can be monitored by periodic assessment of treated patients. For repeated administrations over several days or longer, depending on the condition, the treatment can be repeated until a desired suppression of disease symptoms occurs. However, other dosage regimens may be useful and are within the scope of the present disclosure. The desired dosage can be delivered by a single bolus administration of the composition, by multiple bolus administrations of the composition, or by continuous infusion administration of the composition.

[0094] The method of treating or preventing a *S. aureus* infection may comprise administering the ClfA-binding antibody described herein, the AT-binding described herein, both the ClfA-binding and AT-binding antibodies described herein, or the ClfA-

AT bispecific antibody described herein, or antigen-binding fragments thereof. In embodiments where both the ClfA-binding and AT-binding antibodies or fragments (e.g., monoclonal antibodies or fragments) are administered to a subject, each antibody or fragment may be present in the same composition or in separate compositions. When separate compositions are administered to the subject, each of the compositions can be administered simultaneously or sequentially in any order.

[0095] The composition(s) comprising an effective amount of any one or combination of the antibodies described herein, or antigen-binding fragments thereof, the nucleic acid sequence(s) encoding any of the foregoing, or the vector comprising the nucleic acid sequence may be administered to a subject, such as a human, using standard administration techniques, including intravenous, intraperitoneal, subcutaneous, and intramuscular administration routes. The composition may be suitable for parenteral administration. The term "parenteral," as used herein, includes intravenous, intramuscular, subcutaneous, and intraperitoneal administration. In some embodiments, the composition is administered to a subject using peripheral systemic delivery by intravenous, intraperitoneal, or subcutaneous injection.

[0096] The ClfA-binding antibody or antigen-binding fragment, the AT-binding antibody or antigen-binding fragment, the and/or the anti-ClfA/AT bispecific antibody or antigen-binding fragment, or composition(s) comprising same, may be administered alone or in combination with other drugs (e.g., as an adjuvant) conventionally used for treating *S. aureus* infections. The composition(s) comprising the ClfA-binding antibody or antigen-binding fragment, the AT-binding antibody or antigen-binding fragment, or the ClfA-AT bispecific antibody or antigen-binding fragment may be used in combination with, for example, one or more antibiotics, such as a penicillinase-resistant β-lactam antibiotic (e.g., oxacillin or flucloxacillin). Gentamicin may be used to treat serious infections, such as endocarditis. Most strains of *S. aureus*, however, are now resistant to penicillin, and two in 100 people carry methicillin-resistant strains of *S. aureus* (MRSA). MRSA infections typically are treated with vancomycin, and minor skin infections may be treated with triple antibiotic ointment.

[0097] In addition to therapeutic uses, any one or combination of the antibodies described herein can be used in diagnostic or research applications. In this respect, the ClfA-binding antibody or antigen-binding fragment, the AT-binding antibody or antigen-binding

fragment, or the ClfA-AT bispecific antibody or antigen-binding fragment may be used in an assay to monitor *S. aureus* infection in a subject. Research applications include, for example, methods that utilize the ClfA-binding antibody or antigen-binding fragment, the AT-binding antibody or antigen-binding fragment, or the ClfA-AT bispecific antibody or antigen-binding fragment and a label to detect *S. aureus* in a sample, e.g., in a human body fluid or in a cell or tissue extract. The ClfA-binding antibody or antigen-binding fragment, the AT-binding antibody or antigen-binding fragment, or the ClfA-AT bispecific antibody or antigen-binding fragment may be used with or without modification, such as covalent or non-covalent labeling with a detectable moiety. For example, the detectable moiety can be a radioisotope (e.g., ^{3}H, ^{14}C, ^{32}P, ^{35}S, or ^{125}I), a fluorescent or chemiluminescent compound (e.g., fluorescein isothiocyanate, rhodamine, or luciferin), an enzyme (e.g., alkaline phosphatase, beta-galactosidase, or horseradish peroxidase), or prosthetic groups. Any method known in the art for separately conjugating an antibody or antigen-binding fragment thereof to a detectable moiety may be employed in the context of the present disclosure (see, e.g., Hunter et al., *Nature*, *194*: 495-496 (1962); David et al., *Biochemistry*, *13*: 1014-1021 (1974); Pain et al., *J. Immunol. Meth.*, *40*: 219-230 (1981); and Nygren, J., *Histochem. And Cytochem.*, *30*: 407-412 (1982)).

[0098] Any one or combination of the antibodies described herein, or antigen-binding fragments thereof (e.g., monoclonal antibodies or fragments), the nucleic acid sequence(s) encoding any of the foregoing, the vector(s) comprising the nucleic acid sequence(s), or the composition(s) comprising any of the foregoing, can be provided in a kit, i.e., a packaged combination of reagents in predetermined amounts with instructions for performing a diagnostic assay. If the ClfA-binding antibody or antigen-binding fragment, the AT-binding antibody or antigen-binding fragment, or the ClfA-AT bispecific antibody or antigen-binding fragment is labeled with an enzyme, the kit desirably includes substrates and cofactors required by the enzyme (e.g., a substrate precursor which provides a detectable chromophore or fluorophore). In addition, other additives may be included in the kit, such as stabilizers, buffers (e.g., a blocking buffer or lysis buffer), and the like. The relative amounts of the various reagents can be varied to provide for concentrations in solution of the reagents which substantially optimize the sensitivity of the assay. The reagents may be provided as dry powders (typically lyophilized), including

excipients which on dissolution will provide a reagent solution having the appropriate concentration.

[0099] The following examples further illustrate the invention but, of course, should not be construed as in any way limiting its scope.

EXAMPLE 1

[0100] This example demonstrates the selection and characterization of a monoclonal antibody that specifically binds to *S. aureus* ClfA protein.

[0101] Enhanced protective capacity and isolate coverage afforded by prophylaxis with an anti-*S. aureus* alpha toxin (AT) monoclonal antibody (mAb) (referred to as "MEDI4893*" described in International Patent Application Publications WO 2012/109285 and WO 2014/074540 as "LC10") in combination with an anti-ClfA mAb (referred to as "11H10") relative to the individual mAbs in a *S. aureus* lethal bacteremia model has been previously reported (Tkaczyk et al., *MBio.*, *7*(3). pii: e00528-16 (2016)). (Note that MEDI4893, which contains a YTE mutation not present in MEDI4893* was not used in mice because, although the YTE mutation increases IgG half-life in humans, it reduces serum exposure in mice.) Although 11H10 showed potent anti-ClfA activity, it exhibited a greater than 1000-fold reduced affinity (K_{on} was below limit of detection, ND in Table 1) and about a 40-fold increase in IC_{50} for the ClfA founder sequence ClfA002 in a fibrinogen binding inhibition assay relative to the other ClfA founder sequences ClfA001 and ClfA004, as shown in Figure 1A and Table 1. ClfA002 is expressed by a prominent *S. aureus* hospital acquired MRSA (HA-MRSA; USA100 or sequence type 5 (ST5)) (Sharma-Kuinkel et al., *J. Clin. Microbiol.*, *53*: 227-236 (2015); and Mendes et al., *J. Clin. Microbiol.*, *50*: 3694-3702 (2012)).

Table 1. Anti-ClfA mAbs: Correlation between affinity and *in vitro* activity

		Affinity				Fibrinogen binding
		Kon ($M^{-1}s^{-1}$)	**Koff (s^{-1})**	**Kd**	**CHI^2**	**IC_{50} (µg/ml)**
SAR114	ClfA001	2.41E+06	6.01E-06	2.493pM	0.206	1.166
	ClfA002	2.13E+06	9.53E-05	44.77pM	0.383	1.161
	ClfA004	5.62E+06	6.46E-06	1.15pM	0.330	1.627
11H10	ClfA001	1.092E+06	6.80E-03	6.22nM	0.214	0.881

	Affinity				Fibrinogen binding
	Kon ($M^{-1}s^{-1}$)	Koff (s^{-1})	Kd	CHI^2	IC_{50} (μg/ml)
ClfA002			27.6μM		9.772
ClfA004	8.457E+5	6.390E-3	7.555nM	0.502	0.662

[0102] To increase potential clinical isolate coverage, a human tonsillar B-cell library was screened to search for more broadly reactive anti-ClfA mAbs. Specifically, memory B cells were isolated from cryopreserved lymphocytes isolated from tonsils using phycoerythrin (PE)-Cy7-labelled CD19 microbeads (BD Biosciences, San Jose, CA), followed by staining with anti-PE-beads (Miltenyi Biotec, Inc., San Diego, CA), and by depletion of cells carrying IgM, IgD, and IgA by cell sorting on a FACSAria (BD Biosciences, San Jose, CA). Cells were immortalized under clonal condition with Epstein Barr Virus (EBV) as described in Traggiai et al., *Nat. Med.*, *10*: 871-875 (2004). After two weeks, the culture supernatants were screened for the presence of ClfA001-specific monoclonal antibodies using a 384-well based ELISA assay. Briefly, serial dilutions (1:2 or 1:600) of the anti-ClfA mAbs were added to ClfA coated plates, followed by addition of biotinylated 11H10 (1:600). Percent competition was calculated as $100*(OD_{mAb+11H10biot}) / (OD_{11H10biot})$. Positive cultures were expanded in complete RPMI medium and selected for their ability to bind to ClfA genotypes 001, 002, and 004 with high affinity. The VH and VL sequences were retrieved by RT-PCR.

[0103] From this effort, a monoclonal antibody was identified (referred to as "SAR114") that exhibited high affinity for ClfA001, 002, and 004 (KD =1.15 - 44.7 pM, Table 1) and potent inhibition of fibrinogen binding by the three prominent founder ClfA genotypes (IC_{50} ~20 μM), as shown in Figure 1B. SAR114 also exhibited opsonophagocytic killing (OPK) activity against several *S. aureus* clinical isolates, as shown in Figures 3A-3F (see, e.g., Tkaczyk et al., *supra* for methods of measuring OPK killing) and improved inhibition of bacterial agglutination in human plasma compared to 11H10, as shown in Figure 2, Figure 4, and Table 2, below). Agglutination inhibition in human plasma was measured by culturing 112 *S. aureus* clinical isolates overnight in tryptic soy broth (TSB), washing in PBS, and suspending to one tenth of the original volume in ice-cold PBS. Anti-ClfA monoclonal antibodies were serially diluted (two-fold) in 30 μl PBS starting at 200 μg/ml and mixed with 30 μl of citrated human plasma in a 96-well U bottom plate (ThermoFisher Scientific, Waltham, MA). Bacteria were added (30 μl) and incubated for

5 minutes at 37 °C. Each well was evaluated visually, and the lowest monoclonal antibody concentration where bacteria agglutinated was recorded. R347, a human anti-gp120 monoclonal antibody was utilized as an isotype control human IgG1 (c-IgG). Human negative control monoclonal antibody (c-IgG) did not show any inhibitory effect up to 200 μg/ml.

Table 2: Minimal concentration of SAR114 required to inhibit bacterial agglutination.

Strain	CC	μg/ml	Strain	CC	μg/ml
2784	1	3	NRS383	8	1.5
801	5	3	3691	8	0.7
4211	5	1.5	3406	8	25
ARC634	5	1.5	3691	8	3
ARC635	5	0.7	3527	8	6
ARC797	5	6	ARC2081	30	0.7
NRS382	5	3	NRS383	30	6
9105	5	1.5	UAMS-1	30	1.5
9057	8	6	484	30	0.35
ARC2464	8	3	9048	45	3
BAA1556	8	6	NRS22	45	1.5
NRS384	8	6	9112	45	1.5

Data are representative of three independent experiments with the same donor as a plasma source.

[0104] The heavy chain polypeptide of the SAR114 antibody was determined to comprise a variable region amino acid sequence of SEQ ID NO: 13, with a CDR1 amino acid sequence of SEQ ID NO: 1, a CDR2 amino acid sequence of SEQ ID NO: 2, and a CDR3 amino acid sequence of SEQ ID NO: 3. The light chain polypeptide of the SAR114 antibody was determined to comprise a variable region amino acid sequence of SEQ ID NO: 14, with a CDR1 amino acid sequence of SEQ ID NO: 4, a CDR2 amino acid sequence of SEQ ID NO: 5, and a CDR3 amino acid sequence of SEQ ID NO: 6. 11H10 and SAR114 were found to compete for binding to ClfA001 by ELISA and in an Octet-based competition assay, as shown in Figures 5A and 5B. Briefly, mAbs diluted at 5 μg/ml in PBS were captured on a aminopropylsilane (APS) biosensors for 7 min. Coated biosensors were moved into blocking buffer-containing wells (PBS, 1 mg/ml BSA (Sigma Aldrich, St. Louis, MO)) for 6 minutes to block free sensor binding sites, incubated for 7 minutes with 2.5 μg/ml ClfA001 diluted in blocking buffer, and finally moved into wells containing the competing mAbs diluted at 5 μg/ml in blocking buffer. Data were analyzed using the OCTET® Data Acquisition and Analysis Software (Pall ForteBio LLC,

Fremont, CA). Absence of association of the competing mAb resulted in competition, and thus recognition of the same antigenic site, while non-competition was observed when association of the second mAb was detected.

[0105] The results of this example indicate that the anti-ClfA monoclonal antibodies 11H10 and SAR114 bind an overlapping epitope on ClfA001, which suggests that their difference in activity against ClfA002 may result from different binding affinities.

EXAMPLE 2

[0106] This example describes the generation of SAR114-N3, which has an increased half-life as compared to SAR114.

[0107] It is well known that Fc regions of antibodies play a role in their half-life, and Fc engineering has been used to manipulate the half-life of therapeutic biologics. For example, a triple amino acid substitution M252Y/S254T/T256E (called the "YTE" substitution), has been engineered into the Fc regions of antibodies, including the anti-*S. aureus* MEDI4893 antibody, and it can lead to a 3-4 fold increase in half-life. However, the YTE mutation has also been shown to result in decreased binding to C1q and FcγRs and to reduce effector functions such as ADCC and CDC activity. (Monnet C., *et al.*, *Front Immunol. 6*: 39 (2015).) The YTE mutation also reduces opsonophagocytic killing (OPK) of anti-bacterial antibodies. (See Figure 6 showing that the YTE substitution reduces OPK of the anti-pseudomonas antibody Cam004.) Thus, although half-life extension was desirable for an anti-ClfA antibody, the YTE mutation was not suitable for SAR114.

[0108] Borrok et al., (*J. Biol. Chem.*, *290*(7): 4282-4290 (2015).) studied the effects of other Fc alterations, including the "N3" variant. The "N3" variant contains the sequence CSWHLC (SEQ ID NO:19) in the CH3 domain instead of the wild-type sequence (LHNHYT; SEQ ID NO:22) at those same positions. This Fc variant also increases half-life (see Figure 9, top panel), but as shown in Figure 6, does not reduce OPK killing of the anti-bacterial antibodies Cam004 (top panel) or 2F4 (bottom panel).

[0109] Therefore, the effect of the N3 mutation on binding of SAR114 was evaluated. In these experiments, the Biacore platform was used to determine the kinetic rate/affinity (K_D) constants for binding of parental and Fc-variant antibodies, SAR-114 and SAR114-

N3, respectively, against CLFA001, CLFA002, and CLFA004 proteins. The results are shown in Table 3 below.

Table 3. SAR-114 and SAR114-N3 binding affinities for the three main ClfA genotypes

Capture	Sample	Ka($M^{-1}s^{-1}$)	Kd (s^{-1})	K_D (pM)
SAR114-N3	CLFA001	3.383E+6	7.725E-4	228
SAR114-N3	CLFA002	3.921E+6	10.41E-4	265
SAR114-N3	CLFA004	2.387E+6	7.558E-4	316
SAR114	CLFA001	3.911E+6	6.013E-5	15.4
SAR114	CLFA002	3.816E+6	1.821E-4	47.7
SAR114	CLFA004	2.968E+6	6.210E-5	20.9

[0110] The kinetic fit to a 1:1 binding model were adequate. SAR114 and SAR114-N3 both bind to CLFA001, CLFA002, and CLFA004 with similar affinities. However, the binding (K_D) of SAR114 to all CLFA proteins was about 10-fold tighter than that of SAR114-N3. The weaker binding of SAR114-N3 is attributable to faster off-rates.

[0111] The ability of SAR114-N3 to inhibit fibrinogen binding was also assessed. In these assays, ClfA binding to fibrinogen was measured in the presence of serially diluted (200 to 0.5 μg/ml) of SAR114, SAR114-N3, or a control IgG antibody. The results are shown in Figure 7 and Table 4 below.

Table 4. SAR-114 and SAR114-N3 inhibition of fibrinogen binding

IC50 (μg/ml)	SAR114	SAR114-N3
ClfA001	2.576	2.134
ClfA002	2.910	3.108
ClfA004	1.720	2.516

[0112] These data demonstrate that SAR114-N3 inhibits the binding of the three main ClfA genotypes to fibrinogen.

EXAMPLE 3

[0113] This example describes the generation of SAR114-N3Y, which has improved stability as compared to SAR114-N3.

[0114] However, the "N3" variant contains a tryptophan (W434) that contributes to enhanced FcRn affinity, but also resulted in light sensitivity such that normal light conditions resulted in about 20% monomer loss over the course of one week, and intense light conditions resulted in more than 60% monomer loss in the same time period. Non-oxidizable hydrophobic residues (F, Y, L, I, V, A, and S) were substituted for the

tryptophan (W434) and their effect on SAR114 half-life, OPK, and light sensitivity were evaluated. The F and Y substitutions were most similar to SAR114 N3 in terms of binding, and both had similar half-life extensions as the N3 alteration (see Figure 9, top panel). A photostability assessment was conducted on SAR114 antibodies with the F ("N3F"; SEQ ID NO:20) and Y ("N3Y; SEQ ID NO:21) alterations. In this assessment, the mAbs were exposed to CWL (conventional white light) at 2kLux/hr (intensity measure) at 23^0C for 14 days, and the monomer purities observed are summarized in Table 5 below.

