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(54) Title: SCREENING METHODS FOR TRANSFUSION RELATED ACUTE LUNG INJURY (TRALI)

(57) Abrégé/Abstract:
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SCREENING METHODS FOR TRANSFUSION RELATED ACUTE LUNG INJURY (TRALI)

[0001] This application claims priority to German Application No. 10 2008 045 696.9 filed September 4, 2008.

Field of Invention

[0002] The invention relates to the identification of the polypeptide sequences of HNA-3a and HNA-3b antigens which are implicated in the occurrence of transfusion related acute lung injury syndrome (TRALI). This invention provides methods and kits for screening for HNA-3a and HNA-3b specific antibodies, HNA-3a and HNA-3b polypeptides, and HNA-3a and HNA-3b nucleic acids in a sample of a biological tissue intended for transplantation or transfusion. The invention also relates to methods and kits for determining whether donor tissues intended for transplant or transfusion will induce TRALI. The invention further provides for methods and kits for determining the susceptibility of a human transplant or transfusion recipient of developing TRALI

Background

[0003] Antibodies to human neutrophil-specific antigens (HNA) were shown to cause clinical complications such as pulmonary transfusion reactions and in some cases transfusion related acute lung injury (TRALI) (Popovsky *et al. Am. Rev. Resp. Dis.* 128(1): 185-9, 1983) or causing neonatal alloimmune neutropenia (NAIN) (Bux, *et al. Transfus. Med.* 2(2): 143-9, 1992). Therefore, detection of HNA specific antibodies has important clinical applications.

[0004] TRALI is a life-threatening transfusion complication and is one of the most frequent causes of transfusion-related death in the United States. TRALI is the second most frequent transfusion-related cause of death in Europe after administration of ABO-incompatible stored blood (Holness *et al. Transfus Med Rev.* 18: 184 – 188, 2004). The risk of developing TRALI as a complication of blood transfusion is at least 2000-times higher than contracting an HIV- or hepatitis C infection.

[0005] TRALI is defined as a clinical entity consisting of sudden acute shortness of breath within six hours after blood transfusion, connected with bilateral

lung infiltrations (lung edema) with no indication of cardiac insufficiency or volume overload (European Haemovigilance Network (EHN). Definitions of Adverse Transfusion Events. www.ehn-org.net).

[0006] TRALI syndrome is difficult to diagnose, because initially it often does not differ from a transfusion-independent lung insufficiency (ALI) or its maximum variant ARDS ("acquired respiratory distress syndrome") (Popovsky& Moore, *Transfusion* 25: 573-577, 1985). Symptoms of TRALI include hypoxemia, tachycardia, hypotension, cyanosis and fever. Often, TRALI is not recognized or misdiagnosed in the clinic because the symptoms are often attributed to other causes, such as fluid overload. TRALI has been associated with the transfusions of all plasma containing blood components, including whole blood, red blood concentrates, fresh frozen plasma, whole blood derived from platelets, pooled platelets, intravenous gamma-globulin, cryoprecipitate, stem cells and granulocytes. TRALI is an injury to the pulmonary microvascular; and therefore, treatment focuses on respiratory support and saline infusion.

[0007] TRALI is an immune-related disorder that is primarily associated with antibodies specific for HNA, granulocyte- and human leukocyte antigens (HLA) Class I. Other factors that have induced TRALI in transfusion recipients include biologically active lipids and HLA Class II antibodies. In most cases, antibodies of the donor (in the donor plasma) are transferred with the stored blood and then react with the leucocytes (granulocytes) of the recipient. The binding of the antibodies to the granulocytes leads to their activation and partially to aggregation. Through the subsequent release of the microbicidal arsenal from the granulocytes, the capillary endothelium is damaged which results in lung edema. The immune reaction induces complement-activated granulocytes to release oxygen radicals and proteases that damage the endothelium resulting in the extravasation of protein-rich fluid into the pulmonary alveoli and interstitium. In addition, antibodies within stored blood will bind to and activate granulocytes of the recipient resulting in the expression of adhesion molecules (Uchiyama *et al. Transfu.s Med. Rev.* 8: 84-95, 1994), transmigration of granulocytes into the interstitial space between alveolar and vessel endothelium of the lung, and the release of cytokines, proteases and oxygen radicals (Snyder,. Immol Invest. 24: 333-9, 1994). These cellular effects cause damage to the

capillary walls with subsequent hyperpermeability. A lung edema develops and 10% of the affected patients die from this complication.

[0008] In TRALI, recipient antibodies rarely react with the granulocytes of the donor (Bux *et al.*, *Br. J. Heamatol.* 93: 707-713, 1996). However, there have also been cases of TRALI that were induced by antibodies in the transfusion recipient. In very rare cases, anti-IgA-antibodies can also induce TRALI (Saigo *et al.*, J. *Int. Med. Res.* 27: 96-100, 1999).

[0009] Blood donations of multiparous women carry particular risk, because an antibody formation against granulocyte- or HLA-antigen of the child can occur during the pregnancies. Likewise, a patient may be immunizing due to an earlier transfusion (Voss et al., *Anaesthesist* 50: 930-932, 2001). Donor plasma that will trigger TRALI cannot be detected clinically. Currently produced erythrocyte concentrates contain very little plasma and only a few granulocytes, therefore TRALI is most likely to occur after administration of fresh plasma and platelet concentrates.

[0010] In addition to HLA antibodies, antibodies against three different antigen systems on granulocytes are thought to be responsible for inducing TRALI (Leger *et al. Anesthesiology* 91: 1529-1532, 1999; Davoren *et al, Transfusion* 43: 641-645, 2003; Kopko *et al. JAMA* 287: 1968-1971, 2000; Reil *et al. Vox Sanguinis* (printing, already accessible online), 2008. Two of the antigen systems (HNA-1 and HNA-2) are known with regard to their structure and localization. The antigen HNA-2 was characterized by Prof. Dr. Bux and applied for as a patent (DE 100 28 725 A1). The third antigen system, HNA-3 (consisting of the antithetic antigens HNA-3a and HNA-3b), has not been characterized. The antigen HNA-3a occurs in approximately 95% of the population (Davoren *et al, Transfusion* 43: 641-645, 2003) and is involved particularly frequently in severe courses of TRALI (Reil *et al., Vox Sanguinis* (printing, already accessible online), 2008).

[0011] According to the current report by SHOT (Serious Hazards of Transfusion), the British notification and evaluation centre for side-effects in blood transfusions, TRALI is the most frequent cause of a serious side-effect due to transfusion. The report shows a mortality of 9% for the period 1996 – 2003 (Additional cumulative data 1996-2003, SHOT, UK.). Since 2001, United States Food and Drug Administration likewise reported TRALI as the main cause of

transfusion-associated complications (Goldman *et al., Transfus. Med. Rev.* 19: 2-31, 2005; Boshkov, *Vox Sang.* 83: 299-303, 2002).

[0012] Currently, most blood and tissue donors have not been HNA typed. The specialized nature of neutrophil immunobiology, the scarcity of HNA typing sera and the need to test fresh neutrophils places restraints on typing HNA compatible blood components. A high percentage of cases of TRALI are caused by blood donated by females, particularly multiparous females, and from the transfusion of fresh frozen plasma. Proposed current solutions for reducing the incidence of TRALI include the exclusion of all females as donors, to exclude multiparous (three or more pregnancies) females as donors, and reducing the transfusion of fresh, frozen plasma

[0013] Currently, the detection of granulocyte-specific antibodies is laborious; and detection of HLA antibodies in the serum of the blood donor is not sufficient. The most reliable determination of a TRALI risk currently consists in a cross-matching between donor serum and patient leucocytes. This test can only be carried out in specialized laboratories (Voss, *Anaesthesist* 50: 930-932, 2001) which are not suitable for donor screening. Other strategies are currently directed to a more restrictive donor management (Mair et al., *Crit. Care Med.* 34: 137-143, 2006) (as described above). This is not acceptable because the exclusion of women from blood donation after a pregnancy leads to a serious reduction in the amount of stored blood.

[0014] The exclusion of female donors was investigated systematically in Canada. Through the exclusion of multiparous female donors, 12% of all blood donations would be omitted from the Canadian Blood Service (Goldman *et al Transfus. Med. Rev.* 19: 2-31, 2005). According to some studies, implementing such a strategy would exclude every third potential female donor. (Densmore *et al., Transfusion* 39: 103-106, 1999). An alternative strategy would be the testing of all stored blood for granulocyte-specific antibodies. Currently, this technically cannot be carried out. Other strategies for processing the blood components are proposed, but these strategies would involve new risks such as bacterial contaminations and due to their time requirement are only suitable for planned transfusions, and not for those in emergencies (Mair et al., *Crit Care Med.* 34: 137-143, 2006). Furthermore, evidence is lacking as to whether such strategies can actually reduce the incidence of TRALI.

[0015] Human neutrophil antigens are also known as neutrophil-specific antigens or HNA. Currently there are 5 HNA antigen systems: HNA-1, HNA-2, HNA-3, HNA-4 and HNA-5. Alleles for HNA-1, 2, 4 and 5 were identified and the corresponding glycoproteins were characterized; however, the allele for HNA-3 remains unknown (reviewed by Stroncek, *ASHI Quarterly* 2004). There are three HNA-1 antigens (HNA-1a, HNA-1b and HNA-1c) that are expressed solely on neutrophils and are located on low affinity Fc-γ receptor IIIb. The HNA-2 system has one well established antigen (HNA-2a). HNA-2 is only expressed on neutrophils and neutrophil precursors and is located on the glycoprotein CD177 (NB1 gp). HNA-4 and HNA-5 are located on the β2 integrin. HNA-4 is expressed on granulocytes, monocytes and lymphocytes. (See Stroncek, *ASHI Quarterly* 2004)

[0016] The HNA-3 system has one known antigen, HNA-3a, which is also known as 5b. HNA-3 is expressed on neutrophils, lymphocytes, platelets, endothelial cells, kidney, spleen and placenta cells, and is known to be located on a 70 to 95 kDa neutrophil glycoprotein. (See Stroncek, *ASHI Quarterly* 2004). The gene for HNA-3a has not been cloned and the nature and function of glycoprotein was previously unknown. Therefore, current detection of HNA-3 antibody is only based on non-specific assays, such as agglutination tests (Lalezari & Bernard, *Transfusion* 5: 135-42, 1965) or GIFT-FC assay (Davoren *et al.*, *Transfusion* 43(5): 641-5, 2003).

[0017] The presumed allele of HNA-3, also known as 5b, has a gene frequency about 0.82 (Van Leeuwen *et al. Vox Sang* 9: 431-46, 1964). It was also reported to have a 0.66 gene frequency (Lalezari & Bernard, Transfusion 5: 135-42, 1965). The protein of 5b was reported to have a molecular weight of 70 to 95 kD (De Haas *et al*, Transfusion 40(2): 222-7, 2000), yet the 5b gene has not been cloned and the nature and function of the protein remain unknown.

[0018] Of interest to the present invention is CTL2 is a 706 amino acid membrane-spanning protein (about 80.152 kD) that comprises 10 helical transmembrane domains. This protein is also known as which is also known as SLC44A2, DKFZp666A071 2, FLJ44586 2 and PP1292 and is known to be involved in choline transport within the inner ear and is expressed on inner ear supporting cells. The gene encoding CTL2 is located on chromosome 19p13. In addition, the antigen, Inner Ear Supporting Cell Antigen (IESCA) is known to be a CTL2 protein which is

reactive with an autoantibody associated with autoimmune sensorineural hearing loss (AISNHL).

[0019] Currently, the methods of screening and typing transplant tissue or transfusions for HNA antibodies that induce TRALI are inadequate and problematic. In addition, excluding a large portion of the human population from donating blood and tissue is an extreme solution. Therefore, a strong need exists for the development of methods of screening for HNA antigens.

[0020] It was therefore an object of the present invention to clarify the protein- or DNA sequences of the human neutrophil antigen-3a or -3b (HNA-3a, HNA-3b) involved in TRALI and to provide the corresponding sequences.

Summary of Invention

[0021] The present invention relates to the discovery that HNA-3a is within the amino acids sequence of SEQ ID NO: 1 and HNA-3b is within the amino acid sequence of SEQ ID NO: 3b, and these amino acid sequence are highly similar to that of choline transporter-like protein 2 (CTL2).

[0022] A single nucleotide polymorphism (SNP) within codon 154 on an extracellular loop is crucial (SNP rs2288904), as this SNP is the difference between HNA-3a and HNA-3b. The polynucleotide encoding HNA-3a has a "G" (guanine) at position 461 and as a result encodes an "R" (Arginine, Arg) at position 154 of the HNA-3a amino acid sequence, and therefore represents the HNA-3a allele. The polynucleotide encoding HNA-3b has an "A" (adenine) at position 461 and as a result encodes a "Q" (glutamine, Gln) at position 154 of the amino acid sequence, and therefore represents the HNA-3b allele.

[0023] It is proposed that the existence of the SNP within codon 154 of the HNA-3 gene results in a portion of the population which may generate alloantibodies to HNA-3a or HNA-3b if exposed to the opposing HNA-3 antigen. This difference allows for portions of the population to have one of two anti-HNA-3 specific antibodies and when exposed to blood or tissue containing a foreign HNA-3 antigen will induce transfusion related acute lung injury (TRALI) in the recipient.

[0024] The invention provides for methods of detecting an HNA-3a specific antibody in a biological sample comprising a) obtaining a biological sample, b) contacting the biological sample with a cell transformed or transfected to express the

HNA-3a polypeptide of SEQ ID NO: 1 or a fragment thereof to form a complex with HNA-3a in the sample, and c) detecting the complex, wherein the presence of the complex indicates that the biological sample contains HNA-3a specific antibodies.

[0025] The preceding methods may be carried out with an antigenic fragment comprising an amino acid sequence selected from the group consisting of SEQ ID NO: 13, SEQ ID NO: 14, SEQ ID NO: 15, SEQ ID NO: 16, SEQ ID NO: 17, SEQ ID NO: 18, SEQ ID NO: 25, SEQ ID NO: 27, SEQ ID NO: 34, SEQ ID NO: 35, SEQ ID NO: 36, SEQ ID NO: 37, SEQ ID NO: 38, SEQ ID NO: 39, SEQ ID NO: 40, SEQ ID NO: 41 and SEQ ID NO: 42.

[0026] The invention also provides for methods of detecting an HNA-3b specific antibody in a biological sample comprising a) obtaining a biological sample, b) contacting the biological sample with a cell transformed or transfected to express the HNA-3b polypeptide of SEQ ID NO: 2 or a fragment thereof to form a complex with HNA-3b in the sample, and detecting the complex, wherein the presence of the complex indicates that the biological sample contains HNA-3b specific antibodies.

[0027] The preceding methods may be carried out with an antigenic fragment comprising an amino acid sequence selected from the group consisting of SEQ ID NO: 19, SEQ ID NO: 20, SEQ ID NO: 21, SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24 and SEQ ID NO: 26.

[0028] The invention contemplates using any cell type including those which do not endogenously express HNA-3a or HNA-3b such as B-cells, CHO cells or insect cells, so that the cell expresses a heterologous HNA-3a or HNA-3 polypeptide. The term "heterologous" refers to cytologic elements, e.g. DNA or protein that are derived from a different species or different cell type.

[0029] The invention also contemplates using a cell that expresses low levels of HNA-3a or HNA-3b and increasing expression of the endogenous protein by inserting heterologous promoters or enhancers, or increasing copy number of the HNA-3a or HNA-3b gene. Exemplary cells that may be used include EB-3 cells and K-562 cells.

[0030] The invention also provides for methods of detecting an HNA-3a specific antibody in a biological sample comprising a) obtaining a biological sample, b) contacting the biological sample with an aptamer that mimics an antigenic

fragment of the HNA-3a polypeptide of SEQ ID NO: 1 to form a complex with the HNA-3a specific antibodies in the sample, and c) detecting the complex, wherein the presence of the complex indicates that the biological sample contains HNA-3a specific antibodies. These methods may be carried out with aptamers that mimic an antigenic fragment comprising an amino acid sequence selected from the group consisting of SEQ ID NO: 13, SEQ ID NO: 14, SEQ ID NO: 15, SEQ ID NO: 16, SEQ ID NO: 17, SEQ ID NO: 18, SEQ ID NO: 25, SEQ ID NO: 27, SEQ ID NO: 34, SEQ ID NO: 35, SEQ ID NO: 36, SEQ ID NO: 37, SEQ ID NO: 38, SEQ ID NO: 39, SEQ ID NO: 40, SEQ ID NO: 41 and SEQ ID NO: 42.

[0031] The invention also provides for methods of detecting an HNA-3a specific antibody in a biological sample comprising a) obtaining a biological sample, b) contacting the biological sample with an aptamer that mimics an antigenic fragment of the HNA-3b polypeptide of SEQ ID NO: 2 to form a complex with the HNA-3b specific antibodies in the sample, and c) detecting the complex, wherein the presence of the complex indicates that the biological sample contains HNA-3b specific antibodies. These methods may be carried out with aptamers that mimic an antigenic fragment comprises an amino acid sequence selected from the group consisting of SEQ ID NO: 19, SEQ ID NO: 20, SEQ ID NO: 21, SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24 and SEQ ID NO: 26.

[0032] The invention provides for methods of screening for HNA-3a and/or HNA-3b specific antibodies in donor tissue intended for transplants or transfusion in order to determine whether the donor tissue, as a result of the presence of the HNA-3a or HNA-3b specific antibodies, will induce TRALI or graph versus host disease (GVHD) in a human recipient that expresses the HNA-3a or HNA-3b.

[0033] In one embodiment, the invention provides for methods of determining whether a donor tissue intended for transplant or transfusion will induce TRALI or GVHD in a human recipient wherein the human recipient expresses the HNA-3a antigen comprising a) obtaining a sample of the tissue intended for transplant or transfusion in the human subject, b) contacting the sample with a polypeptide comprising the amino acid sequence of SEQ ID NO: 1 or an antigenic fragment thereof to form a complex with HNA-3a specific antibodies in the sample, and c) detecting the complex, wherein the presence of the complex indicates that the donor tissue is likely to induce TRALI or GVDH in a human recipient that expresses the

HNA-3a antigen. These methods may be carried out the with an antigenic fragment of the HNA-3a amino acid sequence (SEQ ID NO: 1) selected from the group consisting of SEQ ID NO: 13, SEQ ID NO: 14, SEQ ID NO: 15, SEQ ID NO: 16, SEQ ID NO: 17, SEQ ID NO: 18, SEQ ID NO: 25, SEQ ID NO: 27, SEQ ID NO: 34, SEQ ID NO: 35, SEQ ID NO: 36, SEQ ID NO: 37, SEQ ID NO: 38, SEQ ID NO: 39, SEQ ID NO: 40, SEQ ID NO: 41 and SEQ ID NO: 42.

[0034] In another embodiment, the invention provides for methods of determining whether a donor tissue intended for transplant or transfusion will induce TRALI or GVHD in a human recipient wherein the human recipient expresses the HNA-3b antigen comprising a) obtaining a sample of the tissue intended for transplant or transfusion in the human subject, b) contacting the sample with a polypeptide comprising the amino acid sequence of SEQ ID NO: 2 or an antigenic fragment thereof to form a complex with HNA-3b specific antibodies in the sample, and c) detecting the complex, wherein the presence of the complex indicates that the donor tissue is likely to induce TRALI or GVHD in a human recipient that expresses the HNA-3b antigen. These methods may be carried out with antigenic fragments of the HNA-3b amino acid sequence (SEQ ID NO: 2) selected from the group consisting of SEQ ID NO: 19, SEQ ID NO: 20, SEQ ID NO: 21, SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24 and SEQ ID NO: 26.

[0035] In a further embodiment, the methods of determining whether a donor tissue intended for transplant or transfusion will induce TRALI or GVHD in a human recipient wherein the human recipient expresses the HNA-3a or HNA-3b antigen, wherein in addition to detecting HNA-3a or HNA-3b specific antibodies, the methods further comprise one or more of the following steps: contacting the sample with Fc-γ receptor IIIb polypeptide or an antigenic fragment thereof to form a complex with HNA-1 specific antibodies in the sample, contacting the sample with CD177 polypeptide or an antigenic fragment thereof to form a complex with HNA-2 specific antibodies in the sample, contacting the sample with CD11b polypeptide or an antigenic fragment thereof to form a complex with HNA-4 specific antibodies in the sample, contacting the sample with CD11a polypeptide or an antigenic fragment thereof to form a complex with HNA-5 specific antibodies in the sample, or contacting the sample with an HLA antigen to form a complex with HLA specific antibodies in the sample, and detecting the complex, wherein the presence of any of

the complexes indicates that the sample is likely to induce TRALI or GVHD in a human recipient.

[0036] The invention also provides for methods of screening a transplant or transfusion recipient for HNA-3a and/or HNA-3b specific antibodies. This screening is of interest because if a donor tissue intended for transplants or transfusion comprises the HNA-3a or HNA- antigen, it is likely that the transplanted or transfused tissue will be rejected if the recipient comprises antibodies to the corresponding antigen. In rejection, the recipients' antibodies will bind to and target the tissue as foreign which will result it destruction by its immune system.

[0037] In one embodiment, the invention provides for methods of determining the susceptibility of a human transplant or transfusion recipient for rejecting transplanted or transfused tissue, wherein the donor tissue contains HNA-3a polypeptide or an antigenic fragment thereof, comprising a) obtaining a biological sample from the human transplant or transfusion recipient prior to transplantation or transfusion, b) contacting the biological sample with polypeptide comprising the amino acid sequence of SEQ ID NO: 1 or an antigenic fragment thereof to form a complex with HNA-3a specific antibodies in the biological sample, and c) detecting the complex, wherein the presence of the complex in the biological sample indicates that the human transplant or transfusion recipient is susceptible for rejecting the transplanted or transfused tissue. These methods may be carried out the with an antigenic fragments of the HNA-3a amino acid sequence (SEQ ID NO: 1) selected from the group consisting of SEQ ID NO: 13, SEQ ID NO: 14, SEQ ID NO: 15, SEQ ID NO: 16, SEQ ID NO: 17, SEQ ID NO: 18, SEQ ID NO: 25, SEQ ID NO: 27, SEQ ID NO: 34, SEQ ID NO: 35, SEQ ID NO: 36, SEQ ID NO: 37, SEQ ID NO: 38, SEQ ID NO: 39, SEQ ID NO: 40, SEQ ID NO: 41 and SEQ ID NO: 42.

[0038] In another embodiment, the invention provides for methods of determining the susceptibility of a human transplant or transfusion recipient for rejecting transplanted or transfused tissue, wherein the donor tissue contains HNA-3b polypeptide or an antigenic fragment thereof, comprising a) obtaining a biological sample from the human transplant or transfusion recipient prior to transplantation or transfusion, b) contacting the biological sample with polypeptide comprising the amino acid sequence of SEQ ID NO: 2 or an antigenic fragment thereof to form a complex with HNA-3b specific antibodies in the biological sample, and c) detecting

the complex, wherein the presence of the complex in the biological sample indicates that the human transplant or transfusion recipient is susceptible for rejecting the transplanted or transfused tissue. These methods may be carried out with an antigenic fragments of the HNA-3b amino acid sequence (SEQ ID NO: 2) selected from the group consisting of SEQ ID NO: 19, SEQ ID NO: 20, SEQ ID NO: 21, SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24 and SEQ ID NO: 26.

[0039] In a further embodiment, the invention provides for methods of determining the susceptibility of rejecting transplanted or transfused tissue, wherein the donor tissue contains HNA-3a or HNA-3b polypeptide or an antigenic fragment thereof, wherein in addition to detecting HNA3a or HNA-3b specific antibodies, the methods further comprise one of more of the following steps: contacting the biological sample with Fc-γ receptor IIIb polypeptide or an antigenic fragment thereof to form a complex with HNA-1 specific antibodies in the biological sample, contacting the biological sample with CD177 polypeptide or an antigenic fragment thereof to form a complex with HNA-2 specific antibodies in the biological sample, contacting the biological sample with CD11b polypeptide or an antigenic fragment thereof to form a complex with HNA-4 specific antibodies in the biological sample, contacting the biological sample with CD11a polypeptide or an antigenic fragment thereof to form a complex with HNA-5 specific antibodies in the biological sample, or contacting the biological sample with an HLA antigen to form a complex with HLA specific antibodies in the biological sample, and detecting the complex, wherein the presence of any of the complexes in the biological sample indicates that that the human transplant or transfusion recipient is susceptible for rejecting the transplanted or transfused tissue, wherein the donor tissue contains any of HNA-1, HNA-2, HNA-3a, HNA-3b, HNA-4, HNA-5, and HLA.

[0040] Any of the preceding methods may be carried out with aptamers which mimic the HNA-3a or HNA-3b epitope and therefore bind to HNA-3a or HNA-3b specific antibodies.

[0041] The invention provides for methods of screening for HNA-3a and/or HNA-3b antigen in donor tissue. Screening for HNA-3a or HNA-3b antigen is important when a transplant or transfusion recipient is known to express HNA-3a or HNA-3b antibodies. The recipient's antibodies may bind to the cells within the donor

tissue causing or increasing the risk of rejection of the transplanted or transfused tissue.

[0042] In one embodiment, the invention provides for methods of determining whether a donor tissue intended for transplant or transfusion is likely to be rejected in a human recipient wherein the human recipient has HNA-3a specific antibodies, comprising a) obtaining a sample of the tissue intended for transplant or transfusion in the human recipient, b) contacting the sample with an antibody that specifically binds to a HNA-3a polypeptide comprising the amino acid sequence of SEQ ID NO: 1 or a fragment thereof to form a complex with HNA-3a in the sample, and c) detecting the complex, wherein the presence of the complex indicates that the donor tissue is likely to be rejected in a human recipient that expresses HNA-3a specific antibodies.

[0043] In another embodiment, the invention provides for methods of determining whether a donor tissue intended for transplant or transfusion is likely to be rejected in a human recipient wherein the human recipient has HNA-3b specific antibodies, comprising a) obtaining a sample of the tissue intended for transplant or transfusion in the human recipient, contacting the sample with an antibody that specifically binds to HNA-3b polypeptide comprising the amino acid sequence of SEQ ID NO: 2 or a fragment thereof to form a complex with HNA-3b in the sample, and detecting the complex, wherein the presence of the complex indicates that the donor tissue is likely to be rejected in a human recipient that expresses HNA-3b specific antibodies.

[0044] In a further embodiment, the invention provides for methods of determining whether a donor tissue intended for transplant or transfusion will induce TRALI or GVHD in a human recipient wherein the human recipient has HNA-3a specific antibodies or HNA-3b specific antibodies, wherein in addition to detecting HNA-3a and/or HNA-3b antigen, the method further comprise one or more of the following steps: contacting the sample with an antibody that specifically binds to HNA-1 to form a complex with HNA-1 in the sample, contacting the sample with an antibody that specifically binds to HNA-2 to form a complex with HNA-2 in the sample, contacting the sample with an antibody that specifically binds to HNA-4 to form a complex with HNA-4 in the sample, contacting the sample with an antibody that specifically binds to HNA-5 to form a complex with HNA-5 in the sample, or

contacting the sample with an antibody that specifically binds to HLA antigen to form a complex with an HLA in the sample, and detecting the complex, wherein the presence of any of the complexes indicates that the sample is likely to induce TRALI or GVHD in a human recipient.