Table 5. SAR114-N3F and SAR114-N3Y stability

Clone	Monomer purity at T0	Monomer purity at 7 days	Monomer purity at 14 days
N3F	95.9%	91.8%	86.2%
N3Y	98.9%	97.6%	95.3%

[0115] The results demonstrate that N3Y has superior light stability. Agglutination and fibrinogen potency assays also indicated that N3Y had better activity than N3F as shown in Figure 8. Measurements of antibody levels in mice demonstrated that both N3Y and N3F had similar pK values to N3 mutant (Figure 9, top panel), and OPK killing of the N3Y variant was unchanged (Figure 9, bottom panel).

EXAMPLE 4

[0116] This example describes the effects of SAR114 or SAR114 N3Y anti-ClfA monoclonal antibody, alone or in combination with an anti-alpha toxin (AT) monoclonal antibody, in a murine bacteremia model.

[0117] Groups of ten 6-8 week old female BALB/c mice (Envigo, Huntingdon, Cambridgeshire, United Kingdom) were passively immunized by intra-peritoneal (IP) injection of an isotype control IgG (c-IgG), the SAR114 anti-ClfA monoclonal antibody, and/or the MEDI4893* anti-AT monoclonal antibody. Mice were challenged 24 hours later by intravenous (IV) injection of an LD_{90} of *S. aureus* clinical isolates. Survival was monitored over two weeks. Statistical analysis of specific anti-staphylococcal antigen versus c-IgG was performed with a Log Rank (Mantel Cox) test. Data were considered statistically different if $p<0.05$.

[0118] SAR114 (15 mg/kg (mpk)) prophylaxis resulted in increased survival compared to an isotype control IgG (c-IgG) following challenge with *S. aureus* isolates representing sequence types (ST) ST8, ST5 or ST30, which were confirmed to encode ClfA genotypes ClfA001, 002, and 004 respectively, as shown in Figure 10. Similar to the combination of the 11H10 and MEDI4893* antibodies, prophylaxis with the combination of SAR114 and MEDI4893* (7.5 mg/kg (mpk) each) significantly increased survival relative to c-IgG following challenge with all strains tested, and provided a benefit over the corresponding individual monoclonal antibodies against some strains (Tkaczyk et al., *supra*).

[0119] The results of this experiment demonstrate that the anti-ClfA SAR114 monoclonal antibody is functional *in vivo* and suggests that the combination of SAR114 and an anti-AT monoclonal antibody provides broader strain coverage for *S. aureus* prophylaxis.

EXAMPLE 5

[0120] This example describes the effects of SAR114 anti-ClfA monoclonal antibody, alone or in combination with an anti-alpha toxin (AT) monoclonal antibody, in a diabetic murine lethal bacteremia model.

[0121] Groups of 6-week old diabetic BKS.Cg-Dock7^{m} +/+ Lepr^{db}/J male mice were immunized by intra-peritoneal (IP) injection of an isotype control IgG (c-IgG), the SAR114 anti-ClfA monoclonal antibody, and/or the MEDI4893* anti-AT monoclonal antibody. Mice were challenged 24 hours later by intravenous (IV) injection of LD_{90} (5e7CFU) of *S. aureus* clinical isolates SF8300. Survival was monitored over two weeks. Figure 11, top panel. Ten animals were euthanized after 48 hours for bacterial enumeration in the kidneys (Figure 11, middle panel) and liver (Figure 11, bottom panel). Statistical analysis of specific anti-staphylococcal antigen versus c-IgG was performed with a Log Rank (Mantel Cox) test. Data were considered statistically different if $p<0.05$.

[0122] SAR114 (15 mg/kg (mpk)) prophylaxis resulted in increased survival compared to an isotype control IgG (c-IgG) following the challenge, and prophylaxis with the combination of SAR114 and MEDI4893* (7.5 mg/kg (mpk) each) significantly increased survival relative to c-IgG following the challenge. Figure 11, top panel. The combination of SAR114 and MEDI4893* (7.5 mg/kg (mpk) each) also significantly decreased bacteria in the kidneys (Figure 11, middle panel) and liver (Figure 11, bottom panel).

[0123] The results of this experiment demonstrate that the anti-ClfA SAR114 monoclonal antibody is functional *in vivo* and suggests that the combination of SAR114 and an anti-AT monoclonal antibody provides protection against CA-MRSA SF8300 induced lethal bacteremia in diabetic db/db mice.

EXAMPLE 6

[0124] This example describes the effects of SAR114 anti-ClfA monoclonal antibody, alone or in combination with an anti-alpha toxin (AT) monoclonal antibody on pro-inflammatory cytokine levels in murine bacteremia models.

[0125] Groups of 6-week old diabetic (db) BKS.Cg-Dock7^{m} +/+ Lepr^{db}/J male mice (n=20) and non-diabetic C57/B6 (B6) male mice (n=20) were immunized by intra-peritoneal (IP) injection of an isotype control IgG (c-IgG), the SAR114 anti-ClfA monoclonal antibody, and/or the MEDI4893* anti-AT monoclonal antibody. Mice were challenged 24 hours later by intravenous (IV) injection of LD_{90} of *S. aureus* clinical isolates SF8300. Ten animals per group were euthanized after 8 hours or 24 hours, and blood was collected from cardiac punctures. Pro-inflammatory cytokines were measured from plasma using a Mesoscale Multiplex pro-inflammatory cytokine kit. Statistical differences between group were analyzed with a Mann-Whitney U test, and considered statistically different if $p<0.05$.

[0126] The combination of SAR114 and MEDI4893* significantly decreased IL-6, TNF-α, and KC levels at 24 hours in diabetic db/db mice as shown in Table 6.

Table 6: SAR114 and MEDI4893* decreases pro-inflammatory cytokines

Cytokine	Time	Mice	MEDI4893*	SAR114	MEDI4893* and SAR114
IL-6	8 hrs	B6		0.004	
IL-6	8 hrs	db			
IL-6	24 hrs	B6	0.0156	0.0041	0.008
IL-6	24 hrs	db	0.0034	0.043	0.011
TNF-α	8 hrs	B6		0.0017	0.0002
TNF-α	8 hrs	db	0.0503	0.076	0.0015
TNF-α	24 hrs	B6	0.028		0.0014

TNF-α	24 hrs	db		0.0055	0.038
KC	8 hrs	B6		<0.0001	
KC	8 hrs	db	0.032	0.0127	0.0008
KC	24 hrs	B6		0.0006	0.0002
KC	24 hrs	db	0.008	0.028	0.014

The data are representative of three independent experiments.

[0127] The combination also significantly decreased IL-6, TNF-α, and KC levels at 24 hours in non-diabetic C57/B6 mice.

EXAMPLE 7

[0128] This example describes the effects of SAR114 anti-ClfA monoclonal antibody, alone or in combination with an anti-alpha toxin (AT) monoclonal antibody, on liver damage in a diabetic murine bacteremia model.

[0129] Groups of 6-week old diabetic BKS.Cg-Dock7^{m} +/+ Lepr^{db}/J male mice (n=10) were immunized by intra-peritoneal (IP) injection of an isotype control IgG (c-IgG), the SAR114 anti-ClfA monoclonal antibody (15mg/kg (mpk)), the MEDI4893* anti-AT monoclonal antibody (15mpk), or a combination of SAR114 +MEDI4893* (15mpk each). Mice were challenged 24 hours later by intravenous (IV) injection of LD_{90} of *S. aureus* clinical isolates SF8300. Mice were euthanized 48h after infection, and livers harvested. Gross pathology was recorded photographically (Figure 12, left panel), and liver section stained with hematoxylin/eosin after fixation with 10% formalin (Figure 12, right panel). The SAR114 antibody, the MEDI4893* antibody, and the combination of SAR114 +MEDI4893* all prevented liver damage in diabetic mice exposed to *S. aureus*.

EXAMPLE 8

[0130] This example describes the effects of SAR114 anti-ClfA monoclonal antibody, alone or in combination with an anti-alpha toxin (AT) monoclonal antibody, in a murine diabetic bacteremia model.

[0131] Groups of 6-week old diabetic BKS.Cg-Dock7^{m} +/+ Lepr^{db}/J male mice (n=10) were immunized by intra-peritoneal (IP) injection of an isotype control IgG (c-IgG), the SAR114 anti-ClfA monoclonal antibody, and/or the MEDI4893* anti-AT monoclonal

antibody. Mice were challenged 24 hours later by intravenous (IV) injection of an LD_{90} of *S. aureus* clinical isolates. Survival was monitored over two weeks. Figure 13.

[0132] The combination of SAR114 and MEDI4893* (7.5 mg/kg (mpk) each) increased survival relative to c-IgG following challenge with most strains tested, and also provided a benefit over the corresponding individual monoclonal antibodies in most strains.

[0133] The results of this experiment demonstrate that the anti-ClfA SAR114 monoclonal antibody is functional *in vivo* and suggests that the combination of SAR114 and an anti-AT monoclonal antibody provides broader strain coverage for *S. aureus* prophylaxis in diabetic mice.

EXAMPLE 9

[0134] This example describes the generation of a bispecific monoclonal antibody that specifically binds to both ClfA and AT and its efficacy *in vitro*.

[0135] Because passive immunization with the combination of an anti-ClfA monoclonal antibody and an anti-AT monoclonal antibody provided a benefit for strain coverage in lethal bacteremia and retained the anti-AT protective capacity in murine dermonecrosis and pneumonia models (Tkaczyk et al., *supra*), a bispecific antibody (BiSAb) directed against ClfA and AT was generated to determine if such a bispecific antibody provided a benefit over the combination of the corresponding individual antibodies. To this end, BiSAbs were engineered as previously described (see, e.g., Dimasi et al., *J. Mol. Biol.*, *393*: 672-692 (2009); and Coloma, M.J. and S.L. Morrison, *Nat. Biotechnol.*, *15*: 159-163 (1997)). Briefly, anti-ClfA mAbs 11H10 or SAR114 were used as IgG scaffold, and MEDI4893* was grafted in scFv format. MEDI4893* scFv was synthesized in the VL-VH format with a 20-amino acid (GGGGSx4) linker between the light and heavy variable domains (GeneArt, ThermoFisher Scientific, Waltham, MA). "BiS_2" antibodies were constructed by fusing MEDI893* scFv sequences to the N-terminus of the heavy chains of 11H10 or SAR114 anti-ClfA IgG1. "BiS_3" constructs were generated by appending the linker-scFv of MEDI4893* to the C terminus of the heavy chain of 11H10 or SAR114. The BiS_2 and BiS_3 constructs are illustrated schematically in Figure 14. BiS_2 and BiS_3 molecules were expressed by transient transfection in 293 cells, purified by protein A affinity chromatography, and polished by size exclusion chromatography. The integrity of each molecule was assessed by mass spectrophotometry and by intact mass and peptide

mapping to verify proper formation of engineered and endogenous disulfide bounds.The BiS_2 and BiS_3 formats were selected because the scFv is located in disparate locations on the IgG and the only way to determine if one format has an advantage over another is to test them empirically for the antibody specificities of interest.

[0136] To understand if the BiSAbs retained the functional activities of the corresponding individual monoclonal antibodies, the ability of each BiSAb to inhibit AT-dependent rabbit red blood cell (RBC) lysis and inhibit fibrinogen binding to ClfA001, ClfA002 and ClfA004 was assessed. The rabbit RBC hemolytic assay was performed by mixing serial dilutions of the BiS Abs and MEDI4893* (500 to 1.7 nM) with AT (0.1μg/ml=3nM) and incubating with 50 μl of washed rabbit RBC (Peel Freeze) for 1 hour at 37 °C. In some assays, anti-AT scFv of BisAb was saturated with 10M excess of ClfA (5 μM). Plates were then centrifuged at 1200 rpm for 3 minutes, and 50 μl of supernatant was transferred to new plates. Non-specific human IgG1 R347 was used as negative control (c-IgG) (see, e.g., Tkaczyk et al., *Clin. Vaccine Immunol.*, *19*: 377-385 (2012)). OD450 nm was measured with a spectrophotometer (Molecular Devices, Sunnyvale, CA). Inhibition of hemolysis was calculated using the following equation:

$$100-(100*[ODAT+mAb]/[ODAT]).$$

[0137] For the fibrinogen-binding assay, NUNC MAXISORP™ plates (ThermoFisher Scientific, Waltham, MA) were coated overnight at 4 °C with 2 μg/ml human fibrinogen (Sigma Aldrich, St. Louis, MO), washed 3 times with PBS containing 0.1% Tween 20 (wash buffer) and blocked for 1 hour at room temperature (RT) with 200 μl/well casein (ThermoFisher Scientific, Waltham, MA). Following 3 washes, the plates were incubated for 1 hour at RT with a mix of 50 μl Avi-tag ClfA221-559 (2 μg/ml) and serial dilutions of anti-ClfA monoclonal antibody or BiS antibody in 100 μl final volume PBS. In some assays, the anti-ClfA IgG1 of the BiSAb was saturated with 10M excess of AT (6.6 mM). After washes, bound ClfA was detected using horseradish peroxidase (HRP)-conjugated streptavidin (1:20000, GE Healthcare, Chicago, IL) and 100 μl 3,3',5,5'-tetramethylbenzidine (TMB) substrate (KPL). The reaction was stopped after 10 minutes with 100 μl 0.2 M H_2S0_4. Plates were read on a spectrophotometer at OD450 nm. Percentage inhibition of ClfA binding to fibrinogen was calculated using the following formula: $100-(100*[OD_{ClfA+mAb}] / [OD_{ClfA,no\ mAb}])$.

[0138] The 11H10-BiS_2 and BiS_3 antibodies and the SAR114-BiS_2 antibody exhibited IC_{50} values similar to MEDI4893* in an AT hemolytic assay, whereas SAR114-BiS_3 exhibited reduced AT neutralization activity, as shown in Figure 15A. Both 11H10 BiSAbs and the SAR114 BiS_3Ab exhibited IC_{50} values similar to the respective parental anti-ClfA IgG in the fibrinogen binding inhibition assay, whereas the SAR114 BiS_2Ab lost some activity against ClfA002 but was still superior to 11H10, as shown in Figure 15B, Figure 16, and Table 7. The BiSAbs also mediated similar opsonophagocytic bacterial killing (OPK) as the parental anti-ClfA IgG, as shown in Figure 17. Importantly, saturation of the anti-AT scFv in the presence of 10 M excess of AT did not interfere with anti-ClfA activity in the fibrinogen binding assay, as shown in Figure 15C. Similarly, saturation of ClfA binding with a 10 M ClfA excess did not decrease AT neutralizing activity of the BiSAbs in the hemolytic assay, as shown in Figure 15D.

Table 7. IC_{50} for SAR114 and 11H10-BiS2 and BiS3 molecules in fibrinogen binding assay

IC_{50} (nM)		**SAR114**	**BiS_2**	**BiS_3**
	ClfA001	19.16	90.31	41.78
	ClfA002	14.26	40.48	27.52
	ClfA004	8.083	34.69	20.93
IC_{50} (nM)		**11H10**	**BiS_2**	**BiS_3**
	ClfA001	12.67	124.3	57.75
	ClfA002	493.7	3023	1530
	ClfA004	3.094	1.504	0.9786

[0139] The results of this example demonstrate that the anti-ClfA/AT BiS molecules retain *in vitro* functional activity that in most cases was similar to the parental IgG, and this activity was not diminished in the presence of a 10-fold molar excess of the other antigen recognized by the BiSAb.

EXAMPLE 10

[0140] This example describes the protective effects of an anti-ClfA/AT bispecific antibody in an *S. aureus* lethal bacteremia model.

[0141] Mice were passively immunized with the anti-ClfA SAR114 antibody and MEDI4893* monoclonal antibody combination (7.5 mpk or 1 mpk each) or equimolar doses of the BiSAbs (9 or 1.2 mpk, respectively) 24 hours prior to IV infection with *S. aureus* strain SF8300 as described in Example 4, and survival was monitored for 14 days. Both SAR114-BiSAbs at 9 mpk exhibited reduced but not significantly different protection ($p=0.234$ for BiS_2 and $p=0.412$ for BiS_3) compared to the monclonal antibody combination at 7.5 mpk each, as shown in Figure 18A. The monoclonal antibody combination at 1 mpk ($p=0.0051$ vs c-IgG) and SAR114-BiS_2 at 1.2 mpk ($p=0.0336$ vs c-IgG) significantly increased survival relative to c-IgG. Consistent with the observed loss of AT neutralization activity *in vitro* (see Figure 15A), SAR114-BiS_3 did not significantly increase survival when administered at 1.2 mpk ($p=0.657$, Figure 18A). When tested against *S. aureus* strain 3049057 (MRSA, ST8), a strain where neither monoclonal alone is sufficient for significant protection (see Figure 10), the SAR114-BiS molecules at 1.2 mpk did not significantly increase survival relative to c-IgG ($p=0.4310$), whereas an equimolar concentration (1 mpk) of the monoclonal antibody combination did increase survival, as shown in Figure 18B ($p=0.0348$ vs c-IgG). This result suggested a defect in the SAR114-BiS_2 antibody *in vivo*. Interestingly, passive immunization with the 11H10-BiSAbs resulted in protection similar to the monoclonal combination at both doses tested (9 mpk and 1.2 mpk) and provided a significant increase in survival relative to c-IgG against both ClfA001 expressing strains, SF8300 and 3049057, as shown in Figures 18C and 18D.

[0142] The results of this example demonstrate that the anti-ClfA/AT BiSAbs do not provide a benefit over the combination of corresponding individual antibodies. Rather, the SAR114/MEDI4893* bispecific antibody exhibited a loss in protection at lower doses against a strain where the corresponding individual monoclonal antibodies were not sufficient to provide protection.

EXAMPLE 11

[0143] This example describes experiments examining the efficacy of the SAR114/MEDI4893* bispecific antibody in a lethal pneumonia model.