[0045] In any of the foregoing methods, the antibodies may comprise a label selected from the group consisting of a radioactive label, fluorescent label, enzymatic label, avidin label or biotin label. In addition, in any of the above described methods, the antigen-antibody complex may be detected with a secondary antibody. The secondary antibodies may comprise a label selected from the group consisting of a radioactive label, fluorescent label, enzymatic label, avidin label or biotin label.

[0046] The invention further provides for methods of genotyping the HNA-3a or HNA-3b allele of a transplant or transfusion donor. The term genotyping refers to detecting the presence of a particular allele, e.g. HNA-3a or HNA-3b, of a human subject. These methods are of interest when the intended transplant or transfusion recipient is known to express HNA-3a or HNA-3b antibodies, and therefore the presence of the HNA-3a or HNA-3b antigen respectively in a transfused or transfected tissue is likely to be rejected by the recipient. The methods of genotyping may employ the oligonucleotide probes that detect the HNA-3a or HNA-3b allele, or PCR to amplify a nucleotide fragment that comprises the HNA-3a or HNA-3b allele or using sequencing methods standard in the art to detect the HNA-3a or HNA-3b allele.

[0047] In one embodiment, the invention provides for methods of determining whether a donor tissue intended for transplant or transfusion is likely to be rejected in a human recipient wherein the human recipient expresses HNA-3a specific antibodies, comprising a) obtaining a sample of the tissue intended for transplant or transfusion, b) extracting nucleic acids from the sample, c) contacting the nucleic acids with an oligonucleotide probe that hybridizes to a fragment of SEQ ID NO: 3, and d) detecting hybridization of the probe to the nucleic acids, wherein hybridization of the probe indicates the presence of an HNA-3a nucleic acid and the presence of HNA-3a nucleic acid in the sample indicates that the sample is likely to be rejected in a human recipient that expresses HNA-3a specific antibodies. These methods may be carried out with an oligonucleotide probe that comprises a nucleotide

sequence that encodes an amino acid sequence selected from the group consisting of SEQ ID NO: 13, SEQ ID NO: 14, SEQ ID NO: 15, SEQ ID NO: 16, SEQ ID NO: 17, SEQ ID NO: 18, SEQ ID NO: 25, SEQ ID NO: 27, SEQ ID NO: 34, SEQ ID NO: 35, SEQ ID NO: 36, SEQ ID NO: 37, SEQ ID NO: 38, SEQ ID NO: 39, SEQ ID NO: 40, SEQ ID NO: 41 and SEQ ID NO: 42.

[0048] The invention also provide for methods of determining whether a donor tissue intended for transplant or transfusion is likely to be rejected in a human recipient wherein the human recipient expresses HNA-3b specific antibodies, comprising a) obtaining a sample of the tissue intended for transplant or transfusion, b) extracting nucleic acids from the sample, c) contacting the nucleic acids with an oligonucleotide probe that hybridizes to a fragment of SEQ ID NO: 4, and d) detecting hybridization of the probe to the nucleic acids, wherein hybridization of the probe indicates the presence of an HNA-3b nucleic acid and the presence of HNA-3b nucleic acid in the sample indicates that the sample is likely to be rejected in a human recipient that expresses HNA-3b specific antibodies. These methods may be carried out with an oligonucleotide probe that comprises a nucleotide sequence that encodes an amino acid sequence selected from the group consisting of SEQ ID NO: 19, SEQ ID NO: 20, SEQ ID NO: 21, SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24 and SEQ ID NO: 26.

[0049] In a further embodiment, the methods of determining whether a donor tissue intended for transplant or transfusion is likely to be rejected in a human recipient wherein the human recipient expresses HNA-3a or HNA-3b specific antibodies, wherein in addition to detecting the presence of HNA-3a allele or HNA-3b allele, the methods may comprise one or more of the following steps: contacting the sample with an oligonucleotide probe that hybridizes to a fragment of SEQ ID NO: 5, contacting the sample with an oligonucleotide probe that hybridizes to a fragment of SEQ ID NO: 7, contacting the sample with an oligonucleotide probe that hybridizes to a fragment of SEQ ID NO: 9, contacting the sample with an oligonucleotide probe that hybridizes to a fragment of SEQ ID NO: 11, or contacting the sample with an oligonucleotide probe that hybridizes to a fragment of a nucleotide sequence encoding an HLA antigen, and detecting the hybridization of the probe to the nucleic acids, wherein hybridization of any of the probes indicates the presence of any one of HNA-1, HNA-2, HNA-3a, HNA-3b, HNA-4, HNA-5 or HLA nucleic acid in the sample

and the presence of any one of HNA-1, HNA-2, HNA-3a, HNA-3b, HNA-4, HNA-5 or HLA nucleic acid in the sample indicates that the sample is likely to be rejected in a human recipient. For example, the invention contemplates that the fragment of HNA-1 (SEQ ID NO: 5) comprises at least one of nucleotide 141, nucleotide 147, nucleotide 226, nucleotide 227, nucleotide 277 or nucleotide 349 of SEQ ID NO: 5.

[0050] In another embodiment, the invention provides for methods of determining the susceptibility of a human transplant or transfusion recipient for developing TRALI or GVHD, wherein the donor tissue contains HNA-3a specific antibodies, comprising a) obtaining a biological sample from the human transplant or transfusion recipient prior to transplantation or transfusion, b) extracting nucleic acids from the biological sample, c) contacting the nucleic acids with an oligonucleotide probe that hybridizes to a fragment of the nucleotide sequence of SEQ ID NO: 1, and d) detecting hybridization of the probe to the nucleic acid, wherein hybridization of the probe to the nucleic acids indicates the presence of HNA-3a nucleic acid in the biological sample and the presence of HNA-3a in the biological sample indicates that a human transfusion or transplant recipient is susceptible for developing TRALI or GVHD. These methods may be carried out with an oligonucleotide probe that comprises a nucleotide sequence that encodes an amino acid sequence selected from the group consisting of SEQ ID NO: 13, SEQ ID NO: 14, SEQ ID NO: 15, SEQ ID NO: 16, SEQ ID NO: 17, SEQ ID NO: 18, SEQ ID NO: 25, SEQ ID NO: 27, SEQ ID NO: 34, SEQ ID NO: 35, SEQ ID NO: 36, SEQ ID NO: 37, SEQ ID NO: 38, SEQ ID NO: 39, SEQ ID NO: 40, SEQ ID NO: 41 and SEQ ID NO: 42.

[0051] The invention also provides for methods of determining the susceptibility of a human transplant or transfusion recipient for developing TRALI or GVHD, wherein the donor tissue contains HNA-3b specific antibodies, comprising a) obtaining a biological sample from the human transplant or transfusion recipient prior to transplantation or transfusion, b) extracting nucleic acids from the biological sample, c) contacting the nucleic acids with a oligonucleotide probe that hybridizes to a fragment of the nucleotide sequence of SEQ ID NO: 2, and d) detecting hybridization of the probe to the nucleic acid, wherein hybridization of the probe to the nucleic acids indicates the presence of HNA-3b nucleic acid in the biological sample and the presence of HNA-3b in the biological sample indicates that a human transfusion or transplant recipient is susceptible for developing TRALI or GVHD.

These methods may be carried out with an oligonucleotide probe that comprises a nucleotide sequence that encodes an amino acid sequence selected from the group consisting of SEQ ID NO: 19, SEQ ID NO: 20, SEQ ID NO: 21, SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24 and SEQ ID NO: 26.

[0052] The invention further provides for methods of determining the susceptibility of a human transplant or transfusion recipient for developing TRALI or GVHD, wherein the donor tissue contains HNA-3a or HNA-3b specific antibodies, wherein in addition to detecting the presence of HNA-3a or HNA-3b allele respectively, the methods may further comprise one or more of the following steps: contacting the sample with an oligonucleotide probe that hybridizes to a fragment of SEQ ID NO: 5, contacting the sample with an oligonucleotide probe that hybridizes to a fragment of SEQ ID NO: 7, contacting the sample with an oligonucleotide probe that hybridizes to a fragment of SEQ ID NO: 9, contacting the sample with an oligonucleotide probe that hybridizes to a fragment of SEQ ID NO: 11, or contacting the sample with an oligonucleotide probe that hybridizes to a fragment of a nucleotide sequence encoding an HLA antigen, and detecting the hybridization of the probe to the nucleic acids, wherein hybridization of any of the probes indicates the presence of any one of HNA-1, HNA-2, HNA-3a, HNA-3b, HNA-4, HNA-5 or HLA nucleic acid in the sample and the presence of any one of HNA-1, HNA-2, HNA-3a, HNA-3b, HNA-4, HNA-5 or HLA nucleic acid in the sample indicates that the sample is likely to induce TRALI or GVHD in a human recipient. For example, the invention contemplates that the fragment of HNA-1 (SEQ ID NO: 5) comprises at least one of nucleotides 141, nucleotide 147, nucleotide 226, nucleotide 227, nucleotide 277 or nucleotide 349 of SEQ ID NO: 5.

[0053] In any of the preceding methods, the oligonucleotide probes may be affixed to a substrate selected from the group consisting of membranes, filters, beads and chips. In addition, the invention provides for methods wherein the oligonucleotide probes are in an array. The methods include oligonucleotides probes that comprise a label selected from the group consisting of a radioactive label, fluorescent label, enzymatic label, avidin label or biotin label.

[0054] Alternatively, the invention provides for methods of determining whether a donor tissue intended for transplant or transfusion will likely be rejected in a human recipient wherein the human recipient has HNA-3a specific antibodies,

comprising a) obtaining a sample from the tissue, b) extracting nucleic acids from the sample, c) amplifying a fragment of HNA-3a nucleic acid of SEQ ID NO: 3 from the extracted nucleic acids using at least one oligonucleotide primer specific for HNA-3a nucleic acid, and d) detecting the fragment of HNA-3a nucleic acid in the sample, wherein the presence of HNA-3a nucleic acid in the sample indicates that the sample is likely to be rejected in a human recipient that has HNA-3a specific antibodies. These methods may be carried out with primers that amplify a fragment of HNA-3a nucleic acid encodes an amino acid sequence selected from the group consisting of SEQ ID NO: 13, SEQ ID NO: 14, SEQ ID NO: 15, SEQ ID NO: 16, SEQ ID NO: 17, SEQ ID NO: 18, SEQ ID NO: 25, SEQ ID NO: 27, SEQ ID NO: 34, SEQ ID NO: 35, SEQ ID NO: 36, SEQ ID NO: 37, SEQ ID NO: 38, SEQ ID NO: 39, SEQ ID NO: 40, SEQ ID NO: 41 and SEQ ID NO: 42.

[0055] The invention also provides for methods of determining whether a donor tissue intended for transplant or transfusion is likely to be rejected in a human recipient wherein the human recipient has HNA-3b specific antibodies, comprising a) obtaining a sample from the tissue, b) extracting nucleic acids from the sample, c) amplifying a fragment of HNA-3b nucleic acid of SEQ ID NO: 4 from the extracted nucleic acids using at least one oligonucleotide primer specific for HNA-3b nucleic acid, and d) detecting the fragment of HNA-3b nucleic acid in the sample, wherein the presence of HNA-3b nucleic acid in the sample indicates that the sample is likely to be rejected in a human recipient that has HNA-3b specific antibodies. These methods may be carried out with at least one primer that amplifies a fragment of HNA-3b nucleic acid that encodes an amino acid sequence selected from the group consisting of SEQ ID NO: 19, SEQ ID NO: 20, SEQ ID NO: 21, SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24 and SEQ ID NO: 26.

[0056] The invention further provides for methods of determining whether a donor tissue intended for transplant or transfusion will likely be rejected in a human recipient wherein the human recipient has HNA-3a or HNA-3b specific antibodies, in addition to detecting the HNA-3a or HNA-3b allele, the method further comprises one or more of the following steps: amplifying a fragment of HNA-1 nucleic acid (SEQ ID NO: 5) using at least one oligonucleotide primer specific for HNA-1 nucleic acid, amplifying a fragment of HNA-2 nucleic acid (SEQ ID NO: 7) using at least one oligonucleotide primer specific for HNA-2 nucleic acid, amplifying a fragment of

HNA-4 nucleic acid (SEQ ID NO: 9) using at least one oligonucleotide primer specific for HNA-4 nucleic acid, amplifying a fragment of HNA-5 nucleic acid (SEQ ID NO: 11) using at least one oligonucleotide primer specific for HNA-5 nucleic acid, or amplifying a fragment of HLA nucleic acid using at least one oligonucleotide primer specific for HLA nucleic acid, and detecting the fragment of any HNA or HLA nucleic acid in the sample, wherein the presence of an HNA or HLA nucleic acid in the sample indicates that the sample is likely to be rejected in a human recipient.

[0057] In another embodiment, the invention provides for methods of determining the susceptibility of a human transplant or transfusion recipient for developing TRALI or GVHD wherein the donor tissue contains HNA-3a specific antibodies, comprising a) obtaining a biological sample from the human transplant or transfusion recipient prior to transplantation or transfusion, b) extracting nucleic acids from the biological sample, c) amplifying a fragment of the HNA-3a nucleic acid (SEQ ID NO: 3) from the extracted nucleic acids using at least one oligonucleotide primer specific for HNA-3a nucleic acid in the biological sample, and d) detecting the presence of HNA-3a nucleic acid in the biological sample, wherein the presence of HNA-3a nucleic acid in the biological sample indicates that the human transfusion or transplant recipient is susceptible for developing TRALI or GVHD. These methods may be carried out with primers that amplify a fragment of HNA-3a nucleic acid sequence that encodes an amino acid sequence selected from the group consisting of SEQ ID NO: 13, SEQ ID NO: 14, SEQ ID NO: 15, SEQ ID NO: 16, SEQ ID NO: 17, SEQ ID NO: 18, SEQ ID NO: 25, SEQ ID NO: 27, SEQ ID NO: 34, SEQ ID NO: 35, SEQ ID NO: 36, SEQ ID NO: 37, SEQ ID NO: 38, SEQ ID NO: 39, SEQ ID NO: 40, SEQ ID NO: 41 and SEQ ID NO: 42.

[0058] In another embodiment, the invention provides for methods of determining the susceptibility of a human transplant or transfusion recipient for developing TRALI or GVHD, wherein the donor tissue contains anti-HNA-3b antibodies, comprising a) obtaining a biological sample from the human transplant or transfusion recipient prior to transplantation or transfusion, b) extracting nucleic acids from the biological sample, c) amplifying a fragment of the HNA-3b nucleic acid (SEQ ID NO: 4) from the extracted nucleic acids using at least one oligonucleotide primer specific for HNA-3b nucleic acid, and d) detecting the presence of HNA-3b nucleic acid in the biological sample, wherein the presence of HNA-3b nucleic acid in

the biological sample indicates that the human transfusion or transplant recipient is susceptible for developing TRALI or GVHD. These methods may be carried out with primers that amplify a fragment of nucleic acid sequence that encodes an amino acid sequence selected from the group consisting of SEQ ID NO: 19, SEQ ID NO: 20, SEQ ID NO: 21, SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24 and SEQ ID NO: 26.

[0059] In a further embodiment, the invention provides for methods of determining the susceptibility of a human transplant or transfusion recipient for developing TRALI or GVHD, wherein the donor tissue contains HNA-3a or HNA-3b specific antibodies, in addition to detecting the HNA-3a or HNA-3b allele, the method further comprises one or more of the following steps: amplifying a fragment of HNA-1 nucleic acid (SEQ ID NO: 5) using at least one oligonucleotide primer specific for HNA-1 nucleic acid, amplifying a fragment of HNA-2 nucleic acid (SEQ ID NO: 7) using at least one oligonucleotide primer specific for HNA-2 nucleic acid, amplifying a fragment of HNA-4 nucleic acid (SEQ ID NO: 9) using at least one oligonucleotide primer specific for HNA-4 nucleic acid, amplifying a fragment of HNA-5 nucleic acid (SEQ ID NO: 11) using an oligonucleotide primer specific for HNA-5 nucleic acid, or amplifying a fragment of HLA nucleic acid using at least one oligonucleotide primer specific for HLA nucleic acid, and detecting the fragment of any one of HNA-1, HNA-2, HNA-3a, HNA-3b, HNA-4, HNA-5 or HLA nucleic acid in the sample, wherein the presence of any one of HNA-1, HNA-2, HNA-3a, HNA-3b, HNA-4, HNA-5 or HLA nucleic acid in the sample indicates that the sample is likely to induce TRALI or GVHD in a human recipient.

[0060] In any of the preceding methods of the invention, the tissue sample or biological sample is selected from the group consisting of blood, blood derivatives, plasma, serum, cells, and tissues. In particular, the tissue sample or biological sample may be a neutrophil.

[0061] The invention also provides for kits for carrying out any of the foregoing methods. In particular, the invention provides for kits for detecting HNA-3a and/or HNA-3b antibodies in conjunction with detecting antibodies specific for one or more of HNA-1, HNA-2, HNA-4, HNA-5 and an HLA. The invention also provides for kits for detecting HNA-3a and/or HNA-3b antigens in conjunction with detecting HNA-1, HNA-2, HNA-4, HNA-5 and an HLA. The invention further

provides for methods of detecting an HNA-3a or HNA-3b allele in conjunction with detecting an allele for one or more of HNA-1, HNA-2, HNA-4, HNA-5 and an HLA.

[0062] In one embodiment, the invention provides for determining whether a donor tissue intended for transplant or transfusion will induce TRALI or GVHD in a human recipient wherein the human recipient expresses the HNA-3a antigen, wherein the kits comprise a polypeptide comprising the amino acid sequence of SEQ ID NO: 1 or an antigenic fragment thereof, and one or more polypeptides or antigenic fragments thereof selected from the group consisting of Fc-γ receptor IIIb polypeptide, CD177 polypeptide, CD11b polypeptide, CD11a polypeptide and an HLA antigen. The kit may also comprise a polypeptide comprising the amino acid sequence of SEQ ID NO: 2 or an antigenic fragment thereof for detection of HNA-3b specific antibodies in conjunction with detection of HNA-3a specific antibodies.

[0063] The kit may optionally also comprise an antibody specific for HNA-3a and one or more antibodies that specifically bind to a peptide comprising an antigen selected from the group consisting of HNA-1, HNA-2, HNA-4, HNA-5 and HLA. The HNA-3a polypeptide fragment of these kits may comprise an amino acid sequence selected from the group consisting of SEQ ID NO: 13, SEQ ID NO: 14, SEQ ID NO: 15, SEQ ID NO: 16, SEQ ID NO: 17, SEQ ID NO: 18, SEQ ID NO: 25, SEQ ID NO: 27, SEQ ID NO: 34, SEQ ID NO: 35, SEQ ID NO: 36, SEQ ID NO: 37, SEQ ID NO: 38, SEQ ID NO: 39, SEQ ID NO: 40, SEQ ID NO: 41 and SEQ ID NO: 42.

[0064] The invention also provides for kits for determining whether a donor tissue intended for transplant or transfusion is likely to be rejected in a human recipient wherein the human recipient has HNA-3a specific antibodies, wherein the kits comprise an antibody specific for HNA-3a, and one or more antibodies that specifically bind to a peptide comprising an antigen selected from the group consisting of HNA-1, HNA-2, HNA-3b, HNA-4, HNA-5 or HLA.

[0065] In addition, the invention provides for kits for determining the susceptibility of a human transplant or transfusion recipient for developing TRALI or GVHD, wherein the donor tissue contains anti-HNA-3a antibodies, wherein the kits comprise an antibody specific for HNA-3a, and one or more antibodies that

specifically bind to a peptide comprising an antigen selected from the group consisting of HNA-1, HNA-2, HNA-3b, HNA-4, HNA-5 and HLA.

[0066] Any of the preceding kits may further comprise a polypeptide comprising the amino acid sequence of SEQ ID NO: 1 or an antigenic fragment thereof and/or one or more polypeptides or antigenic fragments thereof selected from the group consisting of Fc-γ receptor IIIb polypeptide, CD177 polypeptide, CD11b polypeptide, CD11a polypeptide and an HLA antigen. The kit may also comprise an antibody specific for HNA-3b for detection of HNA-3b antigen in conjunction with detection of HNA-3a antigen.

[0067] The invention also provides for kits for determining whether a donor tissue intended for transplant or transfusion will induce TRALI or GVHD in a human recipient wherein the human recipient expresses the HNA-3b antigen, wherein the kits comprise a polypeptide comprising the amino acid sequence of SEQ ID NO: 2 or an antigenic fragment thereof, and one or more polypeptides or antigenic fragments thereof selected from the group consisting of Fc-γ receptor IIIb polypeptide, CD177 polypeptide, CD11b polypeptide, CD11a polypeptide and an HLA antigen. The kit may also comprise an antibody specific for HNA-3b and/or one or more antibodies that specifically bind to a peptide comprising an antigen selected from the group consisting of HNA-1, HNA-2, HNA-3b, HNA-4, HNA-5 and HLA. In particular, the invention contemplates kits in which the antigenic fragment of the amino acid of SEQ ID NO: 2 are selected from the group consisting of SEQ ID NO: 19, SEQ ID NO: 20, SEQ ID NO: 21, SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24 and SEQ ID NO: 26.

[0068] The invention also provides for kits for determining whether a donor tissue intended for transplant or transfusion is likely to be rejected in a human recipient wherein the human recipient has HNA-3b specific antibodies, wherein the kit comprises an antibody specific for HNA-3b, and one or more antibodies that specifically bind to a peptide comprising an antigen selected from the group consisting of HNA-1, HNA-2, HNA-3a, HNA-4, HNA-5 and HLA.

[0069] In another embodiment, the invention provides for kits for determining the susceptibility of a human transplant or transfusion recipient for developing TRALI or GVHD, wherein the donor tissue contains anti-HNA-3b

antibodies, wherein the kits comprise an antibody specific for HNA-3b, and one or more antibodies that specifically bind to a peptide comprising an antigen selected from the group consisting of HNA-1, HNA-2, HNA-3a, HNA-4, HNA-5 and HLA.

[0070] These kits may further comprise a polypeptide comprising the amino acid sequence of SEQ ID NO: 2 or an antigenic fragment thereof and/or one or more polypeptides or antigenic fragments thereof selected from the group consisting of Fc-γ receptor IIIb polypeptide, CD177 polypeptide, CD11b polypeptide, CD11a polypeptide and an HLA antigen.

[0071] In addition, the preceding kits may comprise a polypeptide comprising the amino acid sequence of SEQ ID NO: 1 or an antigenic fragment thereof for detection of HNA-3a specific antibodies in conjunction with detection of HNA-3b specific antibodies.

[0072] Any of the preceding kits may also comprise a secondary antibody. The primary or secondary antibody may comprise a label selected from the group consisting of a radioactive label, fluorescent label, enzymatic label, avidin label or biotin label.

[0073] In a further embodiment, the invention provides for kits for determining whether a donor tissue intended for transplant or transfusion is likely to be rejected in a human recipient wherein the human recipient expresses HNA-3a specific antibodies, wherein the kits comprise an oligonucleotide probe that hybridizes to a fragment of the nucleic acid sequence of SEQ ID NO: 3, and one or more oligonucleotide probes that hybridizes to a fragment of a nucleic acid sequence selected from the group consisting of SEQ ID NO: 5, SEQ ID NO: 7, SEQ ID NO: 9, SEQ ID NO: 11, and an HLA nucleotide sequence.

[0074] The invention also provides for kits for determining the susceptibility of a human transplant or transfusion recipient for developing TRALI or GVHD, wherein the donor tissue contains anti-HNA-3a antibodies, wherein the kits comprise an oligonucleotide probe that hybridizes to a fragment of the nucleic acid sequence of SEQ ID NO: 3, and one or more oligonucleotide probes that hybridizes to a fragment of a nucleic acid sequence selected from the group consisting of SEQ ID NO: 5, SEQ ID NO: 7, SEQ ID NO: 9, SEQ ID NO: 11, and an HLA nucleotide sequence. The oligonucleotide probes of these kits may comprise a fragment of the

nucleotide sequence that encodes an amino acid sequence selected from the group consisting of SEQ ID NO: 13, SEQ ID NO: 14, SEQ ID NO: 15, SEQ ID NO: 16, SEQ ID NO: 17, SEQ ID NO: 18, SEQ ID NO: 25, SEQ ID NO: 27, SEQ ID NO: 34, SEQ ID NO: 35, SEQ ID NO: 36, SEQ ID NO: 37, SEQ ID NO: 38, SEQ ID NO: 39, SEQ ID NO: 40, SEQ ID NO: 41 and SEQ ID NO: 42.

[0075] The invention also provides for kits for determining whether a donor tissue intended for transplant or transfusion is likely to be rejected in a human recipient wherein the human recipient expresses HNA-3b specific antibodies, wherein the kit comprises an oligonucleotide probe that hybridizes to a fragment of the nucleic acid sequence of SEQ ID NO: 4, and one or more oligonucleotide probes that hybridizes to a fragment of a nucleic acid sequence selected from the group consisting of SEQ ID NO: 5, SEQ ID NO: 7, SEQ ID NO: 9, SEQ ID NO: 11, and an HLA nucleotide sequence.

[0076] The invention also provides for kits for determining the susceptibility of a human transplant or transfusion recipient for developing TRALI or GVHD, wherein the donor tissue contains anti-HNA-3b antibodies, wherein the kits comprise an oligonucleotide probe that hybridizes to a fragment of the nucleic acid sequence of SEQ ID NO: 4, and one or more oligonucleotide probes that hybridizes to a fragment of a nucleic acid sequence selected from the group consisting of SEQ ID NO: 5, SEQ ID NO: 7, SEQ ID NO: 9, SEQ ID NO: 11, and an HLA nucleotide sequence. The oligonucleotide probes of these kits may comprise a fragment of the nucleotide sequence that encodes an amino acid sequence selected from the group consisting of a nucleotide sequence that encodes an amino acid sequence selected from the group consisting of SEQ ID NO: 19, SEQ ID NO: 20, SEQ ID NO: 21, SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24 and SEQ ID NO: 26.

[0077] In any of the preceding kits the oligonucleotide probe may comprise a label selected from the group consisting of a radioactive label, fluorescent label, enzymatic label, avidin label and biotin label. In addition, the kits may further comprise buffers for gel loading.

[0078] In another embodiment, the invention provides for kits for determining whether a donor tissue intended for transplant or transfusion is likely to be rejected in a human recipient wherein the human recipient expresses HNA-3a

specific antibodies, wherein the kits comprise at least one oligonucleotide primer for amplifying a fragment of the HNA-3a nucleic acid of SEQ ID NO: 3, and one or more oligonucleotide primers for amplifying a fragment of a nucleic acid sequence selected from the group consisting of SEQ ID NO: 5, SEQ ID NO: 7, SEQ ID NO: 9, SEQ ID NO: 11, and an HLA nucleotide sequence.