[0144] Since SAR114 binds ClfA001 with approximately 1000-fold greater affinity than 11H10 (Table 1), it was hypothesized that SAR114 binding to ClfA sequesters the

SAR114/MEDI4893* BiSAb on the bacterial surface, leading to poorer capture and neutralization of AT as it is secreted. AT is a key virulence factor in *S. aureus* pneumonia (Bubeck Wardenburg, J. and O. Schneewind, *J. Exp. Med.*, *205*: 287-294 (2008)), and passive immunization with an anti-AT monoclonal antibody alone protects mice from lethal *S. aureus* pneumonia (Foletti et al., *J. Mol. Biol.*, *425*(10): 1641-1654 (2013); Hua et al., *Antimicrob. Agents Chemother.*, *58*:1108-1117 (2014); and Ragle, B.E., and J. Bubeck Wardenburg, *Infect. Immun.*, *77*: 2712-2718 (2009)). Moreover, the anti-ClfA monoclonal antibody does not impact survival in the pneumonia model and the combination of anti-ClfA and anti-AT monoclonal antibodies provides protection similar to an anti-AT mAb alone (Tkaczyk et al., *supra*). Therefore, to determine if the decreased protection observed with the SAR114-BiS_2Abs in the lethal bacteremia model may have resulted from inadequate AT neutralization, female C57/B6 mice (Jackson Laboratory, Bar Harbor, ME) were injected IP with MEDI4893* alone or in combination with SAR114, or with the SAR114 BiS_2 or BiS_3 molecules. Pneumonia was induced by intranasal infection with SF8300 ($1e^8$ CFU) as described in Hua et al., *supra*. Animal survival was monitored for 6 days. Statistical analysis versus c-IgG versus was performed with a Log Rank (Mantel Cox) test. Data were considered statistically different if $p<0.05$.

[0145] Passive immunization with MEDI4893* (15 mpk) alone or in combination with SAR114 resulted in 100% protection following challenge with SF8300. However, passive immunization with SAR114-BiS_2 or BiS_3 resulted in 30% and 0% survival, respectively, as shown in Figure 19A. Interestingly, passive immunization with the 11H10BiS_2, which has approximately 1000-fold reduced affinity for ClfA (Table 1), provided 100% survival. These results support the conclusion that binding to ClfA on the bacterial surface sequesters SAR114-BiSAbs, thus impairing AT neutralization. To further test this hypothesis, mice were passively immunized with the BiS_2 molecules prior to intranasal (IN) infection with a ClfA isogenic mutant SF8300Δclfa. Prophylaxis with SAR114-BiSAb provided protection against SF8300Δclfa similar to MEDI4893*, as shown in Figure 19B.

[0146] The results of this example provide further evidence that SAR114-BiSAb binding to surface-localized ClfA prevents effective neutralization of soluble AT.

EXAMPLE 12

[0147] This example describes experiments examining the pharmacokinetics (pK) of SAR114 antibodies in cynomolgus monkeys. The monkeys were treated by intravenous (IV) administration with 5 mg/kg of SAR114, SAR114 N3F, or SAR114 N3Y, and antibody levels were measured in the blood over 60 days. The results are shown in Figure 20 and reported in Table 8 below.

Table 8: Cynomolgus monkey PK parameters.

Sar114 Construct	Clearance (mL/day/kg)	β-phase $t_{1/2}$ (days)	AUC_{last} (μg*day/ml)
Wild-type	5.69±0.27	10.1±1.5	754±21
N3Y	2.14±0.17	23.7±2.4	1900±170
N3F	2.54±0.46	20.3±4.1	1690±254

[0148] The data above demonstrates that the modified versions of SAR114, and in particular SAR114 N3Y, exhibit an increased half-life in primates. The data above are consistent with what would be predicted from the half life extension studies in mice transgenic for human FcRN. The effective extension of half-life in primates indicates that the half-life of SAR114 N3Y will be appropriately extended and important for proper administration, treatment, and prevention of *S. aureus*-related disease in humans.

EXAMPLE 13

[0149] This example describes experiments examining the immunogenicity of the N3Y Fc.

[0150] The immunogenicity of therapeutic proteins can cause problems including neutralization, accelerated clearance of the therapeutic, and/or adverse events. While human proteins such as antibody framework regions are mostly non-immunogenic, mutations in the Fc regions of antibodies present a potential risk of an immune response. Functional activation assays using human CD4 T-cells are now considered a hallmark of immunogenicity prediction as a result of the chief role of helper T cells in immunogenicity responses. Therefore, the effect of the N3Y in the Fc region of IgG1 on T cell activation was analyzed.

[0151] In these experiments, PMBCs were isolated from 39 human whole blood collections using Ficole gradients. CD8 cells were then extracted using positive selection, and the cells were enriched by stimulation with 5 different peptide pools and 10 days *in vitro* expansion with IL-2. The cells were then re-stimulated with an individual peptide library in ELIspot plates for CD4. The results shown in Figure 21 demonstrate that the NY3 mutation dose not significantly increase immunogenicity as compared to the wildtype Fc region.

[0152] All references, including publications, patent applications, and patents, cited herein are hereby incorporated by reference to the same extent as if each reference were individually and specifically indicated to be incorporated by reference and were set forth in its entirety herein.

[0153] The use of the terms "a" and "an" and "the" and "at least one" and similar referents in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The use of the term "at least one" followed by a list of one or more items (for example, "at least one of A and B") is to be construed to mean one item selected from the listed items (A or B) or any combination of two or more of the listed items (A and B), unless otherwise indicated herein or clearly contradicted by context. The terms "comprising," "having," "including," and "containing" are to be construed as open-ended terms (i.e., meaning "including, but not limited to,") unless otherwise noted. Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., "such as") provided herein, is intended merely to better illuminate the invention and does not pose a limitation on the scope of the invention unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the invention.

[0154] Preferred embodiments of this invention are described herein, including the best mode known to the inventors for carrying out the invention. Variations of those preferred

embodiments may become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventors expect skilled artisans to employ such variations as appropriate, and the inventors intend for the invention to be practiced otherwise than as specifically described herein. Accordingly, this invention includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the invention unless otherwise indicated herein or otherwise clearly contradicted by context.

WHAT IS CLAIMED IS:

1. An antibody or antigen-binding fragment thereof that specifically binds to a *Staphylococcus aureus* (*S. aureus*) clumping factor A (ClfA) protein, wherein said antibody or antigen-binding fragment comprises a variable heavy chain (VH) complementarity determining region (CDR) 1 comprising the amino acid sequence of SEQ ID NO: 1, a VH CDR2 comprising the amino acid sequence of SEQ ID NO: 2, a VH CDR3 comprising the amino acid sequence of SEQ ID NO: 3, a variable light chain (VL) CDR1 comprising the amino acid sequence of SEQ ID NO: 4, a VL CDR2 comprising the amino acid sequence of SEQ ID NO: 5, and a VL CDR3 comprising the amino acid sequence of SEQ ID NO: 6, and wherein said antibody or antigen-binding fragment comprises a heavy chain constant domain comprising the amino acid sequence of CSYHLC (SEQ ID NO: 21).

2. The antibody or antigen-binding fragment thereof of claim 1, wherein the antibody or antigen-binding fragment thereof comprises a VH comprising the amino acid sequence of SEQ ID NO: 13.

3. The antibody or antigen-binding fragment thereof of claim 1 or 2, wherein the antibody or antigen-binding fragment thereof comprises a VL comprising the amino acid sequence of SEQ ID NO: 14.

4. An antibody or antigen-binding fragment thereof that specifically binds to a *S. aureus* ClfA protein, wherein said antibody or antigen-binding fragment comprises (1) a VH, (2) a VL, and (3) a heavy chain constant domain comprising the amino acid sequence of CSYHLC (SEQ ID NO: 21); wherein the VH comprises the amino acid sequence of SEQ ID NO: 13.

5. An antibody or antigen-binding fragment thereof that specifically binds to a *S. aureus* ClfA protein, wherein said antibody or antigen-binding fragment comprises (1) a VH, (2) a VL, and (3) a heavy chain constant domain comprising the amino acid sequence of

CSYHLC (SEQ ID NO: 21); wherein the VL comprises the amino acid sequence of SEQ ID NO: 14.

6. An antibody or antigen-binding fragment thereof that specifically binds to a *S. aureus* ClfA protein, wherein said antibody or antigen-binding fragment comprises the VH CDR1, VH CDR2, VH CDR3, VL CDR1, VL CDR2, and VL CDR3 of SAR114.

7. The antibody or antigen-binding fragment thereof of claim 6, wherein the CDRs are the Kabat-defined CDRs, the Chothia-defined CDRs, or the AbM-defined CDRs.

8. The antibody or antigen-binding fragment thereof of claim 6 or 7, wherein said antibody or antigen-binding fragment comprises a heavy chain constant domain comprising the amino acid sequence of CSYHLC (SEQ ID NO: 21).

9. The antibody or antigen-binding fragment thereof of any one of claims 1-8, wherein said heavy chain constant domain comprises the amino acid sequence of MHEACSYHLCQKSLSLS (SEQ ID NO: 23).

10. The antibody or antigen-binding fragment thereof of any one of claims 1-9, wherein said heavy chain constant domain comprises the amino acid sequence of SEQ ID NO: 24.

11. The antibody or antigen-binding fragment thereof of any one of claims 1-10, wherein the antibody or antigen-binding fragment thereof comprises a heavy chain comprising the amino acid sequence of SEQ ID NO: 50.

12. The antibody or antigen-binding fragment thereof of any one of claims 1-11, wherein the antibody or antigen-binding fragment thereof comprises a light chain comprising the amino acid sequence of SEQ ID NO: 26.

13. The antibody or antigen-binding fragment thereof of any one of claims 1-13, wherein the IC50's for ClfA001, ClfA002, and ClfA004 in a fibrinogen binding inhibition assay are within 2 μg/ml of each other.

14. The antibody or antigen-binding fragment thereof of any one of claims 1-13, wherein the IC_{50}'s for ClfA001, ClfA002, and ClfA004 in a fibrinogen binding inhibition assay are all between 1 μg/ml and 5 μg/ml.

15. The antibody or antigen-binding fragment thereof of any one of claims 1-14, wherein the binding affinities (K_D) for ClfA001, ClfA002, and ClfA004 are all between 200 and 350 pM.

16. The antibody or antigen-binding fragment thereof of any one of claims 1-15, wherein the antibody or antigen-binding fragment has a monomer purity that decreases by no more than 5% after exposure of the antibody or antigen-binding fragment to conventional white light at 2kLux/hr at 23^0C for 14 days.

17. The antibody or antigen-binding fragment there of any one of claims 1-16, wherein the antibody or antigen-binding fragment comprises a mutation that extends half-life relative to the same antibody without the mutation in human FcRn mice.

18. The antibody or antigen-binding fragment there of any one of claims 1-16, wherein the antibody or antigen-binding fragment comprises a mutation that extends half-life relative to the same antibody without the mutation, and wherein the mutation does not inhibit OPK activity relative to the same antibody or antigen-binding fragment the mutation.

19. A bispecific antibody or antigen-binding fragment thereof that specifically binds to a *S. aureus* ClfA protein and specifically binds to a *S. aureus* alpha toxin (AT) protein, wherein the antibody or antigen-binding fragment comprises a VH CDR1 comprising the amino acid sequence of SEQ ID NO: 1, a VH CDR2 comprising the amino acid sequence of SEQ ID NO: 2, a VH CDR3 comprising the amino acid sequence of SEQ ID NO: 3, a VL CDR1 comprising the amino acid sequence of SEQ ID NO: 4, a VL CDR2

comprising the amino acid sequence of SEQ ID NO: 5, and a VL CDR3 comprising the amino acid sequence of SEQ ID NO: 6.

20. The antibody or antigen-binding fragment thereof of claim 19, wherein the antibody or antigen binding fragment thereof comprises a VH comprising the amino acid sequence of SEQ ID NO: 13.

21. The antibody or antigen-binding fragment thereof of claim 19 or 20, wherein the antibody or antigen-binding fragment thereof comprises a VL comprising the amino acid sequence of SEQ ID NO: 14.

22. The antibody or antigen-binding fragment thereof of any one of claims 19-21, wherein the antibody or antigen-binding fragment thereof further comprises a VH CDR1 comprising the amino acid sequence of SEQ ID NO: 7, a VH CDR2 comprising the amino acid sequence of SEQ ID NO: 8, a VH CDR3 comprising the amino acid sequence of SEQ ID NO: 9, a VL CDR1 comprising the amino acid sequence of SEQ ID NO: 10, a VL CDR2 comprising the amino acid sequence of SEQ ID NO: 11, and a VL CDR3 comprising the amino acid sequence of SEQ ID NO: 12.

23. The antibody or antigen-binding fragment thereof of any one of claims 19-22, wherein the antibody or antigen-binding fragment comprises a VH comprising the amino acid sequence of SEQ ID NO: 15.

24. The antibody or antigen-binding fragment thereof of any one of claims 19-23, wherein the antibody or antigen-binding fragment comprises a VL comprising the amino acid sequence of SEQ ID NO: 16.

25. An antibody or antigen-binding fragment thereof that specifically binds to a *S. aureus* ClfA protein, wherein said antibody or antigen-binding fragment comprises the VH CDR1, VH CDR2, VH CDR3, VL CDR1, VL CDR2, and VL CDR3 of SAR72, SAR80, SAR113, SAR132, SAR352, SAR372, SAR510, SAR547, SAS1, SAS19, or SAS203.

26. The antibody or antigen-binding fragment thereof of claim 25, wherein the CDRs are the Kabat-defined CDRs, the Chothia-defined CDRs, or the AbM-defined CDRs.

27. The antibody of claim 25 or 26, wherein the antibody or antigen-binding fragment comprises variable heavy chain and variable light chain sequences comprising the amino acid sequences set forth in (a) SEQ ID NOs: 17 and 18, respectively (b) SEQ ID NOs: 30 and 31, respectively, (c) SEQ ID NOs: 32 and 33, respectively, (d) SEQ ID NOs: 34 and 35, respectively, (e) SEQ ID NOs: 36 and 37, respectively, (f) SEQ ID NOs: 38 and 39, respectively, (g) SEQ ID NOs: 40 and 41, respectively, (h) SEQ ID NOs: 42 and 43 respectively (i) SEQ ID NOs: 44 and 45, respectively, (j) SEQ ID NOs: 46 and 47, respectively, or (k) SEQ ID NOs: 48 and 49, respectively.

28. An antibody or antigen-binding fragment thereof that specifically binds to a *S. aureus* ClfA protein, wherein said antibody or antigen-binding fragment comprises a VH and a VL, wherein the VH comprises the amino acid sequence set forth in SEQ ID NO: 17, 30, 32, 34, 36, 38, 40, 42, 44, 46, or 48.

29. An antibody or antigen-binding fragment thereof that specifically binds to a *S. aureus* ClfA protein, wherein said antibody or antigen-binding fragment comprises a VH and a VL, wherein the VL comprises the amino acid sequence set forth in SEQ ID NO: 18, 31, 33, 35, 37, 39, 41, 43, 45, 47, or 49.

30. The antibody or antigen-binding fragment thereof of any one of claims 6-7 and 12-29 wherein said antibody or antigen-binding fragment thereof further comprises a heavy chain constant region.

31. The antibody or antigen-binding fragment thereof of claim 30, wherein the heavy chain constant region is selected from the group consisting of human immunoglobulin IgG_1, IgG_2, IgG_3, IgG_4, IgA_1, and IgA_2 heavy chain constant regions.

32. The antibody or antigen-binding fragment thereof of claim 31, wherein the heavy chain constant region is a human IgG_1 constant region.

33. The antibody or antigen-binding fragment thereof of claim 30, wherein the heavy chain constant region comprises an N3, N3E, or N3F mutation.

34. The antibody or antigen-binding fragment thereof of any one of claims 1-5, 8-10, or 30 wherein the heavy chain constant region comprises a YTE mutation.

35. The antibody or antigen-binding fragment thereof of any one of claims 1-11 and 13-34, wherein said antibody or antigen-binding fragment thereof further comprises a light chain constant region.

36. The antibody or antigen-binding fragment thereof of claim 35, wherein the light chain constant region is selected from the group consisting of human immunoglobulin IgGκ and IgGλ light chain constant regions.

37. The antibody or antigen-binding fragment thereof of claim 36, wherein the light chain constant region is a human IgGκ light chain constant region.

38. The antibody or antigen-binding fragment thereof of any one of claims 1-37, wherein the antibody or antigen-binding fragment is a monoclonal antibody or antigen-binding fragment.

39. The antibody or antigen-binding fragment thereof of any one of claims 1-38, wherein the antibody or antigen-binding fragment is a full–length antibody.

40. The antibody or antigen-binding fragment thereof of any one of claims 1-38, wherein the antibody or antigen-binding fragment is an antigen-binding fragment.

41. The antigen-binding fragment of claim 40, wherein the antigen-binding fragment comprises a Fab, Fab', $F(ab')_2$, single chain Fv (scFv), disulfide linked Fv, intrabody, IgGΔCH2, minibody, $F(ab')_3$, tetrabody, triabody, diabody, DVD-Ig, Fcab, mAb^2, $(scFv)_2$, or scFv-Fc.

42. An antibody that specifically binds to a *S. aureus* ClfA protein comprising a heavy chain comprising the amino acid sequence set forth in SEQ ID NO: 50 and a light chain comprising the amino acid sequence set forth in SEQ ID NO: 26.

43. The antibody or antigen-binding fragment thereof of any one of claims 1-42, further comprising a detectable label.

44. A composition comprising the monoclonal antibody of any one of claims 1-43 and a pharmaceutically-acceptable carrier.

45. A composition comprising the antibody or antigen-binding fragment of any one of claims 1-18 and 25-43 and an antibody or antigen-binding fragment that specifically binds to a *S. aureus* alpha toxin (AT) protein, and optionally a pharmaceutically-acceptable carrier.

46. The composition of claim 45, wherein the antibody or antigen-binding fragment that specifically binds to a *S. aureus* AT protein comprises a VH CDR1 comprising the amino acid sequence of SEQ ID NO: 7, a VH CDR2 comprising the amino acid sequence of SEQ ID NO: 8, a VH CDR3 comprising the amino acid sequence of SEQ ID NO: 9, a VL CDR1 comprising the amino acid sequence of SEQ ID NO: 10, a VL CDR2 comprising the amino acid sequence of SEQ ID NO: 11, and a VL CDR3 comprising the amino acid sequence of SEQ ID NO: 12.

47. The composition of claim 45 or 46, wherein the antibody or antigen-binding fragment that specifically binds to a *S. aureus* AT protein comprises a VH comprising the amino acid sequence of SEQ ID NO: 15.

48. The composition of any one of claims 45-47, wherein the antibody or antigen-binding fragment that specifically binds to a *S. aureus* AT protein comprises a VL comprising the amino acid sequence of SEQ ID NO: 16.

49. The composition of any one of claims 45-48, wherein the antibody or antigen-binding fragment that specifically binds to *S. aureus* AT protein comprises a heavy chain comprising the amino acid sequence of SEQ ID NO: 27.

50. The composition of any one of claims 45-49, wherein the antibody or antigen-binding fragment that specifically binds to *S. aureus* AT protein comprises a light chain comprising the amino acid sequence of SEQ ID NO: 28.

51. A method of treating or preventing a *Staphylococcus aureus* (*S. aureus*) infection in a subject comprising administering to the subject the antibody or antigen-binding fragment of any one of claims 1-43 or the composition of any one of claims 44-50.

52. A method of treating or preventing a *Staphylococcus aureus* (*S. aureus*) infection in a subject comprising administering to the subject the antibody or antigen-binding fragment of any one of claims 1-18 and 25-43 and an antibody or antigen-binding fragment that specifically binds to a *S. aureus* alpha toxin (AT) protein.

53. The method of claim 52, wherein the antibody or antigen-binding fragment that specifically binds to a *S. aureus* AT protein comprises a VH CDR1 comprising the amino acid sequence of SEQ ID NO: 7, a VH CDR2 comprising the amino acid sequence of SEQ ID NO: 8, a VH CDR3 comprising the amino acid sequence of SEQ ID NO: 9, a VL CDR1 comprising the amino acid sequence of SEQ ID NO: 10, a VL CDR2 comprising the amino acid sequence of SEQ ID NO: 11, and a VL CDR3 comprising the amino acid sequence of SEQ ID NO: 12.

54. The method of claim 52 or 53, wherein the antibody or antigen-binding fragment that specifically binds to a *S. aureus* AT protein comprises a VH comprising the amino acid sequence of SEQ ID NO: 15.

55. The method of any one of claims 52-54, wherein the antibody or antigen-binding fragment that specifically binds to a *S. aureus* AT protein comprises a VL comprising the amino acid sequence of SEQ ID NO: 16.

56. The method of any one of claims 52-55, wherein the antibody or antigen-binding fragment that specifically binds to *S. aureus* AT protein comprises a heavy chain comprising the amino acid sequence of SEQ ID NO: 27.

57. The method of any one of claims 52-56, wherein the antibody or antigen-binding fragment that specifically binds to *S. aureus* AT protein comprises a light chain comprising the amino acid sequence of SEQ ID NO: 28.

58. The method of any one of claims 52-57, wherein the antibody or antigen-binding fragment of any one of claims 1-18 and 25-43 and the antibody or antigen-binding fragment that specifically binds to a *S. aureus* AT protein are administered simultaneously.

59. The method of any one of claims 52-57, wherein the antibody or antigen-binding fragment of any one of claims 1-18 and 25-43 and the antibody or antigen-binding fragment that specifically binds to a *S. aureus* AT protein are administered sequentially.

60. The method of any one of claims 51-59, wherein treating or preventing an *S. aureus* infection in a subject comprises inhibiting *S. aureus*-associated sepsis, inhibiting *S. aureus* agglutination, inhibiting thromboembolic lesion formation, toxin neutralization, inducing opsonophagocytosis, inhibiting *S. aureus* fibrinogen binding, inhibiting *S. aureus* agglutination, or any combination of the foregoing.

61. The method of any one of claims 51-60, wherein the subject has diabetes.

62. The method of any one of claims 51-61, wherein the subject is human.

63. An isolated polynucleotide comprising a nucleic acid molecule encoding the VH or heavy chain of the antibody or antigen-binding fragment thereof of any one of claims 1-18 and 25-42.

64. The polynucleotide of claim 63, wherein the nucleic acid molecule encodes the VH of SEQ ID NO: 13 or the heavy chain of SEQ ID NO: 25, 50, or 52.

65. An isolated polynucleotide comprising a nucleic acid molecule encoding the VL or light chain of the antibody or antigen-binding fragment thereof of any one of claims 1-18 and 25-42.

66. The polynucleotide of claim 65, wherein the nucleic acid molecule encodes the VL of SEQ ID NO: 14 or the light chain of SEQ ID NO: 26.

67. An isolated polynucleotide comprising a nucleic acid molecule encoding (i) the VH or heavy chain of the antibody or antigen-binding fragment thereof of any one of claims 1-18 and 25-42 and (ii) the VL or light chain of the antibody or antigen-binding fragment thereof of any one of claims 1-18 and 25-42.

68. An isolated vector comprising the polynucleotide of any one of claims 63-67.

69. A host cell comprising the polynucleotide of any one of claims 63-67, the vector of claim 68, or a first vector comprising the polynucleotide of claim 63 or 64 and a second vector comprising the polynucleotide of claim 65 or 66.

70. The host cell of claim 69, wherein the host cell is selected from the group consisting of CHO, NS0, PER-C6, HEK-293, and HeLa cells.

71. The host cell of claim 69 or 70, wherein the host cell is isolated.

72. A method of producing an antibody or antigen-binding fragment thereof comprising culturing the host cell of any one of claims 69-71 so that the antibody or antigen-binding fragment thereof is produced.

73. A method for detecting *S. aureus* or *S. aureus* ClfA in a sample comprising contacting said sample with the antibody or antigen-binding fragment thereof of any one of claims 1-43.

Figure 1

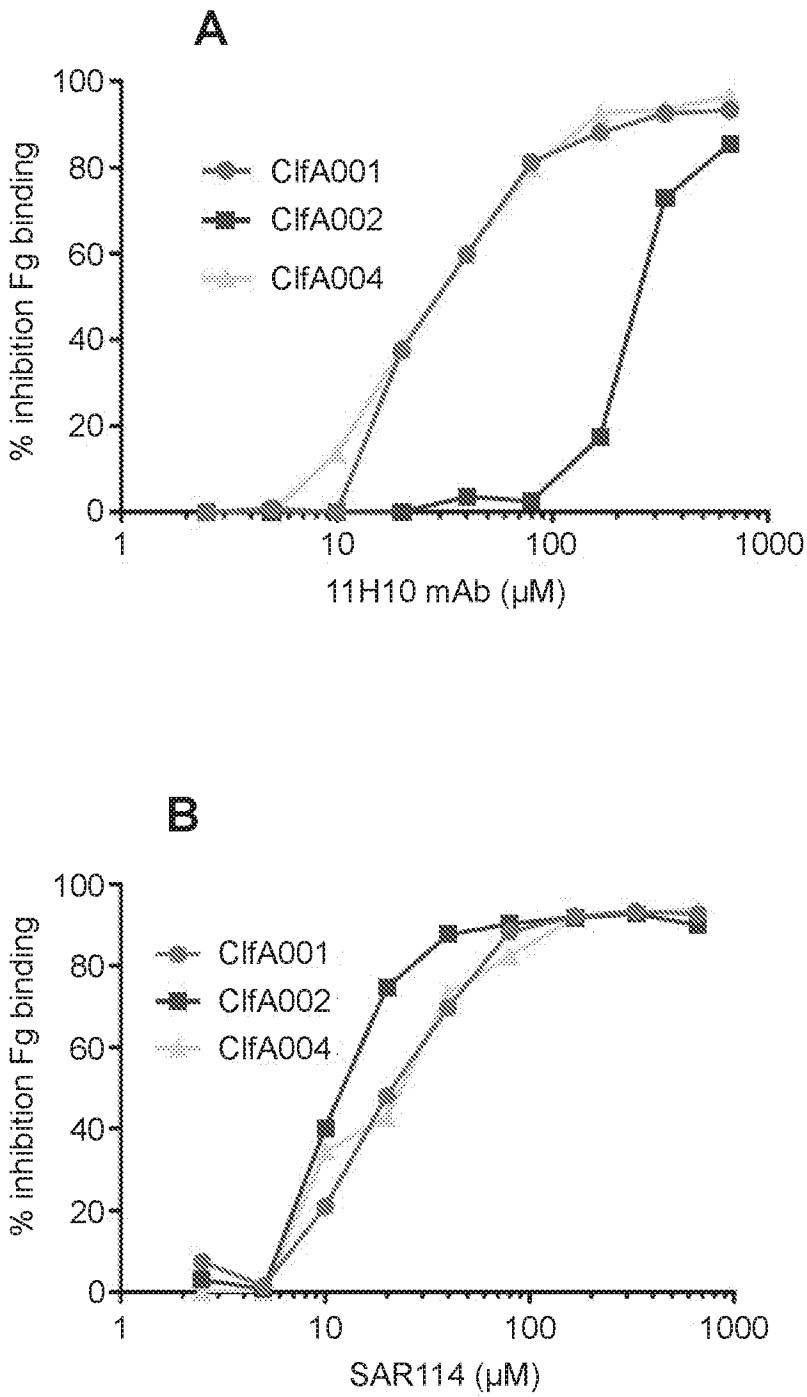

A
100
80
60
40
20
0
% inhibition Fg binding
ClfA001
ClfA002
ClfA004
1
10
100
1000
11H10 mAb (μM)
B
100
80
60
40
20
0
% inhibition Fg binding
ClfA001
ClfA002
ClfA004
1
10
100
1000
SAR114 (μM)

Figure 2

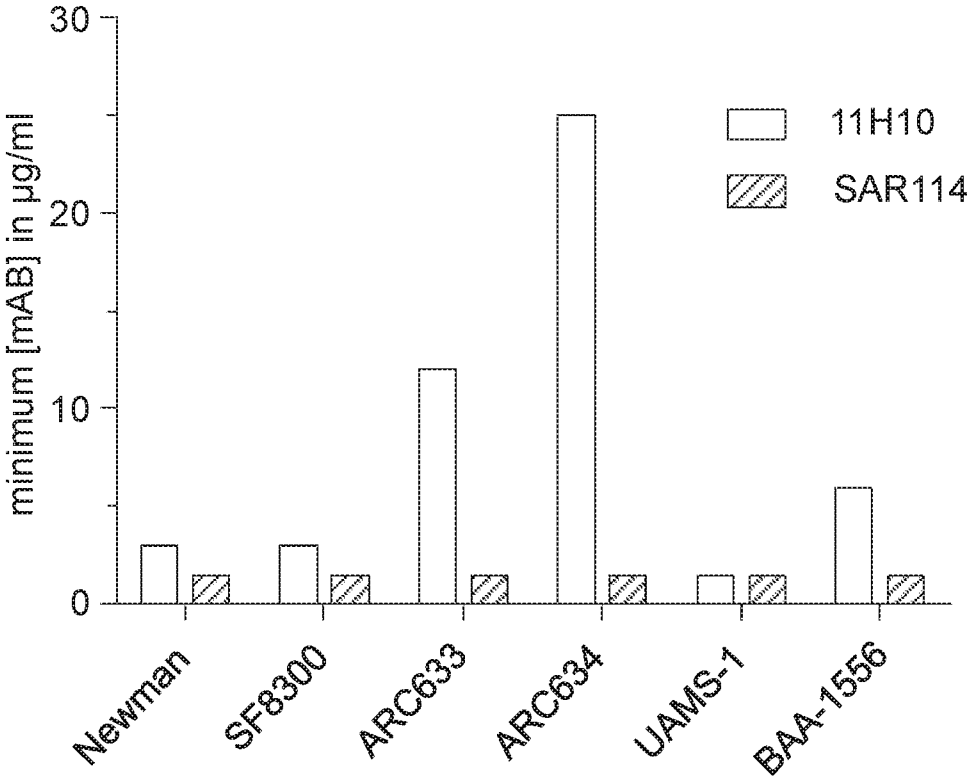

30
20
10
0
minimum [mAB] in µg/ml
11H10
SAR114
Newman
SF8300
ARC633
ARC634
UAMS-1
BAA-1556

Figure 3

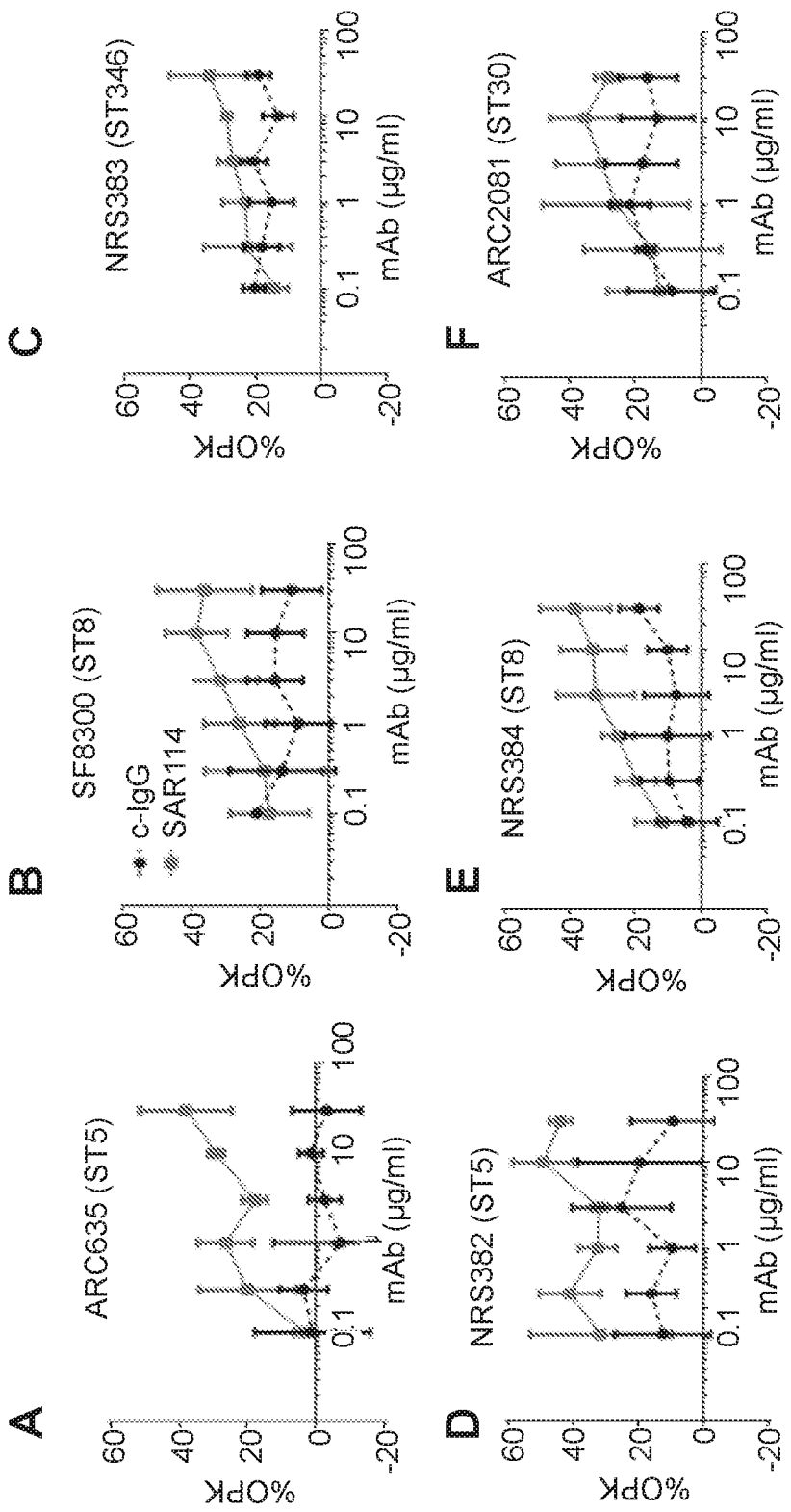

A
ARC635 (ST5)
B
SF8300 (ST8)
c-IgG
SAR114
C
NRS383 (ST346)
D
NRS382 (ST5)
E
NRS384 (ST8)
F
ARC2081 (ST30)
%OPK
mAb (µg/ml)
60
40
20
0
-20
0.1
1
10
100