[0079] The invention also provides for kits for determining the susceptibility of a human transplant or transfusion recipient for developing TRALI or GVHD, wherein the donor tissue contains anti-HNA-3a antibodies, wherein the kits comprise at least one oligonucleotide primers for amplifying a fragment of the HNA-3a nucleic acid of SEQ ID NO: 3, and one or more oligonucleotide primers for amplifying a fragment of a nucleic acid sequence selected from the group consisting of SEQ ID NO: 5, SEQ ID NO: 7, SEQ ID NO: 9, SEQ ID NO: 11, and an HLA nucleotide sequence. These primers may amplify a fragment of HNA-3a nucleic acid which encodes an amino acid sequence selected from the group consisting of SEQ ID NO: 13, SEQ ID NO: 14, SEQ ID NO: 15, SEQ ID NO: 16, SEQ ID NO: 17, SEQ ID NO: 18, SEQ ID NO: 25, SEQ ID NO: 27, SEQ ID NO: 34, SEQ ID NO: 35, SEQ ID NO: 36, SEQ ID NO: 37, SEQ ID NO: 38, SEQ ID NO: 39, SEQ ID NO: 40, SEQ ID NO: 41 and SEQ ID NO: 42.

[0080] The preceding kits may further comprise a fragment of the HNA-3a nucleic acid that is amplified by the oligonucleotide primers and/or one or more fragments of a nucleic acid sequence selected from the group consisting of SEQ ID NO: 5, SEQ NO: ID: 7, SEQ ID NO: 9, SEQ ID NO: 11, and an HLA nucleotide sequence that is amplified by the oligonucleotide primers. In addition, the kits may further comprise oligonucleotide primers for amplifying a fragment of the HNA-3b nucleic acid of SEQ ID NO: 4 in conjunction with the amplification of a fragment of HNA-3a.

[0081] In another embodiment, the invention provides for kits for determining whether a donor tissue intended for transplant or transfusion is likely to be rejected in a human recipient wherein the human recipient expresses HNA-3b specific antibodies, wherein the kit comprises at least one oligonucleotide primer for amplifying a fragment of the HNA-3b nucleic acid of SEQ ID NO: 4, and one or more oligonucleotide primers for amplifying a fragment of a nucleic acid sequence selected

from the group consisting of SEQ ID NO: 5, SEQ ID NO: 7, SEQ ID NO: 9, SEQ ID NO: 11, and an HLA nucleotide sequence.

[0082] The invention also provides for kits for determining the susceptibility of a human transplant or transfusion recipient for developing TRALI or GVHD, wherein the donor tissue contains anti-HNA-3b antibodies, wherein the kit comprises at least one oligonucleotide primer for amplifying a fragment of the HNA-3b nucleic acid of SEQ ID NO: 4, and at least one oligonucleotide primer for amplifying a fragment of a nucleic acid sequence selected from the group consisting of SEQ ID NO: 5, SEQ ID NO: 7, SEQ ID NO: 9, SEQ ID NO: 11, and an HLA nucleotide sequence. These primers may amplify a fragment of HNA-3a nucleic acid which encodes an amino acid sequence selected from the group consisting of SEQ ID NO: 19, SEQ ID NO: 20, SEQ ID NO: 21, SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24 and SEQ ID NO: 26.

[0083] Any of the preceding kits may also comprise buffers for PCR amplification, dNTP's and buffers for gel loading.

[0084] In another embodiment, the invention provides for an isolated HNA-3b polypeptides such as isolated polypeptides comprising the amino acid sequence SEQ ID NO: 2, isolated polypeptide comprising a fragment of the polypeptide of SEQ ID NO: 2 wherein the fragment is at least 7 amino acids in length, at least 10 amino acids in length, at least 20 amino acids in length or at least 50 amino acids in length. The fragments of HNA-3b include a fragment comprising amino acid residue 154 of SEQ ID NO: 2, wherein residue 154 is glutamine (Gln). The fragments of HNA-3b polypeptide include fragments comprising the amino acid sequence of SEQ ID NO: 19, SEQ ID NO: 20, SEQ ID NO: 21, SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24 and SEQ ID NO: 26 and reacts with or specifically binds to HNA-3b-specific alloantibodies. The invention also provides of polynucleotides encoding the HNA-3b polypeptides.

[0085] The invention provides for fragments of the HNA-3a polypeptide of SEQ ID NO: 1, such as an isolated polypeptide comprising the amino acid sequence of SEQ ID NO: 13, SEQ ID NO: 14, SEQ ID NO: 15, SEQ ID NO: 16, SEQ ID NO: 17, SEQ ID NO: 18, SEQ ID NO: 25, SEQ ID NO: 27, SEQ ID NO: 34, SEQ ID NO: 35, SEQ ID NO: 36, SEQ ID NO: 37, SEQ ID NO: 38, SEQ ID NO: 39, SEQ ID NO:

40, SEQ ID NO: 41 and SEQ ID NO: 42, wherein the polypeptide reacts with or specifically binds to HNA-3a-specific alloantibodies. The invention also provides for polynucleotides encoding these HNA-3a polypeptide fragments.

[0086] In another embodiment, the invention provides for use of a HNA-3a polypeptide or fragment thereof for identification of HNA-3a-specific alloantibodies. Use of a HNA-3b polypeptide or fragment thereof for identification of HNA-3b-specific alloantibodies is also provided.

[0087] The invention further provides for a use of a polynucleotide encoding an HNA-3a polypeptide or a fragment thereof which encodes a protein that reacts with or specifically binds to HNA-3a-specific alloantibodies, for determination of the HNA-3a genotype. In addition, the invention provides for use of a HNA-3b polynucleotide or a fragment thereof for determination of the HNA-3b genotype. For example, the invention provides for use of a fragment of SEQ ID NO: 4 comprising codon 154 for determination of the HNA-3b genotype.

[0088] In a further embodiment, the invention provides for use of a protein comprising an amino acid sequence of SEQ ID NO: 1 or a fragment thereof which reacts with HNA-3a-specific alloantibodies, or a HNA-3a protein fragment in the analysis of blood samples or blood plasma for identification of antibodies against the HNA-3a antigen.

[0089] The invention also provides for use of a HNA-3b polypeptide in the analysis of blood samples or blood plasma for identification of antibodies against the HNA-3b antigen.

[0090] Use of a polypeptide comprising an amino acid sequence of SEQ ID NO: 1 (HNA-3a) or a fragment thereof or an amino acid of SEQ ID NO: 2 (HNA-3b) or a fragment thereof in a process, which uses the protein or the protein fragment to separate antibodies from blood samples or blood plasma.

[0091] Use of a polypeptide comprising an amino acid sequence of SEQ ID NO: 1 (HNA-3a) or a fragment thereof or a polypeptide of SEQ ID NO: 2 (HNA-3b) or a fragment thereof in a process, which uses the protein or the protein fragment to produce antibodies, preferably monoclonal antibodies. In a further embodiment, the invention provides for methods of screening for HNA-3b genotype in a human subject comprising a) obtaining a biological sample from the human subject, b) extracting

nucleic acids from the biological sample, and b) detecting a fragment of a nucleic acid sequence of SEQ ID NO: 4 in the biological sample, wherein the fragment comprises codon 154 of SEQ ID NO: 4, wherein the detection of codon 154 of SEQ ID NO: 4 indicates that the human subject has the HNA-3b genotype. The detecting step may include contacting the nucleic acid with an oligonucleotide probe that hybridizes to a fragment of the nucleic acid sequence of SEQ ID NO: 4 or amplifying a fragment of SEQ ID NO: 4 from the extracted nucleic acid using at least one oligonucleotide primer specific for a fragment of SEQ ID NO: 4. For the method of screening for HNA-3b genotype, the biological sample that is used may be selected from the group consisting of blood, blood derivatives, plasma, serum, cells, and tissues.

Sequences of the Invention

[0092] SEQ ID NO: 1 –human HNA-3a protein

[0093] SEQ ID NO: 2 – human HNA-3b protein

[0094] SEQ ID NO: 3 – human HNA-3a DNA

[0095] SEQ ID NO: 4 – human HNA-3b DNA

[0096] SEQ ID NO: 5 – human FCγ receptor IIIb DNA (HNA-1)

[0097] SEQ ID NO: 6 - human FCγ receptor IIIb protein (HNA-1)

[0098] SEQ ID NO: 7 – human CD177 DNA (HNA-2)

[0099] SEQ ID NO: 8 - human CD177 protein (HNA-2)

[00100] SEQ ID NO: 9 – human CD11b DNA (HNA-4)

[00101] SEQ ID NO: 10 - human CD11b protein (HNA-4)

[00102] SEQ ID NO: 11 – human CD11a DNA (HNA-5)

[00103] SEQ ID NO: 12 – human CD11a protein (HNA-5)

[00104] SEQ ID NO: 13 – amino acids 1-231 of HNA-3a (SEQ ID NO: 1)

[00105] SEQ ID NO: 14 – amino acids 55-183 of HNA-3a (SEQ ID NO: 1)

[00106] SEQ ID NO: 15 – amino acids 55-164 of HNA-3a (SEQ ID NO: 1)

[00107] SEQ ID NO: 16 – amino acids 114-164 of HNA-3a (SEQ ID NO: 1)

[00108] SEQ ID NO: 17 – amino acids 55-706 of HNA-3a (SEQ ID NO: 1)

[00109] SEQ ID NO: 18 – amino acids 114-706 of HNA-3a (SEQ ID NO: 1)

[00110] SEQ ID NO: 19 - amino acids 1-231 of HNA-3b (SEQ ID NO: 2)

[00111] SEQ ID NO: 20 - amino acids 55-183 of HNA-3b (SEQ ID NO: 2)

[00112] SEQ ID NO: 21 - amino acids 55-164 of HNA-3b (SEQ ID NO: 2)

[00113] SEQ ID NO: 22 – amino acids 114-164 of HNA-3b (SEQ ID NO: 2)

[00114] SEQ ID NO: 23 - amino acids 55-706 of HNA-3b (SEQ ID NO: 2)

[00115] SEQ ID NO: 24 – amino acids 114-706 of HNA-3B (SEQ ID NO: 2)

[00116] SEQ ID NO: 25 – amino acids 154-164 of HNA-3a (SEQ ID NO: 1)

[00117] SEQ ID NO: 26 – amino acids 154-164 of HNA-3b (SEQ ID NO: 2)

[00118] SEQ ID NOS: 27-47 – fragments of HNA-3a in Table 1

[00119] SEQ UD NO: 48 – amino acids 145-167 of HNA-3a (SEQ ID NO: 1)

[00120] SEQ ID NOS: 49-55 – primer sequences

Detailed Description

[00121] The present invention is based on the discovery that HNA-3 is located on the CTL2 transmembrane protein. A serum sample that was known to induce TRALI in transfusion recipients, but was negative for HNA-1 and HNA-2 antibodies, was used to identify the source of HNA-3a antigen. HNA-3a was identified by first comparing the HNA-3a positive and negative cell surface proteins that were immunoprecipitated by HNA-3a sera. The cells were characterized with HNA-3a positive and negative sera by flow cytometry. The HNA positive and negative granulocytes were then incubated with HNA-3a positive sera and the cell surface proteins that reacted with the sera were immunoprecipitated with Protein-G coated magnetic beads as described in detail in Example 6. The protein profiles were

first analyzed using SDS-PAGE and two identified proteins having a molecular weight of about 80- 100 kD were only present in the positive cells, not in the negative cells. Those proteins were excised from the SDS gel and further analyzed with mass spectrometry (MS) analysis and confirmed by sequencing the amino acid sequence.

[00122] The invention provides for methods of screening biological samples to detect antibodies specific for HNA-3a or HNA-3b antigen. The biological sample includes whole blood, blood derivatives, red blood cell concentrates, plasma, serum, fresh frozen plasma, whole blood derived platelet concentrates, apheresis platelets, pooled platelets, intravenous gamma-globulin, cryoprecipitate, cerebrospinal fluid, tissues and cells such as stem cells, neutrophils and granulocytes. The biological samples may be obtained from a human donor of tissue or cells intended for transplantation or a human donor of blood or blood derivatives intended for transfusion. The biological samples may be obtained from tissues or cells that are intended for transplantation in a human recipient. In addition, the biological sample may be obtained from blood or blood derivatives that are intended for transfusion in a human recipient. The biological sample may also be obtained from a human subject that is an intended recipient of a transplant or transfusion.

[00123] The invention also relates to screening for susceptibility or determining if the recipient will develop graft versus host disease (GVHD). GVHD is when a tissue comprises immunologically competent cells or antibodies that attack the recipient. The leading cause of GVHD is hematopoietic cell transplantation, both allogeneic (between 2 individuals) and autologous (from the same individual). Solid organ transplants, blood transfusions, and maternal-fetal transfusions also reportedly cause GVHD. Acute symptoms of GVDH include abdominal pain or damage, diarrhea, fever, jaundice, skin rash, vomiting and weight loss. Chronic symptoms of GVHD include dry eyes, dry mouth, hepatitis, lung and digestive tract disorders and skin rash.

[00124] The invention also relates to methods and products related to determining if a transplanted or transfused tissue is likely to be rejected by the recipient. Symptoms of rejection include indications that the transplanted organ does not function properly, general discomfort, uneasiness, or ill feeling, pain or swelling in the location of the organ and fever.

Identification of HNA-3a and HNA-3b

[00125] It was therefore an object of the present invention to identify and provide the protein and DNA sequences of the human neutrophil antigen-3a or -3b (HNA-3a, HNA-3b) involved in TRALI.

[00126] In other words, the problem was solved by the provision of the protein (HNA-3a antigen), consisting of an amino acid sequence SEQ ID NO: 1, which reacts with alloantibodies which are specific for HNA-3a, and by the provision of the protein (HNA-3b antigen), consisting of an amino acid sequence SEQ ID NO: 2, which reacts with alloantibodies which are specific for HNA-3b.