Figure 4

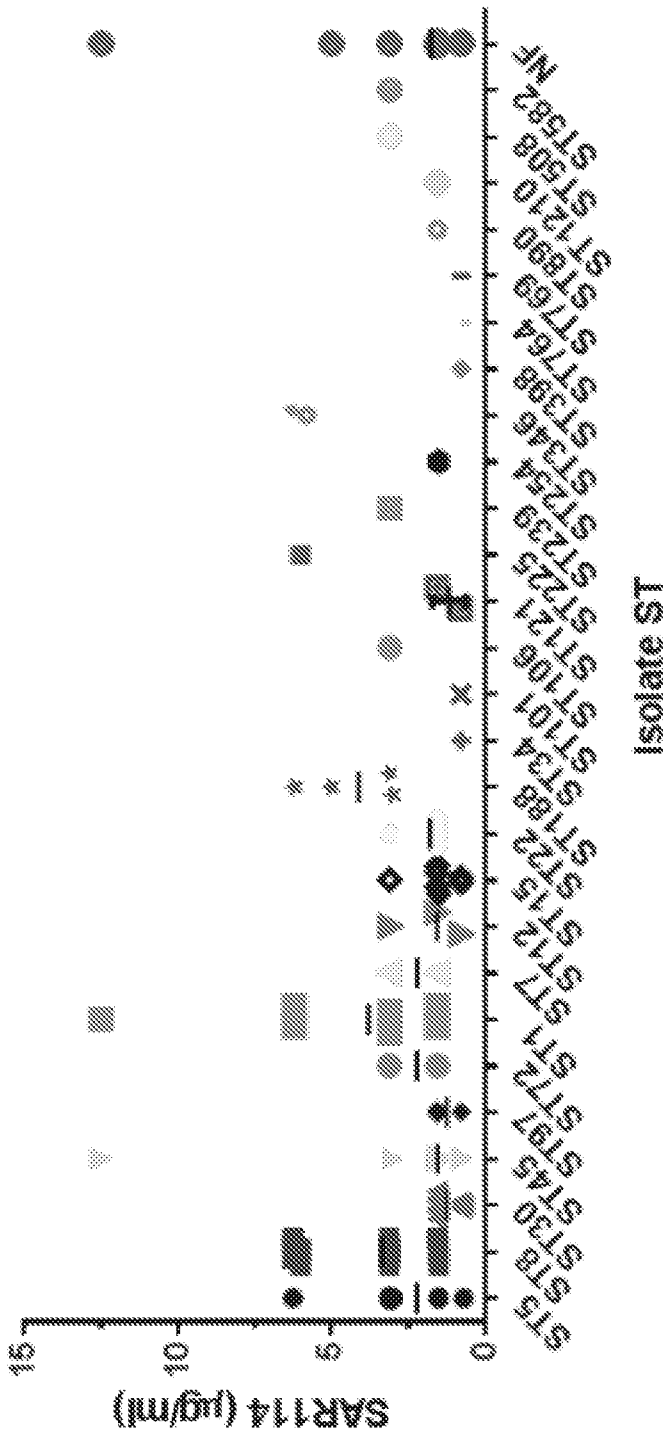

SAR114 (µg/ml)
15
10
5
0
ST5
ST8
ST30
ST45
ST91
ST172
ST1
ST12
ST15
ST22
ST88
ST134
ST101
ST108
ST121
ST225
ST239
ST254
ST346
ST398
ST764
ST63
ST690
ST1210
ST608
ST562
NF
Isolate ST

Figure 5

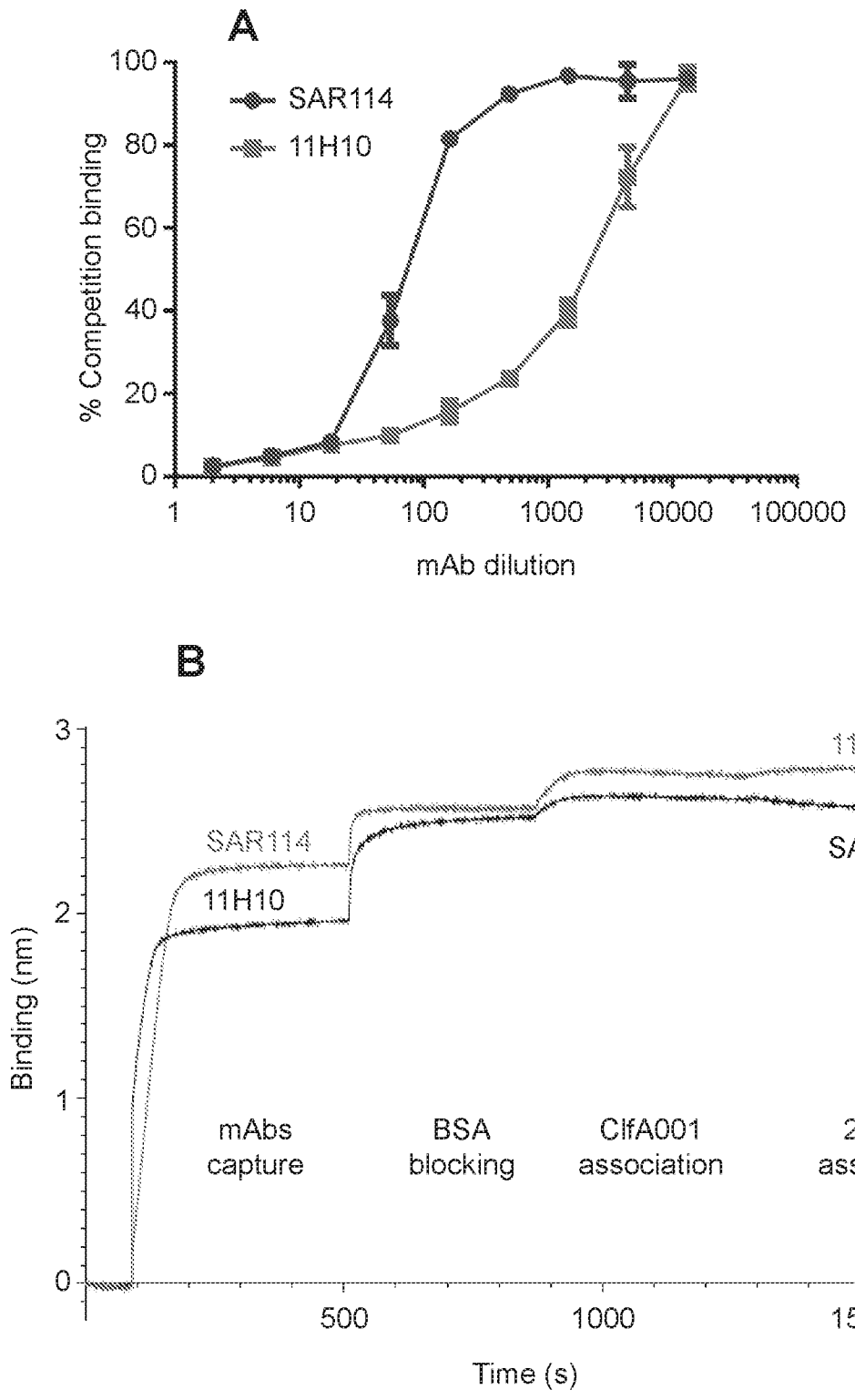

A
100
80
60
40
20
0
% Competition binding
SAR114
11H10
1
10
100
1000
10000
100000
mAb dilution
B
3
2
1
0
Binding (nm)
11H10
SAR114
SAR114
11H10
mAbs capture
BSA blocking
ClfA001 association
2° mAb association
500
1000
1500
Time (s)

Figure 6

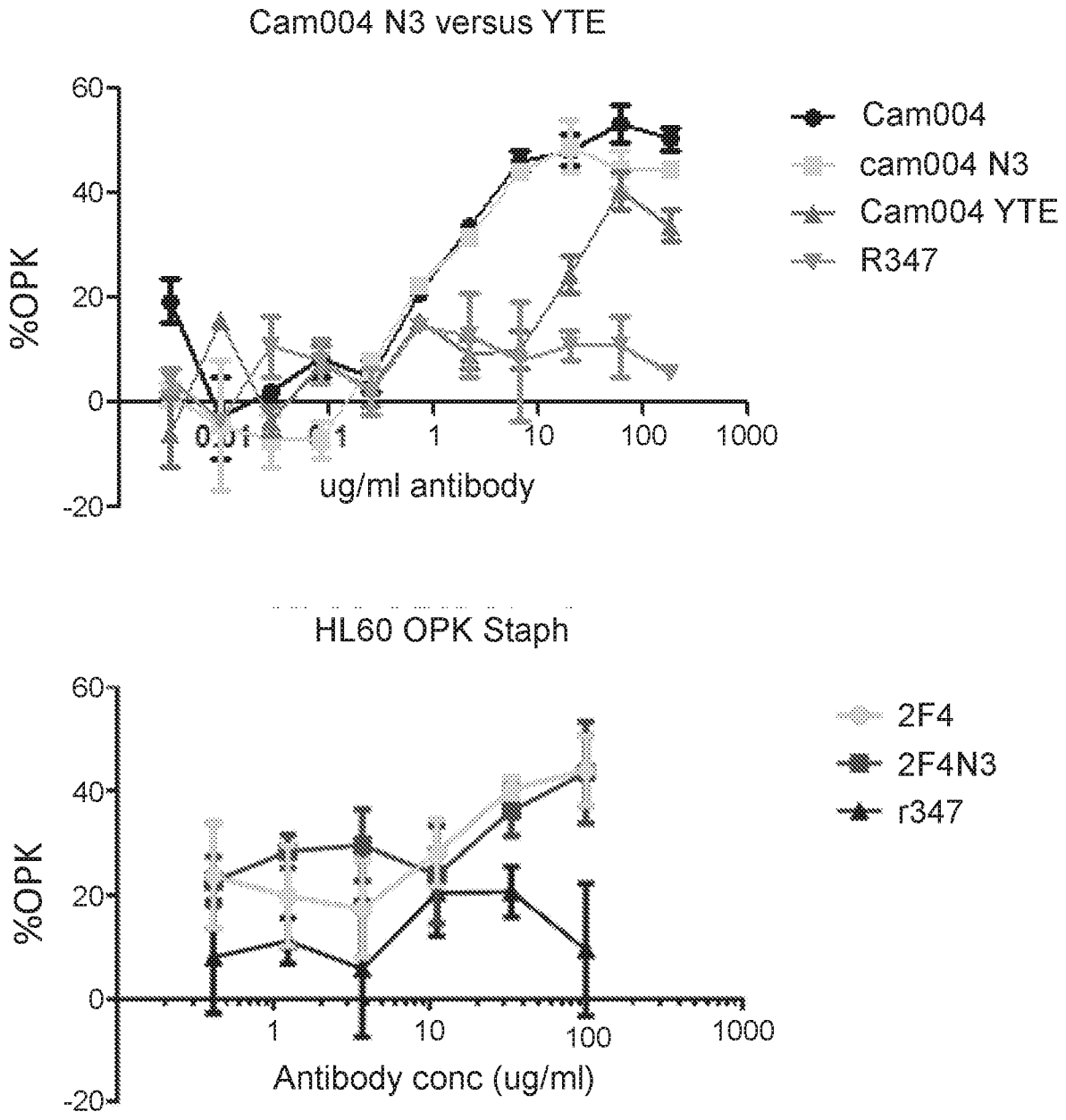

Cam004 N3 versus YTE
%OPK
60
40
20
0
-20
0.01
0.1
1
10
100
1000
ug/ml antibody
Cam004
cam004 N3
Cam004 YTE
R347
HL60 OPK Staph
%OPK
60
40
20
0
-20
1
10
100
1000
Antibody conc (ug/ml)
2F4
2F4N3
r347

Figure 7

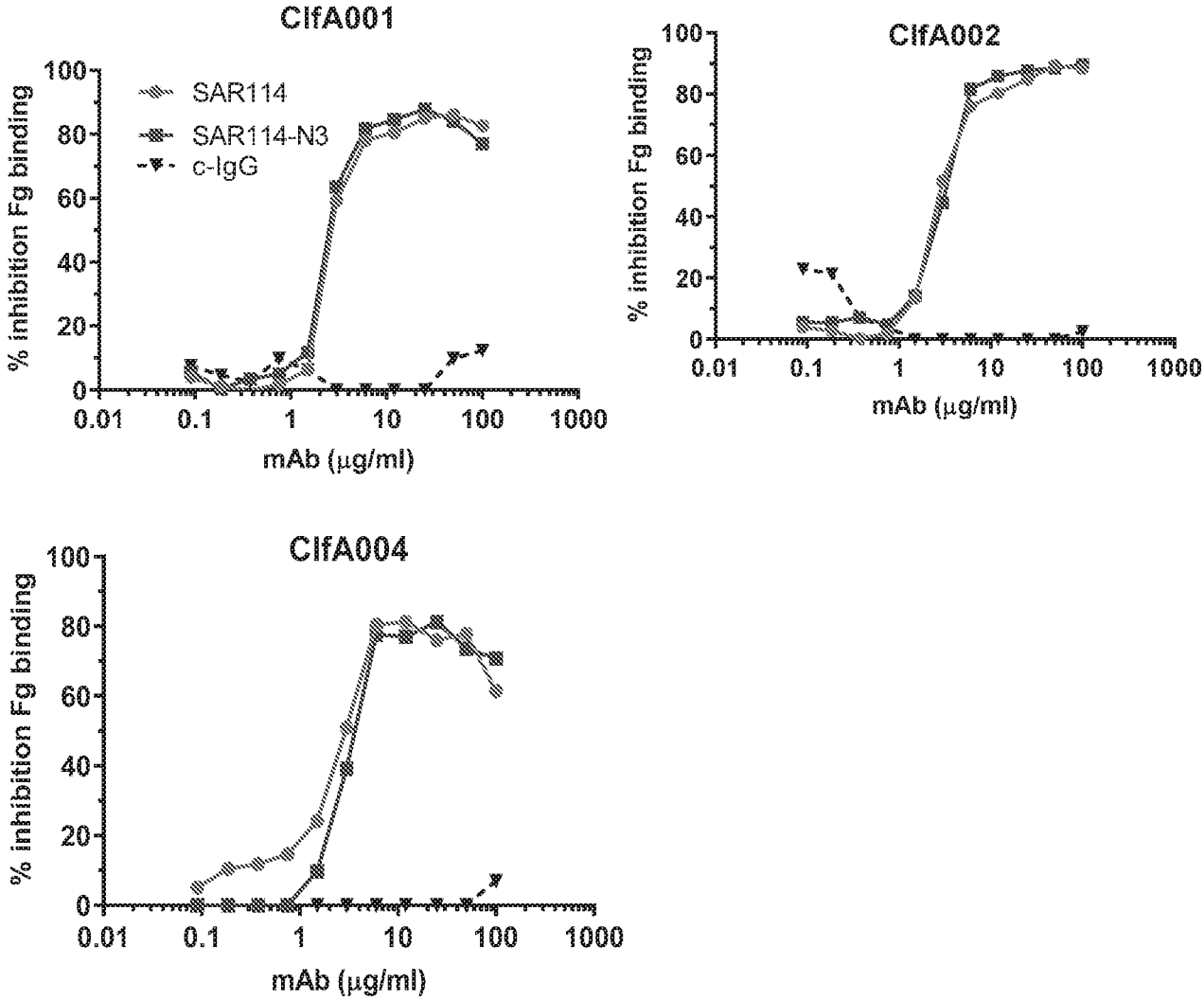


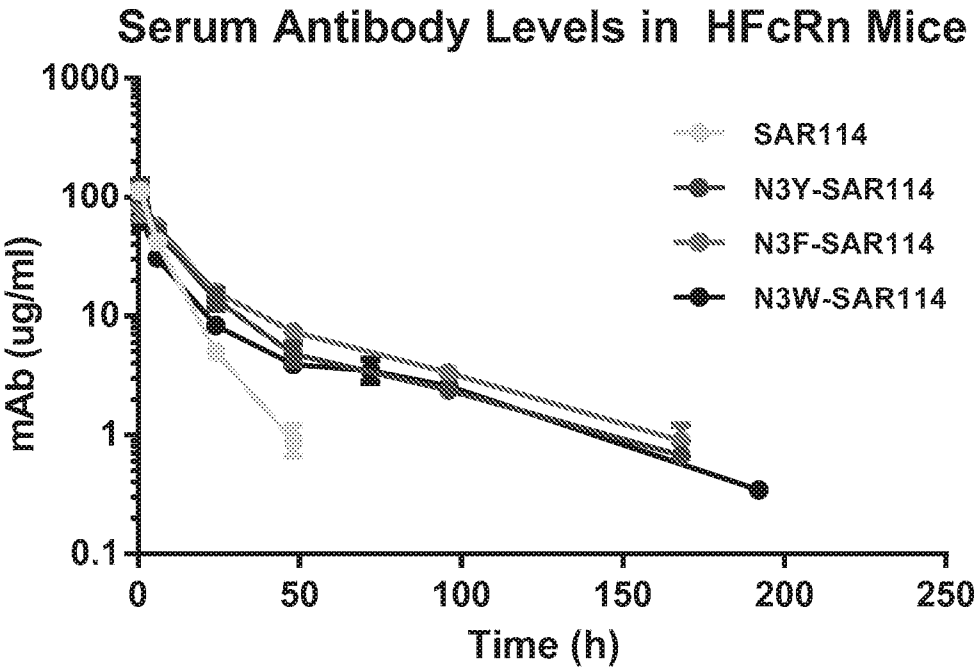
Figure 8

		Fg IH IC50 (ug/ml)	agglutination (ug/ml) SF8300	8989	8984
N3F T0	A	9.946	2.5	0.6	0.6
N3Y T0	B	6.278	2.5	0.6	0.6
N3F 1wk lux	C	19.89	2.5	0.6	0.6
N3Y 1WK lux	D	9.203	2.5	0.6	0.6
N3F 2wk lux	E	27.82	5	0.6	0.6

IC50 (ug/ml) fibrinogen assay

N3F T0	9.946	N3Y T0	6.278
1WK lux	19.89	1WK lux	9.203
2WK lux	27.82	2WK lux	12.69

Figure 9


Serum Antibody Levels in HFcRn Mice
mAb (ug/ml)
1000
100
10
1
0.1
0
50
100
150
200
250
Time (h)
SAR114
N3Y-SAR114
N3F-SAR114
N3W-SAR114