[00127] Subjects coming into question were investigated for the identification of HNA-3a –positive and –negative subjects, whose cells can be used for further investigations. Antibodies from donors whose blood products have triggered TRALI, and the white blood cells on the surfaces of which the corresponding antigens are expressed were used. After the identification of subjects with high-titer HNA-3a antibodies, with which the antigen can be precipitated, the donors were subjected to a plasmapheresis, in order to obtain sufficient material for the antigen-antibody reactions. The antigens were precipitated by means of the antibodies and the still unknown protein/gene structures of HNA-3a were characterized.

[00128] In detail, firstly an optimization of the preparation of granulocytes was developed. Then, by means of a screening program, HNA-3a-positive and –negative subjects were determined, whose cells were able to be used for further investigations. Subjects were then selected with high-titer HNA-3a antibodies, with which the antigen was able to be precipitated. A plasmapheresis of the selected subjects was carried out in order to obtain sufficient material for the antigen-antibody reactions. The method for the preparation of granulocyte membrane proteins for a quantitative gel electrophoresis was first developed with platelets, because these have no nucleus and the preparation was therefore simplified. The method was then transferred and adapted to leucocytes/granulocytes containing a nucleus. This made possible an optimization of the preparation of granulocyte membrane proteins. The corresponding proteins were analyzed by means of analytical methods. The enrichment/isolation of HNA-3a from the prepared membrane proteins was carried

out by means of immunoprecipitation, and confirmed by Western blotting. The protein which carries HNA-3a was identified by mass spectrometry; and subsequently, the primary sequence of HNA-3a was identified by sequence analysis (SEQ ID NO: 1).

[00129] The invention therefore concerns a protein (HNA-3a antigen), consisting of an amino acid sequence SEQ ID NO: 1, which reacts with alloantibodies which are HNA-3a-specific. Additionally included are also proteins (HNA-3a antigens) consisting of an amino acid sequence SEQ ID NO: 1, in which one or more amino acids have been removed, added or replaced and which react with alloantibodies which are HNA-3a specific. The identified HNA-3a antigen proved to be a variant of the transmembrane receptor CTL2. This has a molecular weight in the range 80 to 100 kDa, and deglycosylation shifted the band to 64 kDa in the Western blot.

[00130] The HNA-3 antigen is expressed on the CTL2 protein on granulocytes and lymphocytes. A single nucleotide polymorphism (SNP) on an extracellular loop is crucial (SNP rs2288904), as this SNP is the difference between HNA-3a and HNA-3b. This SNP allows for genotyping of blood donors in relation to their HNA-3a/HNA-3b status. The polynucleotide encoding HNA-3a has a "G" (guanine) at position 461 and as a result encodes an "R" (Arginine, Arg) at position 154 of the HNA-3a amino acid sequence, and therefore represents the HNA-3a allele. The polynucleotide encoding HNA-3b has an "A" (adenine) at position 461 and as a result encodes a "Q" (glutamine, Gln) at position 154 of the amino acid sequence, and therefore represents the HNA-3b allele.

[00131] The primary sequence of the HNA-3b antigen was determined through amino acid exchange at position 154 arginine (Arg, R) to glutamine (Gln, Q) (see SEQ ID NO: 2). Accordingly, the invention concerns a protein (HNA-3b antigen) consisting of an amino acid sequence of SEQ ID NO: 2, which reacts with HNA-3b specific alloantibodies. Likewise, the invention includes HNA-3b proteins consisting of an amino acid sequence of SEQ ID NO: 2, in which one or more amino acids have been removed, added or replaced and which react with HNA-3b specific alloantibodies.

[00132] Likewise, the invention provides for proteins, both with respect to the HNA-3a and also to the HNA-3b, which are protein fragments with a chain length of at least 7, at least 10 amino acids, at least 20 amino acids, or at least 50 amino acids.

[00133] Subsequently, the HNA-3a gene was isolated and heterologously expressed. The corresponding DNA sequences for HNA-3a correspond to the sequence set out as the nucleotide sequence SEQ ID NO: 3 and all sequences hybridizing therewith, which codes an HNA-3a antigen described above, which reacts with or binds to HNA-3a specific alloantibodies. The invention also includes a nucleotide sequence which has an identity on the nucleotide level of at least 90%, preferably at least 95%, most preferably at least 98% to SEQ ID NO: 3 and all sequences hybridizing therewith, which codes an HNA-3a antigen described above, and which reacts with or binds to HNA-3a specific alloantibodies.

[00134] Additionally, the invention provides for splice variants of a nucleotide sequence SEQ ID NO: 3, which are at least 70% identical to the nucleotide sequence SEQ ID NO: 3. Preferably, the sequence identity is at least 80%, more preferably 90% and most preferably 95% to SEQ ID NO: 3.

[00135] The invention further provides for a nucleotide sequence SEQ ID NO: 4 and all sequences hybridizing therewith, which codes the HNA-3b antigen described above, which reacts with HNA-3b specific alloantibodies. This also includes a nucleotide sequence which has an identity on the nucleotide level of at least 90%, preferably at least 95%, most preferably at least 98% and all sequences hybridizing therewith which codes a HNA-3b antigen described above, and which reacts with alloantibodies which are HNA-3b specific. Exemplary stringent hybridization conditions comprise hybridization at 65°C and washing three times for 15 minutes with 0.25x SSC, 0.1% SDS at 65°C. Additional exemplary stringent hybridization conditions comprise hybridization in 0.02 M to 0.15 M NaCl at temperatures of about 50°C to 70°C or 0.5 x SSC 0.25% SDS at 65° for 15 minutes, followed by a wash at 65oC for a half hour or hybridization at 65°C for 14 hours followed by 3 washings with 0.5X SSC, 1% SDS at 65°C.

[00136] Additionally, the invention provides for splice variants of a nucleotide sequence of SEQ ID NO: 4, which are at least 70% identical to the

nucleotide sequence SEQ ID NO: 4. Preferably, the sequence identity is at least 80%, more preferably 90% and most preferably 95%.

[00137] Sequence identity or identity on the nucleotide level generally means 100% identity.

[00138] Based on the determined primary structures, the method for recombinant production of the antigen was optimized on the basis of the already known proteins/antigens HNA-1a, -1b, -1c, -2a. The results obtained for the HNA-1 and HNA-2 antigens were transferred to HNA-3a or HNA-3b, so that these antigens would be produced in a suitable expression system such as expression in *Escherichia coli*, in eukaryotic cells, in insect cells.

[00139] The present invention accordingly contains the use of a protein (HNA-3a antigen) consisting of an amino acid sequence of SEQ ID NO: 1 for the identification of HNA-3a specific alloantibodies. Likewise included in the invention is the use of a protein (HNA-3b antigen) consisting of an amino acid sequence of SEQ ID NO: 2 for the identification of HNA-3b specific alloantibodies.

[00140] In addition, the present invention includes the use of a nucleotide sequence of SEQ ID NO: 3 for determining the HNA-3a genotype, and the use of a nucleotide sequence of SEQ ID NO: 4 for determining the HNA-3b genotype.

[00141] The methods of the present invention may be carried out using ELISA assays, flow cytometry, immunofluorescence methods, electro-chip assays, PCRs and agglutination tests.

[00142] Likewise, the invention provides for a test system for determining HNA-3a specific alloantibodies, which bind to a protein (HNA-3a antigen) consisting of an amino acid sequence of SEQ ID NO: 1. The invention also provides for a test system for determining HNA-3b specific alloantibodies, which bind to a protein (HNA-3b antigen) consisting of an amino acid sequence of SEQ ID NO: 2.

[00143] The invention also provides for a test system for determining the HNA-3a genotype, which comprises a nucleotide sequence of SEQ ID NO: 3 and for a test system for determining the HNA-3b genotype which comprises a nucleotide sequence of SEQ ID NO: 4.

[00144] According to the invention, the protein (HNA-3a antigen), consisting of an amino acid sequence of SEQ ID NO: 1, is used in the analysis of blood samples or blood plasma for the identification of antibodies that specifically bind to HNA-3a antigen. Likewise, the protein (HNA-3b antigen), consisting of an amino acid sequence SEQ ID NO: 2 is used in the analysis of blood samples or blood plasma for the identification of antibodies against the HNA-3b antigen.

[00145] The invention further comprises the use of a protein (HNA-3a antigen) consisting of an amino acid sequence of SEQ ID NO: 1 in a method which uses the antigen in order to separate antibodies from blood samples or blood plasma. The invention likewise comprises the use of a protein (HNA-3b antigen) consisting of an amino acid sequence of SEQ ID NO: 2 as described above in a method which uses the antigen in order to separate antibodies from blood samples or blood plasma. Particularly preferred is the use of the protein in adsorption methods such as plasmapheresis.

[00146] The invention further provides for the use of a protein (HNA-3a antigen) consisting of an amino acid sequence of SEQ ID NO: 1 in a method which uses the antigen in order to produce antibodies, preferably monoclonal antibodies. Likewise the invention provides for the use of a protein (HNA-3b antigen) consisting of an amino acid sequence of SEQ ID NO: 2 in a method which uses the antigen in order to produce antibodies, preferably monoclonal antibodies.

Antigenic Fragments of HNA-3a

[00147] Epitope mapping of antigenic fragments of HNA-3a or HNA-3b, that generate HNA-3a or HNA-3b specific antibodies, may be identified using methods standard in the art such as site-specific mutagenesis, genetic engineering, analysis of CTL2 peptide libraries, predictive algorithms, functional assays, such as ELISpot or intracellular cytokine staining, and cellular binding assays. High throughput systems for analysis of peptide libraries are commercially available, such as the REVEAL & ProVE™ System (Proimmune, Springfield. VA).

[00148] Preferred protein fragments of HNA-3a (SEQ ID NO: 1) include at least the amino acid sequence of SEQ ID NO: 13 (amino acids 1-231 of SEQ ID NO: 1), at least the amino acid sequence of SEQ ID NO: 14 (amino acids 55-183 of SEQ ID NO: 1), at least the amino acid sequence of SEQ ID NO: 15 (amino acids 55-164

of SEQ ID NO: 1), at least the amino acid sequence of SEQ ID NO: 16 (amino acids 114-164 of SEQ ID NO: 1), at least the amino acid sequence of SEQ ID NO: 25 (amino acids 154-164 of SEQ ID NO: 1), at least the amino acid sequence of SEQ ID NO: 17 (amino acids 55-706 of SEQ ID NO: 1), and at least the amino acid sequence of SEQ ID NO: 18 (amino acids 114-706 of SEQ ID NO: 1) ,which would react with or bind to HNA-3a-specific antibodies such as alloantibodies.

[00149] Furthermore, the invention relates to any protein fragment consisting of amino acid sequence of SEQ ID NO: 1 as described herein in which one or more amino acids has been removed, added or have been replaced and which reacts with or binds to HNA-3a-specific antibodies or alloantibodies.

[00150] The present invention relates to protein fragments of the amino acid sequence of SEQ ID NO: 2. Preferred protein fragments of HNA-3b (SEQ ID NO: 2) include at least the amino acid sequence of SEQ ID NO: 19 (amino acids 1-231 of SEQ ID NO: 2), at least the amino acid sequence of SEQ ID NO: 20 (amino acids 55-183 of SEQ ID NO: 2), at least the amino acid sequence of SEQ ID NO: 21 (amino acids 55-164 of SEQ ID NO: 2), at least the amino acid sequence of the SEQ ID NO: 22 (amino acids 114-164 of SEQ ID NO: 2), at least the amino acids of SEQ ID NO: 26 (amino acids 154-164 of SEG ID NO: 2), at least the amino acids of SEQ ID NO: 23 (amino acids 55-706 of SEQ ID NO: 2) and at least the amino acids of SEQ ID NO: 24 (amino acids 114-706 of SEQ ID NO: 2), which react with or bind to the HNA-3b specific antibodies such as alloantibodies.

[00151] Likewise, the invention relates to protein fragments consisting of an amino acid sequence of SEQ ID NO: 2, as described above, in which one or more amino acids has been removed, added or replaced and which reacts with or binds to the HNA-3b specific antibodies or alloantibodies.

Method of Detecting HNA-3 Specific Antibodies

[00152] The invention provides for methods of detecting HNA-3a or HNA-3b specific antibodies in a biological sample. The invention also contemplates detecting other antibodies such as antibodies specific for HNA-1, HNA-2 or HLA in combination with detecting HNA-3a or HNA-3b specific antibodies. Methods of detecting of antibody include non-specific and specific assays such as, granulocyte immunofluorescence test, granulocyte immunofluorescence flow cytometry assay

(GIFT-FC), monoclonal antibody immobilization of granulocyte antigens (MAIGA) assay, single radial immunodiffussion assay (SRID), enzyme immunoassay and hemagglutination inhibition assay (HAI).

[00153] An exemplary non-specific assay uses intact granulocytes as a target, *e.g.* GIFT-FC uses a panel of neutrophils with different HNAs (Davoren, *et al.* Transfusion 43(5): 641-5, 2003, Kobayashi *et al*, *Ped. Res.* 26: 246-249). The neutrophils are first incubated with test sera followed by incubation with a fluorescently labeled secondary antibody, such as antihuman polyvalent immunoglobulin, IgG, IgM and IgA. After washing, the antibody binding to the cell suspensions is examined by flow cytometry.

[00154] An exemplary specific assay uses immobilized HNA glycoprotein as a target, *e.g.* MAIGA assay. MAIGA is an ELISA-based test that uses HNA-3 specific monoclonal antibodies to capture the neutrophil antigens within test sera. Subsequently, the cell mixtures are incubated with an enzyme labeled secondary antibody, such as anti-mouse IgG, and binding is detected with a colorimetric assay (Bux, *et al.* Transfusion Med. 3(2): 157-62, 1993, Metcalfe &Waters, Transfusion Med. 2:283-287, 1992.)

[00155] ELISA assay is used to determine total antibodies in the sample. The immunogen, e.g. the HNA-3a polypeptide of SEQ ID NO: 1, the HNA-3b polypeptide of SEQ ID NO: 2 or antigenic fragments thereof, is adsorbed to the surface of a microtiter plate. The test serum is exposed to the plate followed by an enzyme linked immunoglobulin, such as IgG. The enzyme activity adherent to the plate is quantified by any convenient means such as spectrophotometers and is proportional to the concentration of antibody directed against the immunogen present in the test sample. In addition, HNA-3a or HNA-3b polypeptide or antigenic fragments thereof may be attached to solid substrates such as membranes, beads, filters, glass, silicon, metal, metal-alloy, anopore, polymeric, nylon or plastic for detection of antibodies specific for HNA-3a or HNA-3b.

[00156] The SRID assay utilizes a layer of a gel, such as agarose, containing the antigen being tested. A well is cut in the gel and the test sera are placed in the well. Diffusion of the antibody out into the gel leads to the formation of

a precipitation ring whose area is proportional to the concentration of the antibody in the serum being tested.

[00157] HAI utilizes the capability of an immunogen to agglutinate chicken red blood cells (or the like). The assay detects neutralizing antibodies, *i.e.*, those antibodies able to inhibit hemagglutination. Dilutions of the test serum are incubated with a standard concentration of immunogen, followed by the addition of the red blood cells. The presence of neutralizing antibodies will inhibit the agglutination of the red blood cells by the immunogen.

[00158] Additional assays to detect circulating anti-HNA-3a or anti-HNA-3b antibody in the serum of the transplant or transfusion patient may be used. In such an assay, serum is screened for the presence of anti-HNA-3a or HNA-3b antibodies through detection of complement-mediated lytic activity. Serum is screened for complement-mediated lytic activity against T and B lymphocytes from a panel of individuals representing the most frequently encountered HNA-3a or HNA-3b antigens. The assay is performed in the presence or absence of dithioerythritol.

[00159] The methods of detecting an HNA-3a or HNA-3b antibodies of the invention may be carried out with neutrophils or any cell type transformed or transfected to express HNA-3a or HNA-3b. The methods may be carried out will cells that do not endogenously express HNA-3a or HNA-3, such as B-cells, CHO cells or insect cells. The invention also contemplates using cells that express low levels of HNA-3a or HNA-3b and increasing expression of the endogenous HNA-3a or HNA-3b protein by inserting heterologous promoters or enhancers, or increasing copy number of the HNA-3a or HNA-3b gene.

[00160] Exemplary B cell that may be used in the methods of the invention include EB-3 cells (ATCC CCL85), K-562 cells (ATCC CCL243), RAJI cells (ATCC CCL86), Jiyoye cells (CCL87), IM-9 (ATCC159), Daudi cells (ATCC CCL213), NC-37 cells (ATCC 214), Mo-B cells (ATCC 245), KG-1 cells (ATCC CCL246), H2126 cells (ATCC 256), BL2126 cells (ATCC 256) and MCL-5 cells (ATCC CCL10575). Other exemplary cells that may be used in the methods of the invention include 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), or 3T3 cells (ATCC No. CCL92),

monkey COS-1 (ATCC No. CRL1650) and COS-7 cell (ATCC No. CRL1651), and CV-1 cells (ATCC No. CCL70). In addition, insect cells may be used in the methods of the invention such as SF-9 and HI5 cells.

[00161] Furthermore, cells that endogenously express HNA-3a or HNA-3b at low or moderate levels may be modified to enhance or overexpress endogenous HNA-3a or HNA-3b. For example a promoter, enhancer element, or an exogenous transcription modulatory element is inserted in the genome of the intended cell in proximity and orientation sufficient to influence the transcription of DNA encoding the HNA-3a or HNA-3b polypeptide. The control element controls a portion of the DNA present in the host cell genome. Thus, the expression of the HNA-3a or HNA-3b polypeptide may be achieved not by transfection of DNA that encodes the HNA-3a or HNA-3b gene itself, but rather by the use of targeting DNA (containing regions of homology with the endogenous gene of interest) coupled with DNA regulatory segments that provide the endogenous gene sequence with recognizable signals for transcription.

[00162] The invention also provides for methods of detecting HNA-3a or HNA-3b specific antibodies within a biological sample by contacting a biological sample with an aptamer that mimics an HNA-3a or HNA-3b antigenic fragment or epitope. Aptamers are macromolecules comprising single stranded oligonucleotides that have a sequence-dependent three-dimensional shape that will bind a target protein with high affinity and specificity. The invention contemplates developing and using aptamers that have a sequence that mimics the HNA-3a or HNA-3b epitope and therefore binds to HNA-3a or HNA-3b specific antibodies. These aptamers may be used in any of the methods of the invention to detect the presence of HNA-3a or HNA-3b specific antibodies.

[00163] The aptamers of the invention may comprise single stranded RNA or DNA oligonucleotides ranging in size between 15 and 50 bases that are fused to a scaffold such as thioredoxin. The aptamers will mimic the physical or structural characteristics of the HNA-3a and HNA-3b peptides of the invention. The aptamers are generally derived from combinatorial libraries through an *in vitro* selection process known as Systematic Evolution of Ligands through Exponential enrichment (SELEX). Exemplary methods for identifying and synthesizing aptamers against HNA-3a or HNA-3b antibodies are presented in Lo, *Antibody Engineering: methods*

and protocols Vol 248 of *Methods in Molecular Biology*, Humana Press 2004, Klussmann, *The Aptamer Handbook: functional oligonucleotides and their applications* Wily-VCH, 2006, and Jayasena *Clin. Chem.* 45:168-1650, 1999. Any of the assays described herein may be used to confirm that the contemplated aptamers bind to HNA-3a or HNA-3b specific antibodies.

[00164] Furthermore, the invention provides for methods of detecting HNA-3a or HNA-3b specific antibodies using peptides that mimic the secondary or tertiary structure of the antigenic fragments of HNA-3a or HNA-3b, while differing in primary amino acid structure. The structural characteristics of these peptides cause the HNA-3a or HNA-3b antibodies to cross react with these peptides. These peptides may be identified using standard methods in the art such as phage display peptide libraries and combinatorial libraries.

Methods of Distinguishing HNA-3a or HNA-3b Specific Antibodies

[00165] Any of the techniques described herein to detect HNA-3a or HNA-3b specific antibodies in a biological sample also may be used to distinguish if a particular antibody specifically binds to HNA-3a or HNA-3b. The assays would be carried out with the full length polypeptide or peptides that comprise amino acid 154. In particular, the peptides used in these assays may retain any secondary or tertiary structure that will distinguish the HNA-3a and HNA-3b epitopes.

[00166] Furthermore, assays using cells or tissues known to express HNA-3a or HNA-3b may be used to identify and distinguish HNA-3a or HNA-3b specific antibodies. These assays would include cells transfected or transformed to express HNA-3a or HNA-3b.

[00167] Isolation of these HNA-3a or HNA-3b specific antibodies is useful for carrying out the methods of the invention. In addition, the kits of the invention may comprise isolated HNA-3a or HNA-3b specific antibodies.

Methods of Detecting HNA-3 Protein

[00168] The invention provides for methods of detecting HNA-3a or HNA-3b in a biological sample. The term "HNA-3a" refers to the full length sequence of SEQ ID NO: 1 or at least a fragment of the amino acid sequence of SEQ ID NO: 1. The term "HNA-3b" refers to the full length amino acid sequence of SEQ ID NO: 2 or is at least a fragment of the amino acid sequence of SEQ ID NO: 2. Antigenic

fragments of HNA-3a or HNA-3b that comprise particular epitopes that generate specific antibodies are of interest. For example, regions of the amino acid sequence of SEQ ID NO: 1 or 2 that are exposed to the cell surface are more likely to comprise an epitope.

[00169] Exemplary antigenic fragments that may be used to generate HNA-3a specific antibodies include the amino acid sequence of SEQ ID NO: 13, SEQ ID NO: 14, SEQ ID NO: 15, SEQ ID NO: 16, SEQ ID NO: 17, SEQ ID NO: 18, SEQ ID NO: 25, SEQ ID NO: 27, SEQ ID NO: 34, SEQ ID NO: 35, SEQ ID NO: 36, SEQ ID NO: 37, SEQ ID NO: 38, SEQ ID NO: 39, SEQ ID NO: 40, SEQ ID NO: 41 and SEQ ID NO: 42. Exemplary antigenic fragments that may be used to generate HNA-3b specific antibodies include the amino acid sequence of SEQ ID NO: 19, SEQ ID NO: 20, SEQ ID NO: 21, SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24 and SEQ ID NO: 26.

[00170] The primary structure of CTL2 indicates the existence of multiple polymorphic regions in both the coding region and promoter region of the CTL2 gene. Polymorphisms in the CTL2 gene may provide polymorphic information for HNA-3a or HNA-3b. The differences within the promoter region may cause different transcription efficiency and thus influence the expression of the CTL2 polypeptide. The polymorphisms in the coding region can alter the CTL2 protein conformation and thus the different polymorphic CTL2 proteins become immunogenic to each other. For example, nucleotide 461 of HNA-3a/HNA-3b is polymorphic wherein the HNA-3a allele is a "G" that encodes an arginine at position 154 and the HNA-3b allele is an "A" and encodes a glutamine.

[00171] The human neutrophil antigen HNA-1 has polymorphic epitopes. HNA-1 has three alleles, HNA-1a, HNA-1b and HNA-1c, which are the result of polymorphisms within the FcγRIIIb gene. HNA-1a and HNA-1b differ by four amino acids. The HNA-1c differs from HNA-1b by a single nucleotide substitution (C-to-A) at nucleotide 266 that results in a change of alanine to aspartate at amino acid 78. As described above, the polymorphisms in the CTL2 gene may result in HNA-3 polymorphic epitopes similar to those observed for HNA-1.

[00172] However, the human neutrophil antigen HNA-2 has a monomorphic epitope, in which a portion of the population does not express HNA-2.

HNA-2 has only one well-described allele, HNA-2a. HNA-2a deficiency is caused by a transcription defect which exists among 5-10% individuals. Those individuals may generate HNA-2a antibody when exposed to the HNA-2a antigen. Therefore, it is contemplated that HNA-3A or HNA-3b may have a monomorphic epitope similar to HNA-2.

[00173] The invention also contemplates detecting additional antigens, such as HNA-1, HNA-2, HNA-4, HNA-5 and/or HLA, in combination with detecting HNA-3a or HNA-3b in a biological sample.

[00174] Commercial antibodies that bind to human CTL2 may be used in the methods of the invention. Exemplary commercial antibodies include human monoclonal anti-SLC44A2 antibody (clone 3D11) and human anti-SLC44A2 polyclonal antibody both available from Sigma Aldrich (St. Louis, MO). Additional exemplary antibodies include SLC44A2 antibody (ab57570) available from Abcam (Cambridge, MA), CTL2 monoclonal antibody (M01), clone 3D11 available from Abnova (Walnut, CA), Mouse Polyclonal anti-SLC44A2 - solute carrier family 44, member 2, MaxPab Antibody and Mouse polyclonal anti-CTL2 available from Novus Biologicals (Littleton, CO).

[00175] The antibodies of the invention may be polyclonal antibodies, monoclonal antibodies, antibody fragments which retain their ability to bind their unique epitope (*e.g.*, Fv, Fab and F(ab)2 fragments), single chain antibodies and human or humanized antibodies. Antibodies may be generated by techniques standard in the art using the HNA-3a or HNA-3b epitope on CTL2 or antigenic fragments of SEQ ID NO: 1 or SEQ ID NO: 2. Antibody molecules of the present invention include the classes of IgG (as well as subtypes IgG 1, IgG 2a, and IgG2b), IgM, IgA, IgD, and IgE.

[00176] The antibodies of the invention may be labeled for detection of binding within the biological sample. The antibodies may comprise a radioactive label such as ^{3}H, ^{14}C, ^{32}P, ^{35}S, or ^{125}I. In addition, the labels may be a fluorescent or chemiluminescent compound, such as fluorescein isothiocyanate, phycoerythrin, rhodamine, or luciferin. The labels may be enzymes such as alkaline phosphatase, β-galactosidase, biotin and avidin or horseradish peroxidase (Bayer *et al.*, *Meth. Enz.*, 184:138-163 (1990)).

[00177] The HNA-3a and HNA-3b specific antibodies may be attached to solid substrates such as membranes, beads, filters, glass, silicon, metal, metal-alloy, anopore, polymeric, nylon or plastic for detection of HNA-3a or HNA-3b in a biological sample.

[00178] Antigens of the invention may be a whole protein, a truncated protein, a fragment of a protein or a peptide. Antigens may be naturally occurring, genetically engineered variants of the protein, or may be codon optimized for expression in a particular mammalian subject or host. Generally, a B-cell epitope will include at least about 5 amino acids but can be as small as 3-4 amino acids.

[00179] Normally, an epitope will include between about 7 and 15 amino acids, such as, 9, 10, 12 or 15 amino acids. The term "antigen" denotes both subunit antigens, (*i.e.*, antigens which are separate and discrete from a whole organism with which the antigen is associated in nature). Antibodies such as anti-idiotype antibodies, or fragments thereof, and synthetic peptide mimotopes, that are synthetic peptides which can mimic an antigen or antigenic determinant, are also captured under the definition of antigen as used herein.