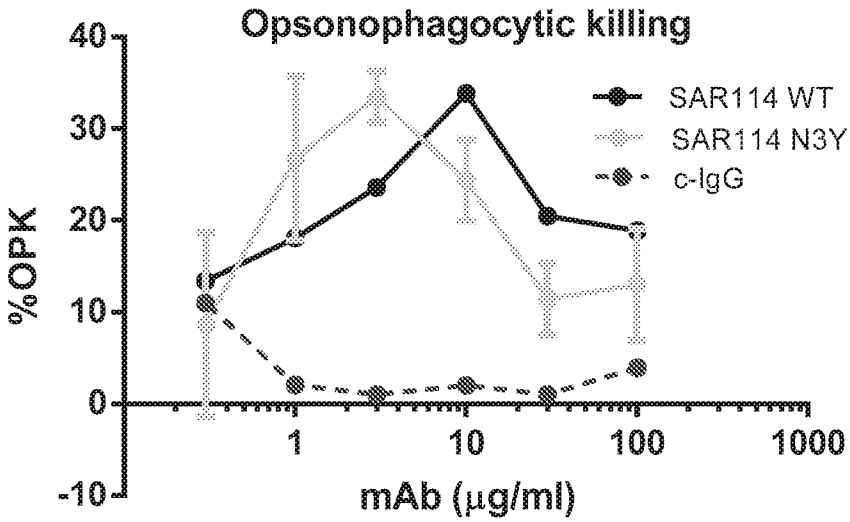

Opsonophagocytic killing
%OPK
40
30
20
10
0
-10
1
10
100
1000
mAb (µg/ml)
SAR114 WT
SAR114 N3Y
c-IgG

Figure 10

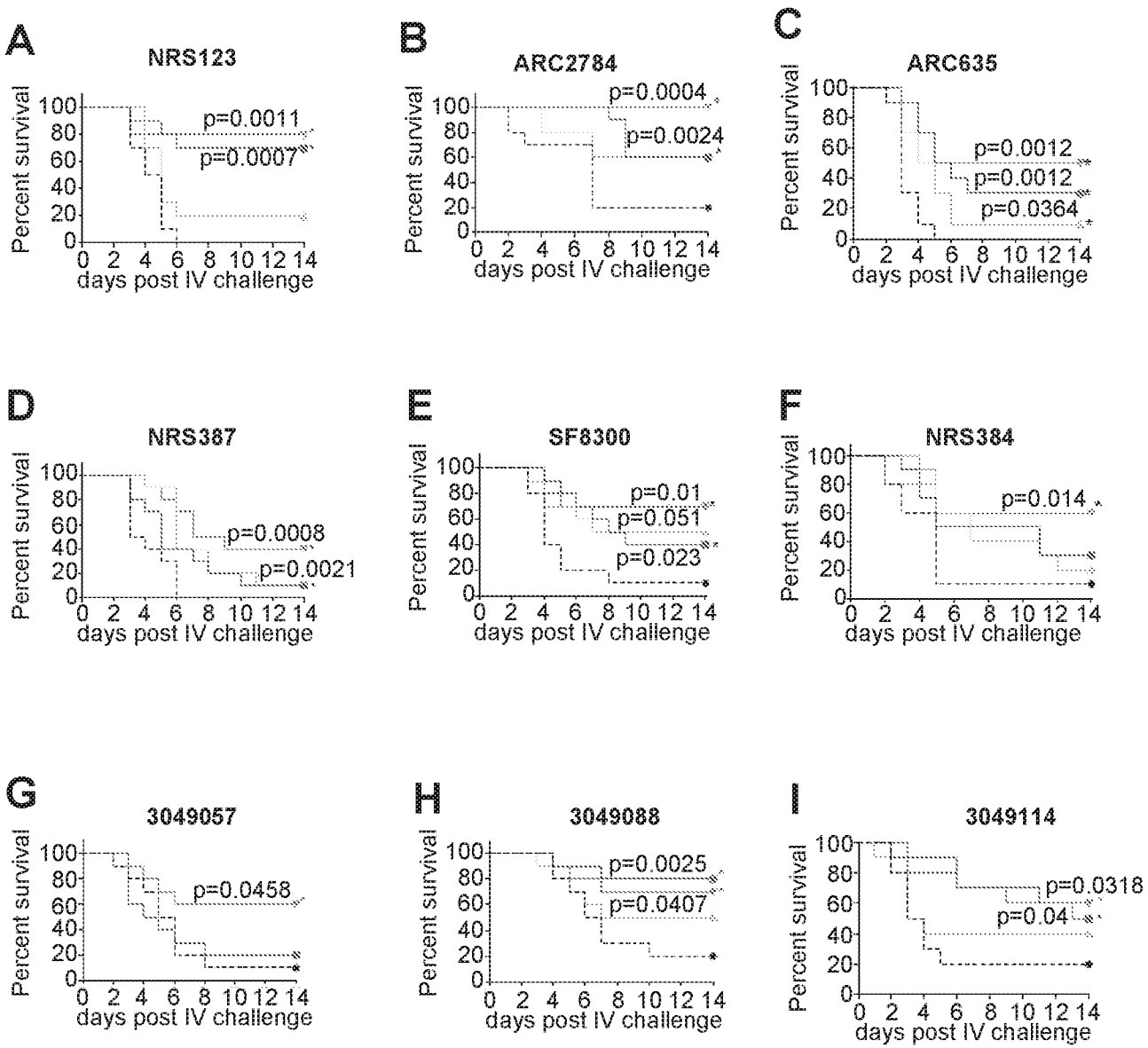

A
NRS123
Percent survival
p=0.0011
p=0.0007
days post IV challenge
B
ARC2784
p=0.0004
p=0.0024
C
ARC635
p=0.0012
p=0.0012
p=0.0364
D
NRS387
p=0.0008
p=0.0021
E
SF8300
p=0.01
p=0.051
p=0.023
F
NRS384
p=0.014
G
3049057
p=0.0458
H
3049088
p=0.0025
p=0.0407
I
3049114
p=0.0318
p=0.04

Figure 10 (cont'd)

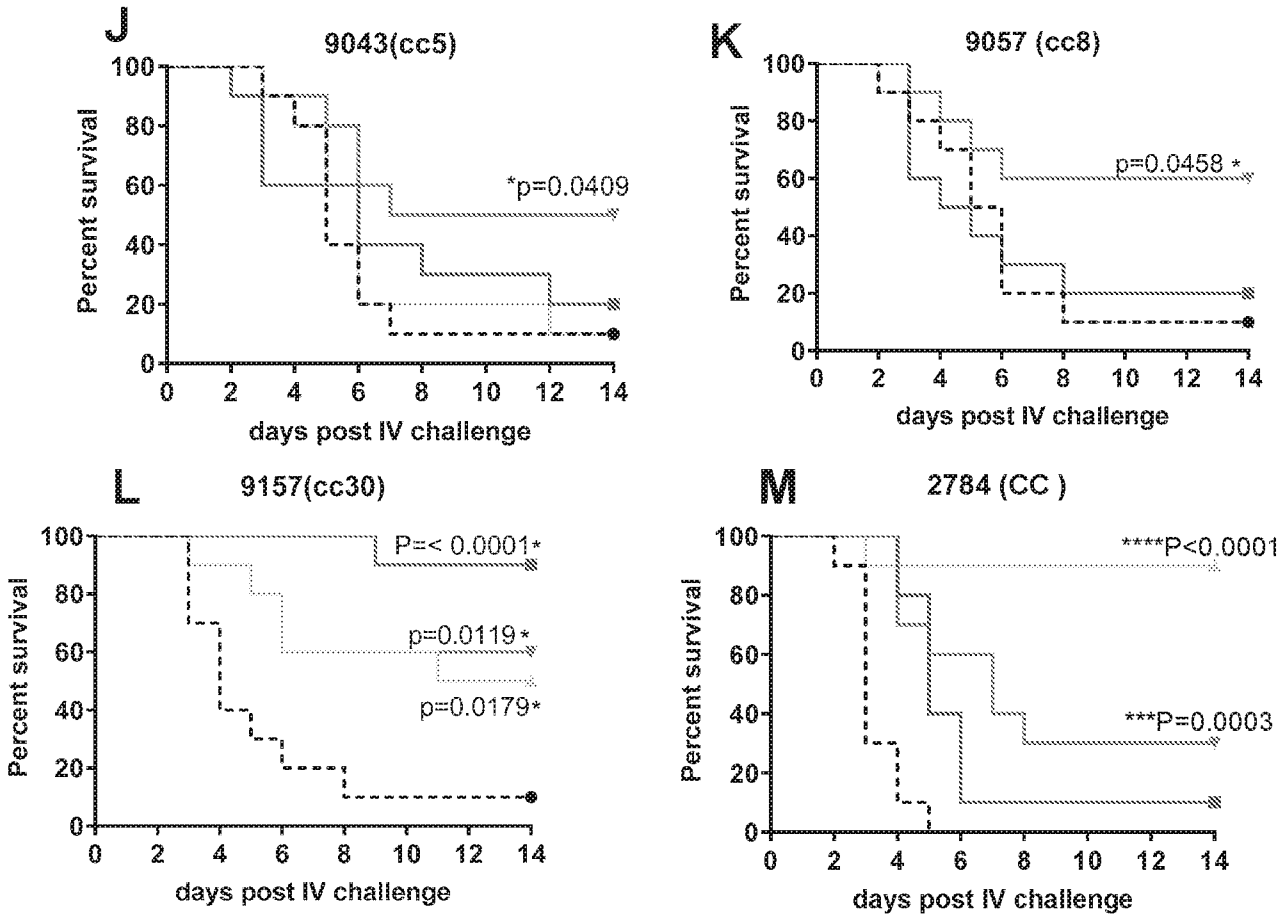


Figure 11

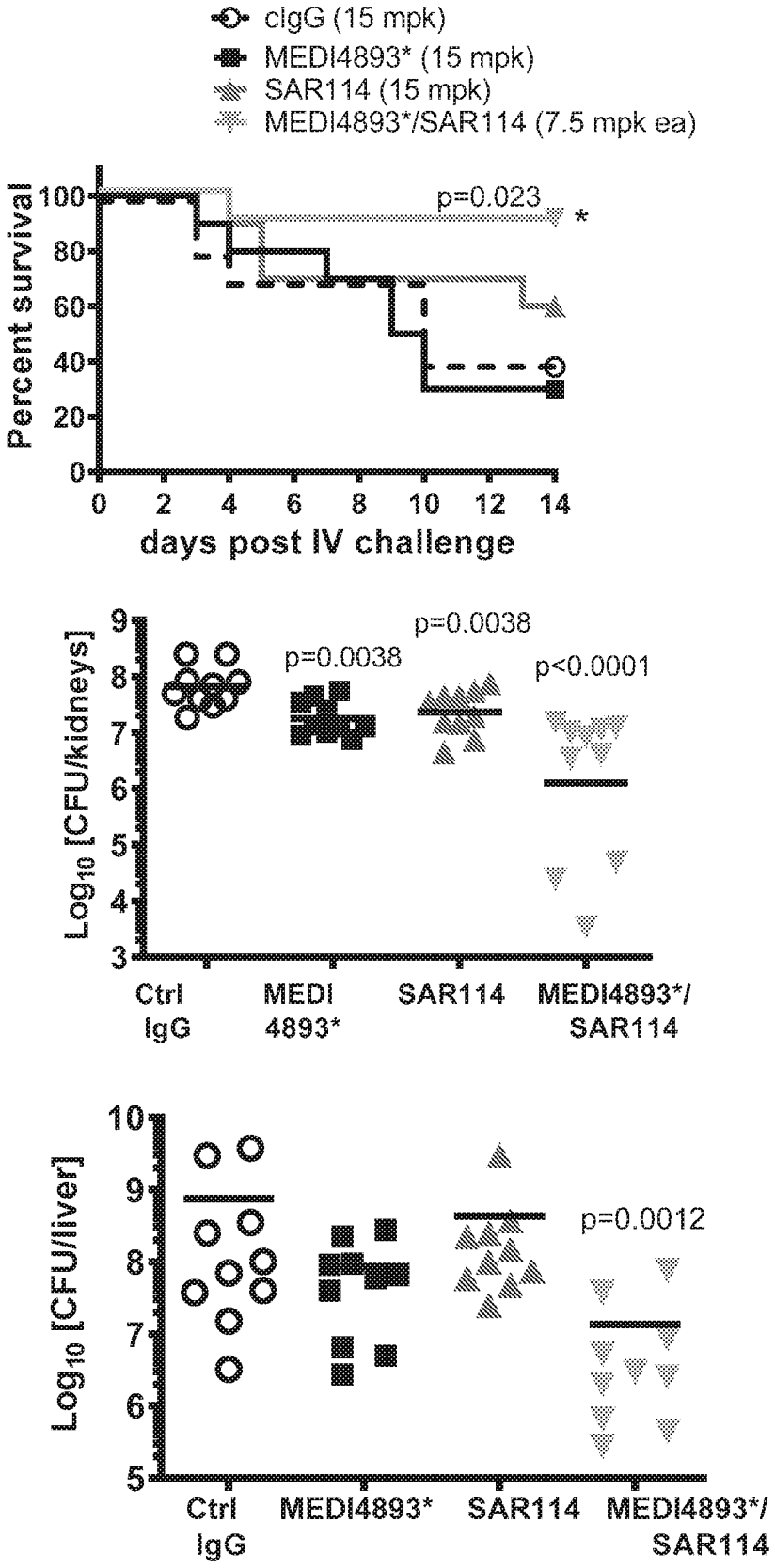

cIgG (15 mpk)
MEDI4893* (15 mpk)
SAR114 (15 mpk)
MEDI4893*/SAR114 (7.5 mpk ea)
Percent survival
100
80
60
40
20
0
p=0.023
*
0 2 4 6 8 10 12 14
days post IV challenge
Log10 [CFU/kidneys]
9
8
7
6
5
4
3
p=0.0038
p=0.0038
p<0.0001
Ctrl IgG
MEDI 4893*
SAR114
MEDI4893*/ SAR114
Log10 [CFU/liver]
10
9
8
7
6
5
p=0.0012
Ctrl IgG
MEDI4893*
SAR114
MEDI4893*/ SAR114

Figure 12

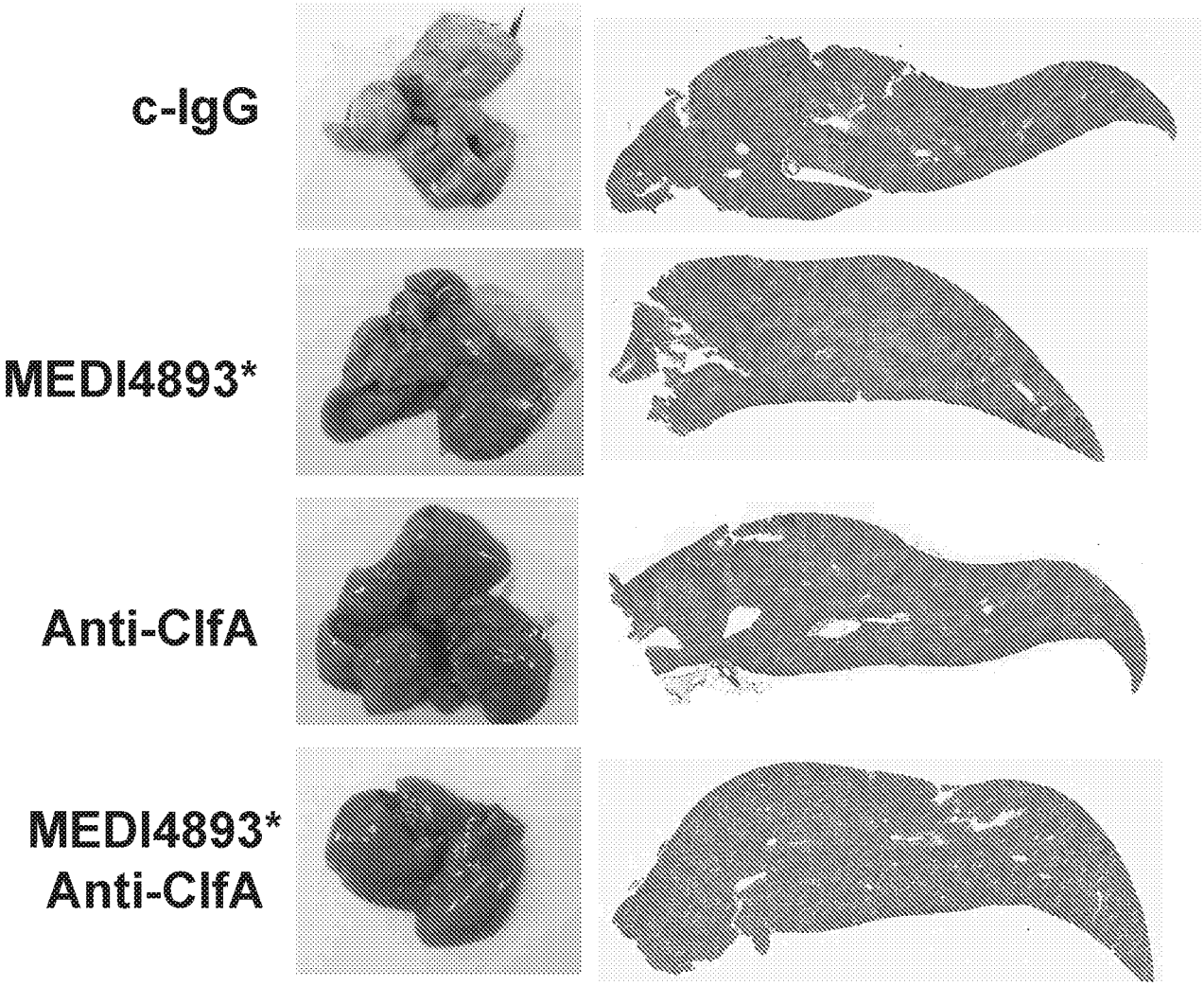


Figure 13

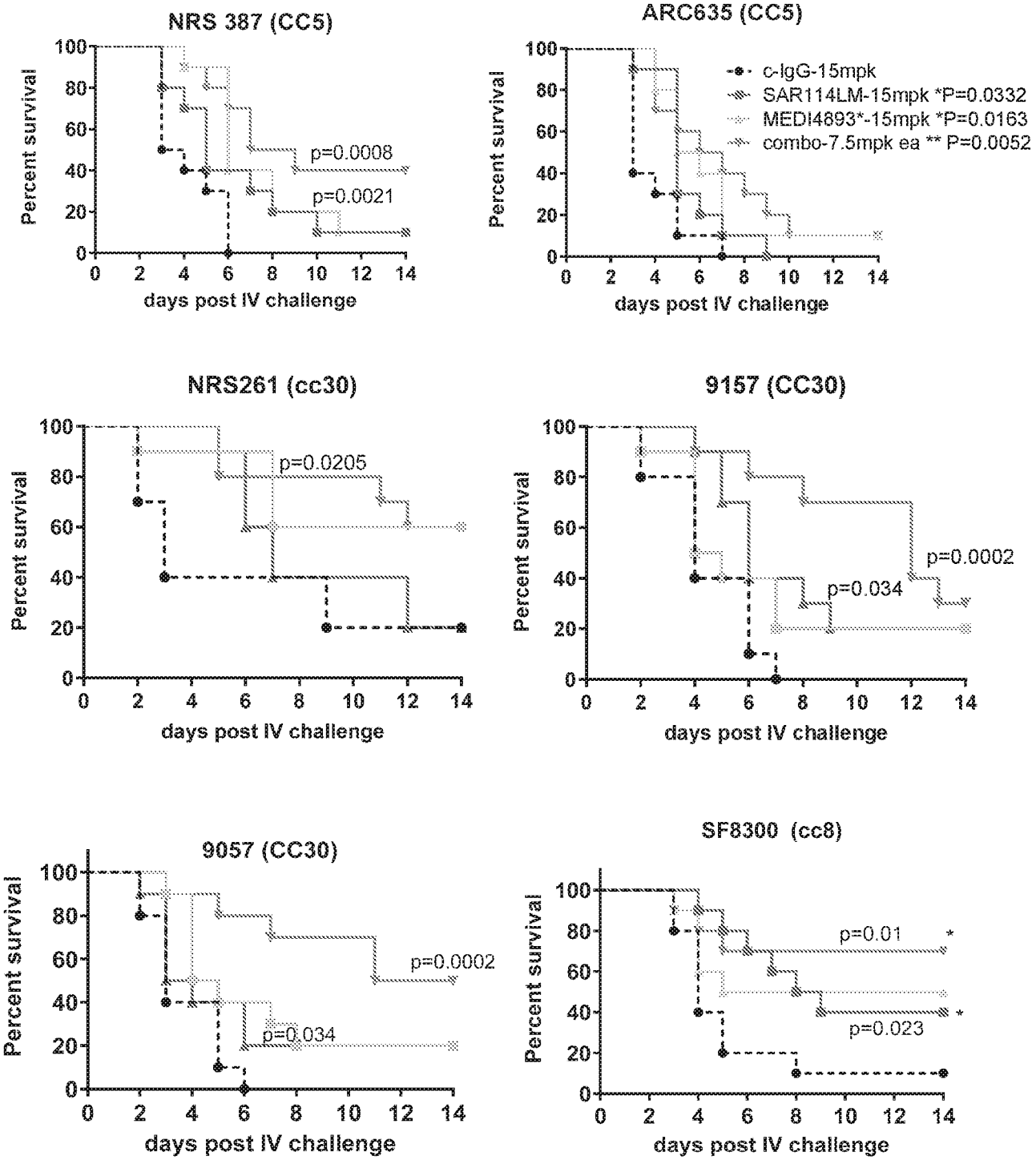

NRS 387 (CC5)
Percent survival
days post IV challenge
p=0.0008
p=0.0021
ARC635 (CC5)
c-IgG-15mpk
SAR114LM-15mpk *P=0.0332
MEDI4893*-15mpk *P=0.0163
combo-7.5mpk ea ** P=0.0052
NRS261 (cc30)
p=0.0205
9157 (CC30)
p=0.0002
p=0.034
9057 (CC30)
p=0.0002
p=0.034
SF8300 (cc8)
p=0.01
p=0.023

Figure 14

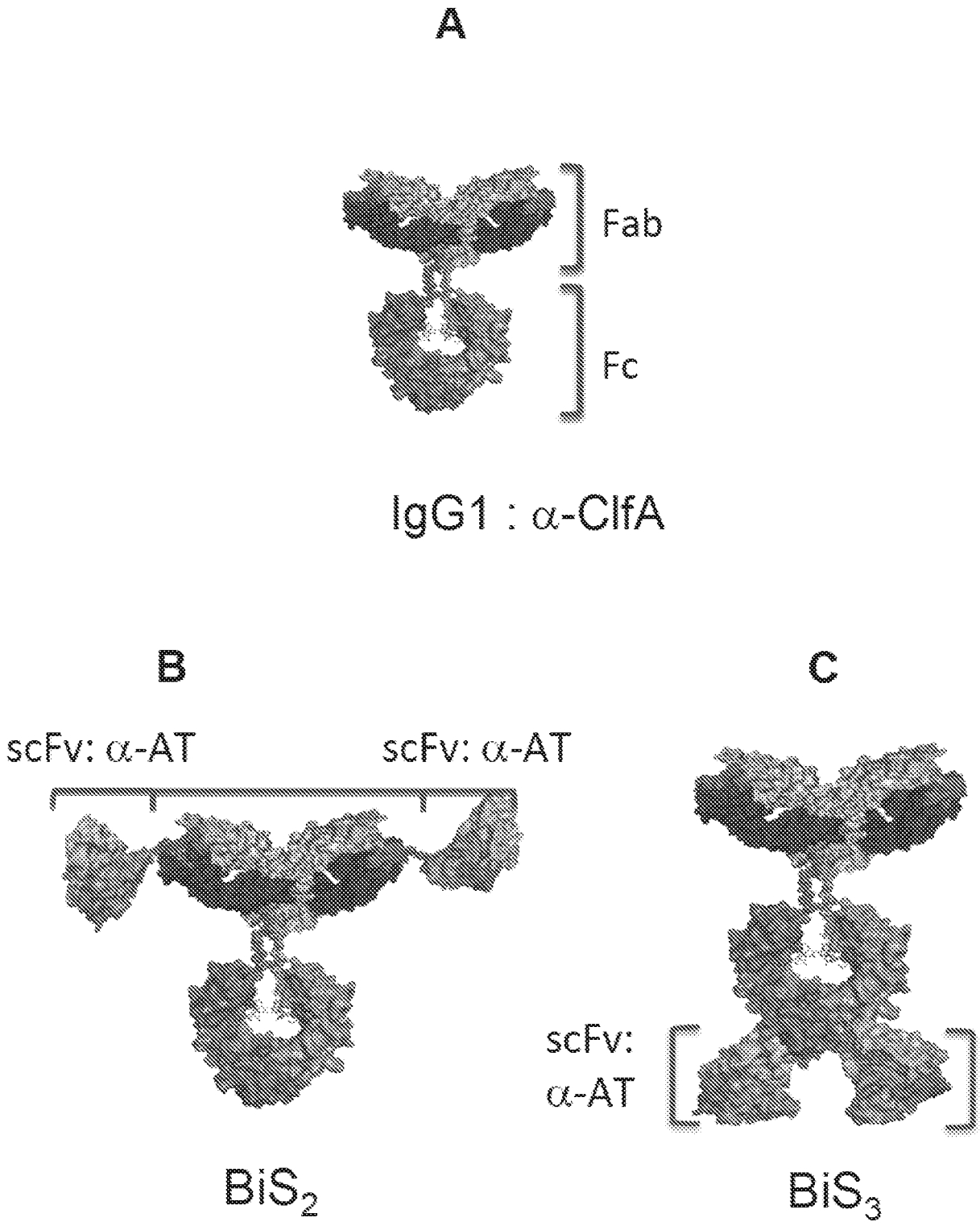


Figure 15

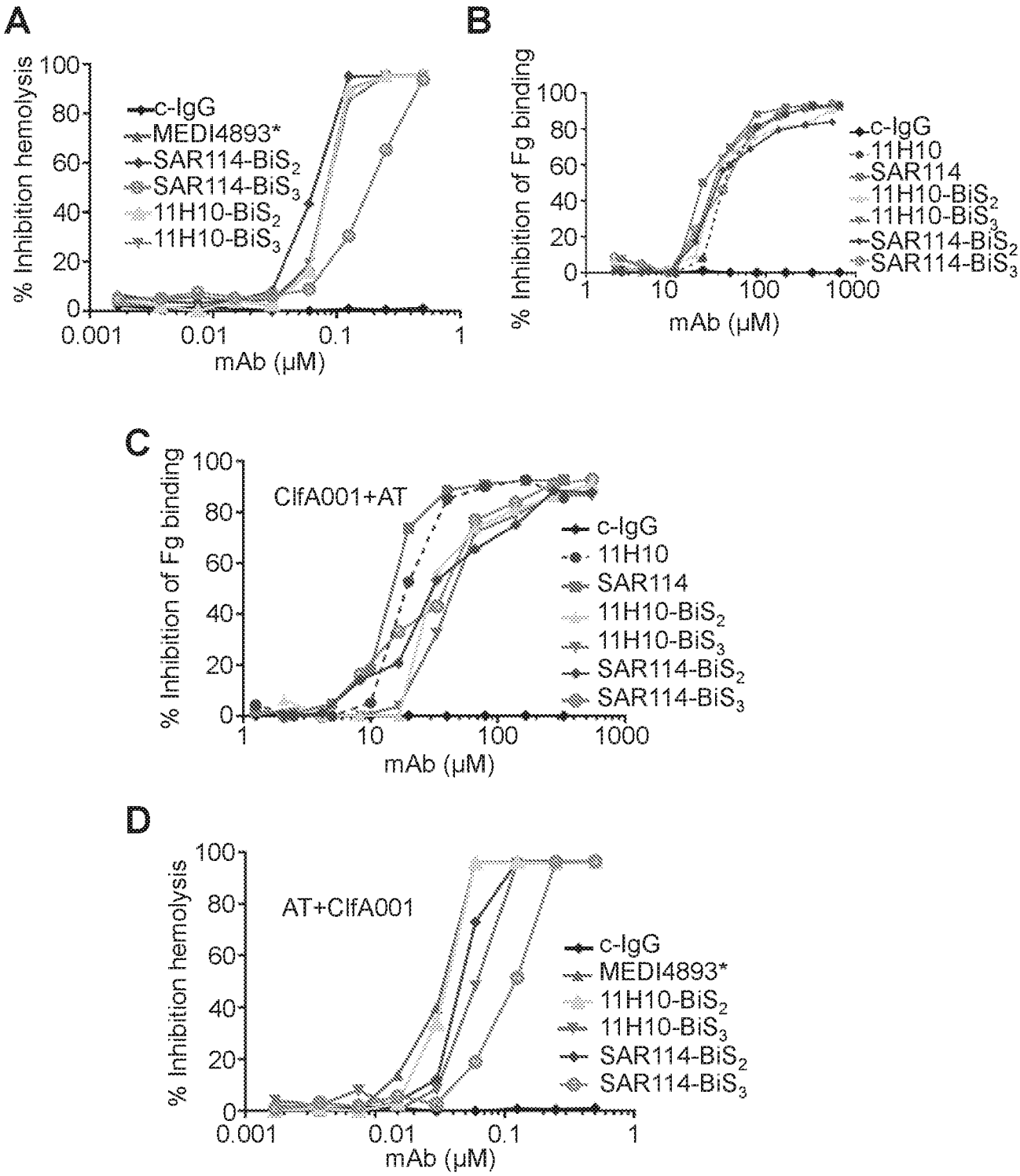

A
% Inhibition hemolysis
100
80
60
40
20
0
0.001
0.01
0.1
1
mAb (μM)
c-IgG
MEDI4893*
SAR114-BiS2
SAR114-BiS3
11H10-BiS2
11H10-BiS3
B
% Inhibition of Fg binding
100
80
60
40
20
0
1
10
100
1000
mAb (μM)
c-IgG
11H10
SAR114
11H10-BiS2
11H10-BiS3
SAR114-BiS2
SAR114-BiS3
C
% Inhibition of Fg binding
ClfA001+AT
100
80
60
40
20
0
1
10
100
1000
mAb (μM)
c-IgG
11H10
SAR114
11H10-BiS2
11H10-BiS3
SAR114-BiS2
SAR114-BiS3
D
% Inhibition hemolysis
AT+ClfA001
100
80
60
40
20
0
0.001
0.01
0.1
1
mAb (μM)
c-IgG
MEDI4893*
11H10-BiS2
11H10-BiS3
SAR114-BiS2
SAR114-BiS3

Figure 16

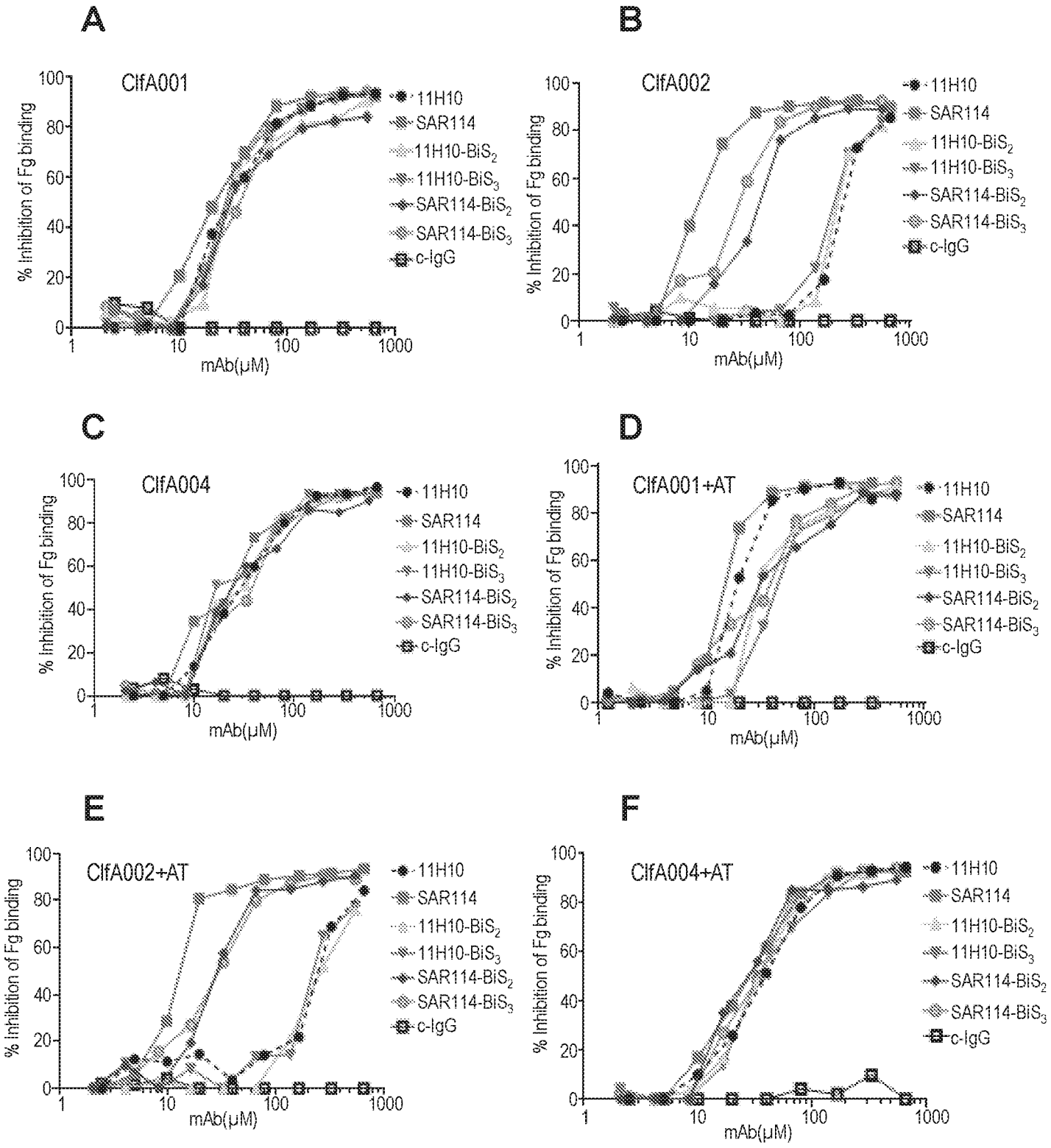

A
ClfA001
B
ClfA002
C
ClfA004
D
ClfA001+AT
E
ClfA002+AT
F
ClfA004+AT
% Inhibition of Fg binding
mAb(μM)
11H10
SAR114
11H10-BiS2
11H10-BiS3
SAR114-BiS2
SAR114-BiS3
c-IgG

Figure 17

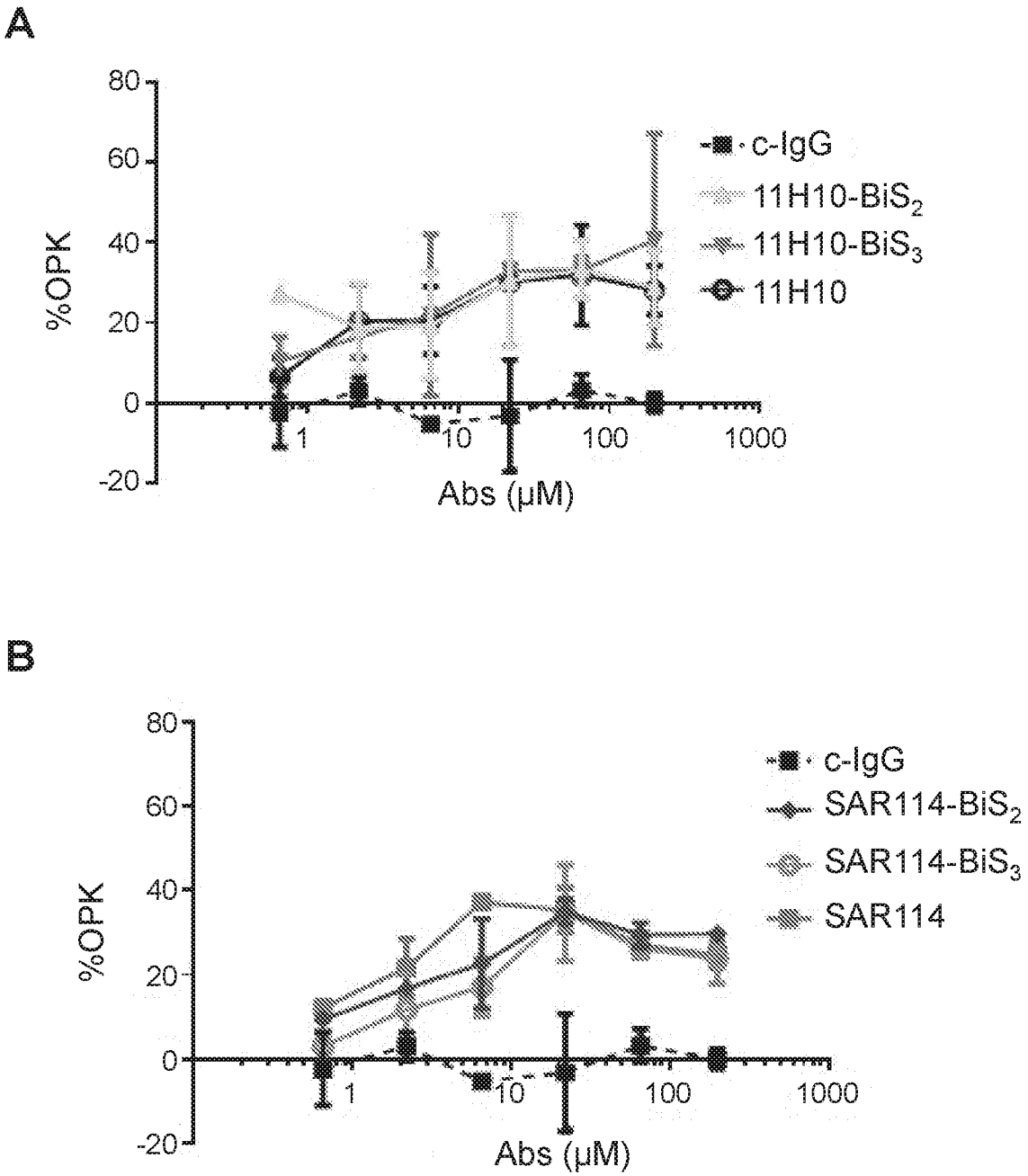

A
80
60
40
20
0
-20
%OPK
1
10
100
1000
Abs (μM)
c-IgG
11H10-BiS2
11H10-BiS3
11H10
B
80
60
40
20
0
-20
%OPK
1
10
100
1000
Abs (μM)
c-IgG
SAR114-BiS2
SAR114-BiS3
SAR114

Figure 18

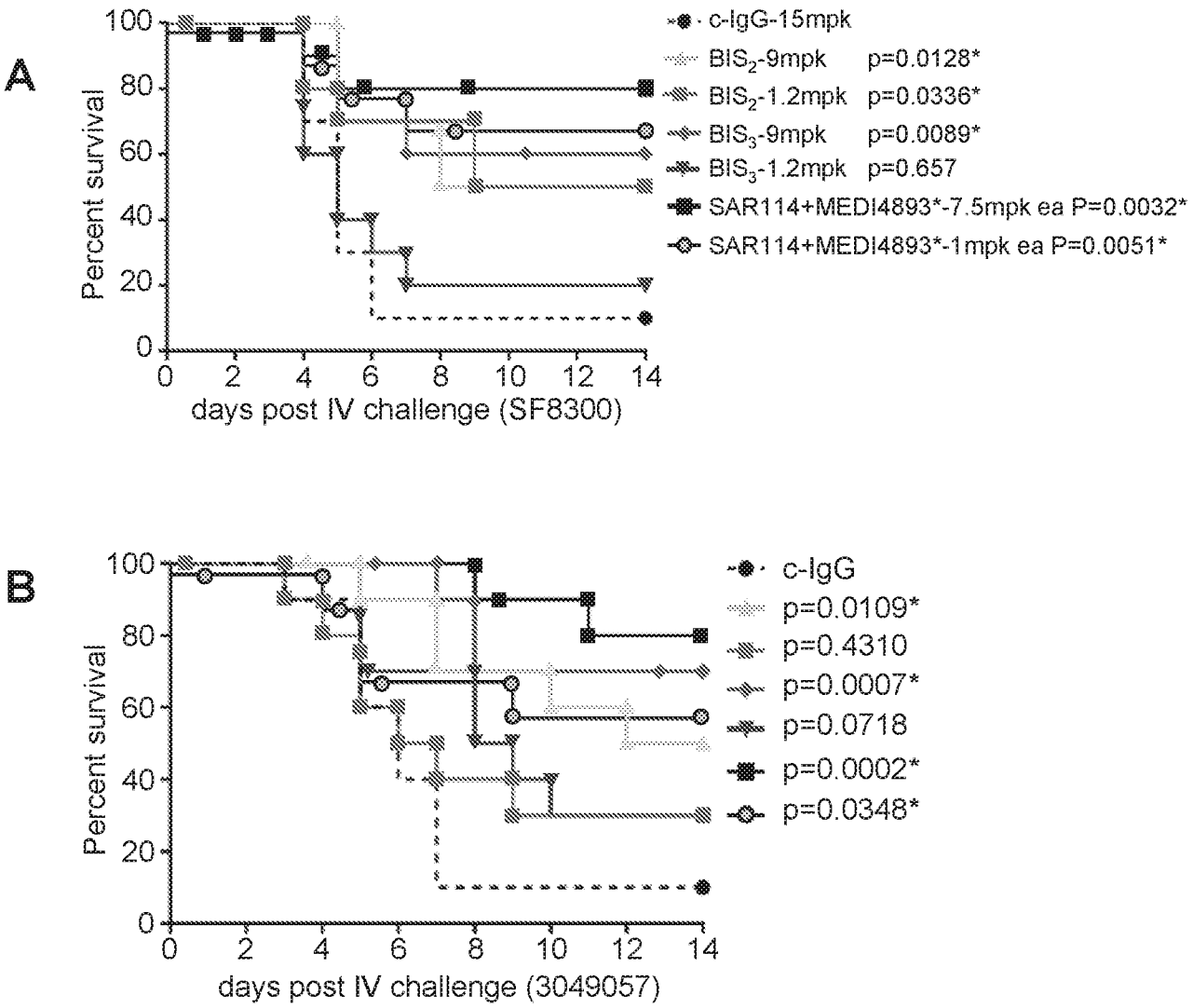
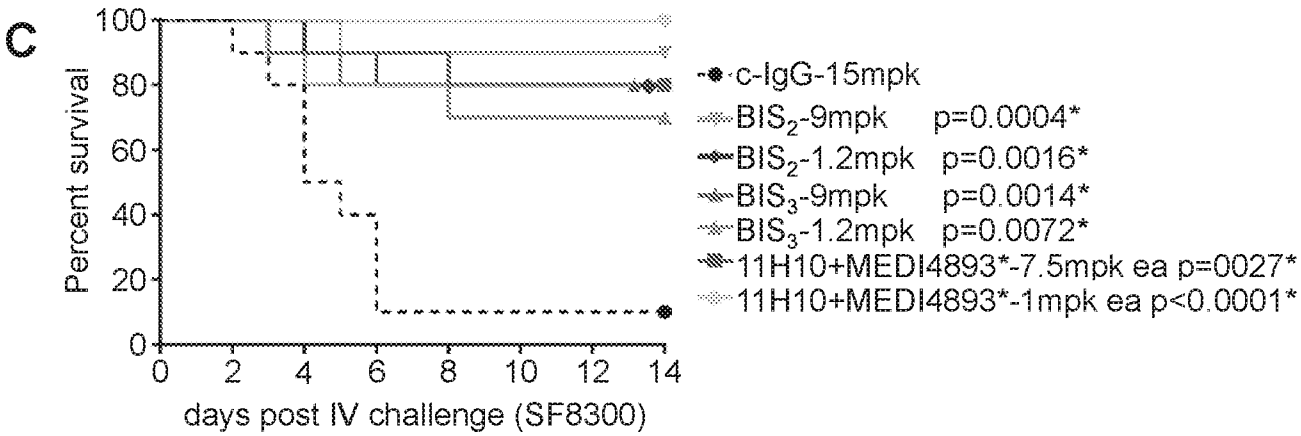

A
Percent survival
days post IV challenge (SF8300)
c-IgG-15mpk
BIS2-9mpk p=0.0128*
BIS2-1.2mpk p=0.0336*
BIS3-9mpk p=0.0089*
BIS3-1.2mpk p=0.657
SAR114+MEDI4893*-7.5mpk ea P=0.0032*
SAR114+MEDI4893*-1mpk ea P=0.0051*
B
Percent survival
days post IV challenge (3049057)
c-IgG
p=0.0109*
p=0.4310
p=0.0007*
p=0.0718
p=0.0002*
p=0.0348*

Figure 18 (cont'd)



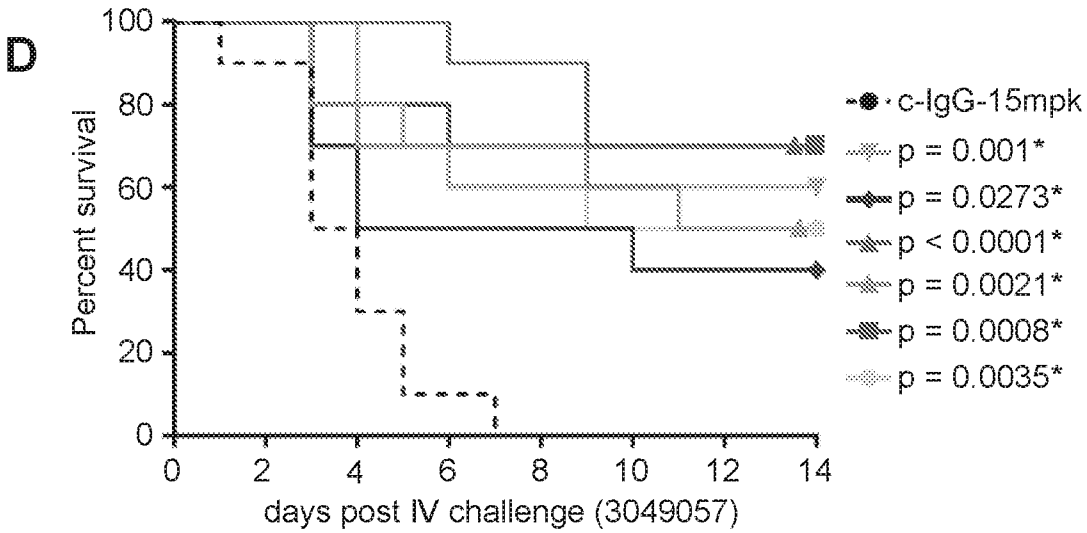


Figure 19

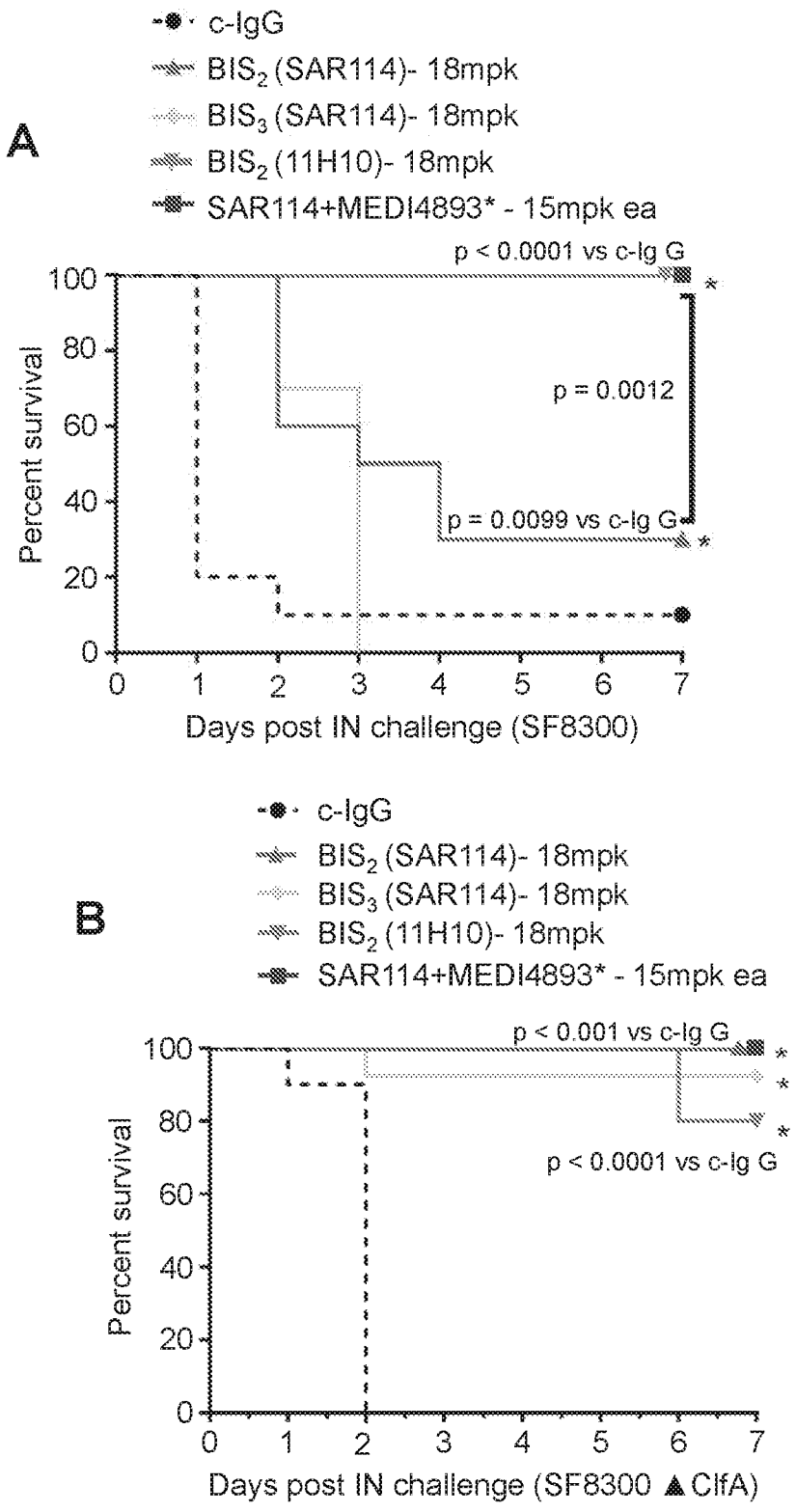

A
c-IgG
BIS2 (SAR114)- 18mpk
BIS3 (SAR114)- 18mpk
BIS2 (11H10)- 18mpk
SAR114+MEDI4893* - 15mpk ea
p < 0.0001 vs c-Ig G
p = 0.0012
p = 0.0099 vs c-Ig G
Percent survival
Days post IN challenge (SF8300)
B
c-IgG
BIS2 (SAR114)- 18mpk
BIS3 (SAR114)- 18mpk
BIS2 (11H10)- 18mpk
SAR114+MEDI4893* - 15mpk ea
p < 0.001 vs c-Ig G
p < 0.0001 vs c-Ig G
Percent survival
Days post IN challenge (SF8300 ▲ClfA)

Figure 20

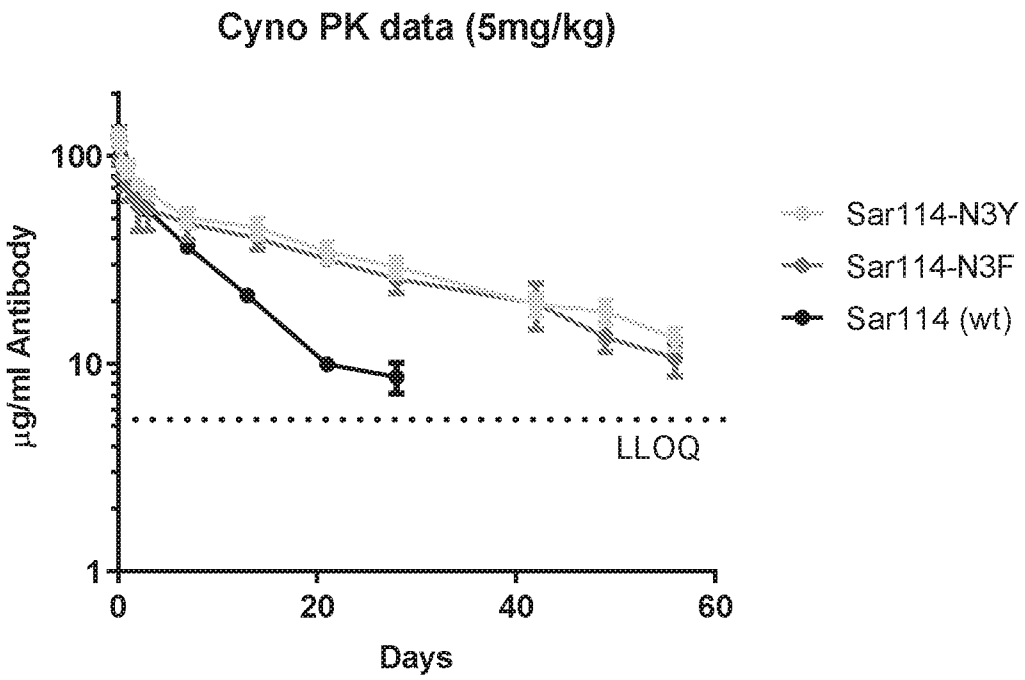


Figure 21