[00180] Furthermore, for purposes of the present invention, an "antigen" refers to a protein, which includes modifications, such as deletions, additions and substitutions, generally conservative in nature, to the naturally occurring sequence, so long as the protein maintains the ability to elicit an immunological response, as defined herein. These modifications may be deliberate, as through site-directed mutagenesis, or may be accidental, such as through mutations of hosts which produce the antigens. Antigens of the present invention may also be codon optimized by methods known in the art to improve their expression or immunogenicity in the host.

[00181] Specific binding of an antibody to an HNA-3a or HNA-3b antigen within a biological sample may be carried out using Western blot analysis with immunoblotting, immunocytochemistry, immunohistochemistry, dot blot analysis, flow cytometry, ELISA assays or RIA assays. These techniques and other approaches are conventional in the art (See Sambrook *et al.*, Molecular Cloning: A Laboratory Manual, Cold Springs Harbor Laboratories (New York, 1989).

[00182] In addition, microcytotoxicity assays may be used to detect HNA-3a or HNA-3b in a biological sample. Microcytotoxicity assays involve the mixing of

pure neutrophils derived from the recipient or donor with well characterized typing antibodies that are HNA-3a or HNA-3b immunoreactive. The mixture is incubated for a sufficient time to allow the antibodies to bind to the neutrophil surface HNA antigens. This is followed by addition of complement, which may be derived from, for example, rabbit serum. The addition of complement results in complement fixation and any cells with antibody bound to their cell surface will lyse due to the complement fixation reaction. The quantity of lysed cells can be measured using a variety of different methods. For example, a vital dye which is excluded from live cells but stains dead cells, such as trypan blue, can be added to the sample and the number of dead cells versus live cells can be determined.

Methods of Detecting HNA-3 Nucleic Acids

[00183] The invention provides for methods of detecting HNA-3a nucleic acids in a biological sample using oligonucleotide probes that hybridize to a fragment of the nucleic acid sequence of SEQ ID NO: 3. The invention provides for methods of detecting HNA-3b nucleic acids in a biological sample using oligonucleotide probes that hybridize to a fragment of the nucleic acid sequence of SEQ ID NO: 4. Hybridization of the HNA-3a or HNA-3b specific oligonucleotide probes may be detected using Northern Blot analysis, Southern Blot analysis, slot-blot analysis or *in situ* hybridization analysis or any other methods convention in the art, such as those techniques described in Sambrook *et al.* (Molecular Cloning: A Laboratory Manual, Cold Springs Harbor Laboratories (New York, 1989).

[00184] Preferred oligonucleotide probes are those which hybridize to sequences within the HNA-3a gene that encode the HNA-3a epitope. For example, preferred probes may hybridize to the nucleotides encoding the amino acid sequence of SEQ ID NO: 13, SEQ ID NO: 14, SEQ ID NO: 15, SEQ ID NO: 16, SEQ ID NO: 17, SEQ ID NO: 18, SEQ ID NO: 25, SEQ ID NO: 27, SEQ ID NO: 34, SEQ ID NO: 35, SEQ ID NO: 36, SEQ ID NO: 37, SEQ ID NO: 38, SEQ ID NO: 39, SEQ ID NO: 40, SEQ ID NO: 41 or SEQ ID NO: 42. In addition, the probes of the invention include those which hybridize to introns or 5' and 3' untranscripted regions of the gene encoding HNA-3a.

[00185] Preferred oligonucleotide probes are those which hybridize to sequences within the HNA-3b gene that encode the HNA-3b epitope. For example,

preferred probes may hybridize to the nucleotides encoding the amino acid sequence SEQ ID NO: 19, SEQ ID NO: 20, SEQ ID NO: 21, SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24 or SEQ ID NO: 26. In addition, the probes of the invention include those which hybridize to introns or 5' and 3' untranscripted regions of the gene encoding HNA-3b.

[00186] The oligonucleotide probes may be labeled for detection of hybridization with the DNA extracted from the biological sample. The probes may comprise a radioactive label such as ^{3}H, ^{14}C, ^{32}P, ^{35}S, or ^{125}I. In addition, the labels may be a fluorescent or chemiluminescent compound, such as fluorescein isothiocyanate, phycoerythrin, rhodamine, or luciferin. The labels may be enzymes such as alkaline phosphatase, β-galactosidase, biotin and avidin or horseradish peroxidase (Bayer *et al.*, *Meth. Enz.*, 184:138-163 (1990)).

[00187] An array or microarray refers to a collection of DNA probes or DNA fragments attached to a solid surface, such as glass, plastic or silicon-chip, forming an array for the purpose of expression profiling or monitoring expression level of many genes simultaneously. Arrays of oligonucleotide probes may be used to detect the HNA-3a or HNA-3b DNA in a biological sample. Preferred arrays include probes that hybridize to HNA-1 and/or HNA-2. In addition, arrays that include probes that hybridize to HNA-1, HNA-2 and HLA are preferred. Commercial arrays may be used to detect HNA-3a or HNA-3b that include probes that hybridize to CTL2 such as Affymetrix™ probe sets nos. 58800, 48798 and 56340 which detect SLC44A2 on array nos. U95-C and U95-B, probe set nos. 225175 and 224609 which detect SLC44A2 on array no. U133-B, and probe set nos. 225175 and 224609 which detect SLC44A2 on array no. U133 Plus 2. The arrays of the invention include microarrays, DNA chips, bead arrays, gene chips and biochips.

[00188] The oligonucleotide probes may be attached to solid substrates such as membranes, beads, filters, glass, silicon, metal, metal-alloy, anopore, polymeric, nylon or plastic. The substrates may be chemically treated with chemical prior to attaching probes to enhance binding or to inhibit nonspecific binding during use. Exemplary treatments include coating glass slides with coating of aminoalkyl silanes or polymeric materials such as acrylamide or proteins. The probes may be covalently or non-covalently attached to the substrate.

[00189] The invention also provides for methods of detecting HNA-3a or HNA-3b in a biological sample using an amplification method such as polymerase chain reaction and at least one oligonucleotide primer specific for a fragment of the nucleic acid sequence encoding HNA-3a (SEQ ID NO: 1) or HNA-3b (SEQ ID NO: 2).

[00190] As used herein, "polymerase chain reaction" or "PCR" means a process such as described in U.S. Pat. No. 4,683,195 and U.S. Pat. No. 4,683,202 for the amplification of a segment of DNA using at least two primers and a DNA polymerase. Other nucleic acid amplification methods strand displacement assay 3(SDA, BD ProbeTec(TM), isothermal amplification methods such as helicase-dependent amplification (HDA) and isothermal reverse transcription-thermophilic helicase-dependent amplification (RT-tHDA), rolling circle amplification (RCA) and loop-mediated isothermal amplification (LAMP). These methods may be carried out using techniques standard in the art. The invention also contemplates using sequencing analysis to confirm the identity of DNA fragments amplified using PCR.

[00191] In the methods of the invention, PCR may be carried out using a "PCR reaction mixture" which is a mixture suitable for carrying out PCR. The PCR reaction mixture will contain a suitable amount of a thermostable DNA polymerase, a linear or circular template DNA, preferably double-stranded DNA, to be amplified, a pair of oligonucleotide primers such that one of the primers is configured for annealing to one strand of the template and the other primer is configured for annealing to the other or complementary strand of the template, ATP, suitable amounts of each of the four deoxyribonucleoside triphosphates (dNTPs), and buffers, salts such as $MgCl_2$, preservatives, reducing agents, and water as may be required.

[00192] The oligonucleotide primers of the invention will be designed to specifically amplify the nucleic acid encoding the HNA-3a epitope or the HNA-3b epitope. When designing the oligonucleotide primers, the length of a primer depends upon its (A+T) content, and the Tm of its partner. In addition, the primer should be complex enough to decrease the likelihood of the primer annealing to sequences other than the chosen target. The methods of the invention may utilize primers ranging in length from 10-30 nucleotides, preferably the primers will be 17 nucleotides in length. Generally, a 40%-60% G+C content is recommended for the primers, avoiding internal secondary structure and long stretches of any one base. In addition, primers

should not anneal to regions of secondary structure (within the target) having a higher melting point than the primer.

[00193] Preferred oligonucleotide primers of the invention for genotyping HNA-3a phenotype include primers that amplify the nucleotides encoding amino acid sequence of SEQ ID NO: 13, SEQ ID NO: 14, SEQ ID NO: 15, SEQ ID NO: 16, SEQ ID NO: 17, SEQ ID NO: 18, SEQ ID NO: 25, SEQ ID NO: 27, SEQ ID NO: 34, SEQ ID NO: 35, SEQ ID NO: 36, SEQ ID NO: 37, SEQ ID NO: 38, SEQ ID NO: 39, SEQ ID NO: 40, SEQ ID NO: 41 or SEQ ID NO: 42. In addition, the primers of the invention include those which amplify fragments of SEQ ID NO: 3 that are within introns or the 5' and 3' untranscripted regions of the gene encoding HNA-3a. Exemplary primers include sense primer 5' AGT GGC TGA GCT TCG 3'(SEQ ID NO: 48) and antisense primer 5' GTG CGC CAA TAT CCT CAC TTG 3' (SEQ ID NO: 50).

[00194] Preferred oligonucleotide primers of the invention for genotyping HNA-3b phenotype include primers that amplify the nucleotides encoding amino acid sequence of SEQ ID NO: 19, SEQ ID NO: 20, SEQ ID NO: 21, SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24 or SEQ ID NO: 26. The invention also contemplates primers the amplify a fragment of SEQ ID NO: 4 that comprise codon 154 of SEQ ID NO: 4. In addition, the primers of the invention include those which amplify fragments of SEQ ID NO: 4 that are within introns or the 5' and 3' untranscripted regions of the gene encoding HNA-3b. Exemplary primers include sense primer 5' GAG TGG CTG TGC TTC A 3' (SEQ ID NO: 49) and antisense primer 5' GTG CGC CAA TAT CCT CAC TTG 3' (SEQ ID NO: 50).

[00195] The invention also contemplates methods of detecting HNA-1 nucleic acid in a biological sample in addition to detecting HNA-3 nucleic acid. HNA-1 nucleic acids may be detected using oligonucleotide probes or oligonucleotide primers that detect the unique HNA-1 epitopes (polymorphisms) at nucleotides 141, nucleotide 147, nucleotide 227, nucleotide 277 or nucleotide 349 (HNA-1a vs. HNA-1b) and nucleotide 266 (HNA-1c vs. HNA-1b). The invention further contemplates methods of detecting HNA-2 nucleic acid in a biological sample in addition to detecting HNA-3 nucleic acid. Since HNA-2 only has one allele, the expression of the HNA-2 can be detected with oligonucleotide probes or primers homologous to any coding region.

[00196] Deoxyribonucleoside triphosphates (dNTPs) include 2'-deoxyadenosine 5'-triphosphate (dATP), 2'-deoxycytidine 5'-triphosphate (dCTP), 2'-deoxyguanosine 5'-triphosphate (dGTP), and 2'-deoxythymidine 5'-triphosphate (dTTP). Generally, the concentration of dNTP in the PCR reaction is about 200 μM. It is important to keep the four dNTP concentrations above the estimated Km of each dNTP (10 μM-15 μM) and balanced for best base incorporation. Lowering the concentrations of dNTP and magnesium ion by an equal molar concentration can improve fidelity. Modified dNTPs (dig-11-dUTP, 5-bromo-dUTP, inosine, biotin-11-dUTP, biotin-16-dUTP and 7-deaza dGTP) and 2'-deoxyuridine 5'-triphosphate (dUTP) also may be used.

Kits

[00197] The invention provides for kits to carry out any of the methods of the invention. Kits according to the invention comprises components for detecting HNA-3a or HNA-3b specific antibodies in a biological sample. The kit can comprise an isolated or recombinant HNA-3a or HNA-3b polypeptide or an antigenic fragment thereof that forms a complex with HNA-3a or HNA-3b specific antibodies in a biological sample and a known HNA-3a or HNA-3b specific antibody for a positive control. The invention further provides for kits for detecting antibodies specific for HNA-1 and HNA-2 in addition to antibodies specific for HNA-3a or HNA-3b, which will contain Fc-γ receptor IIIb or antigenic fragments thereof for HNA-1 detection and CD177 or antigenic fragments thereof for detection of HNA-2 and known antibodies that are specific for HNA-1 and HNA-2. The invention further provides for kits for detecting antibodies specific for HNA-4 and/or HNA-5 in addition to antibodies specific for HNA-3a or HNA-3b, which will contain CD11b (CR3) or antigenic fragments thereof for HNA-4 detection and CD11a (LFA-1) or antigenic fragments thereof for detection of HNA-5 and known antibodies that are specific for HNA-4 and HNA-5. Furthermore, the invention provides for kits for detecting antibodies specific for HLA in a biological sample in addition to antibodies specific for HNA, which will contain polypeptides containing the HLA antigen and known antibodies that are specific for HLA.

[00198] Kits useful for detecting antibodies specific for HNA-3a or HNA-3b and optionally antibodies specific for other HNA and/or HLA antigens may further comprise any components necessary to carry out the detection assays that are

conventional in the art. For example, the kits may comprise the components necessary to carry out SRID, ELISA, HAI, MAIGA assay, GIIFT, MLAT, and GAT.

[00199] Kits according to the invention comprises components for detecting HNA-3a or HNA-3b in a biological sample. The kit can comprise an antibody that specifically binds to HNA-3a or HNA-3b, and an isolated or recombinant protein or a peptide comprising the HNA-3a or HNA-3b epitope for the antibody to use as a positive control. The invention further provides for kits for detecting HNA-1 and HNA-2 in addition to HNA-3a or HNA-3b, which will contain antibodies specific for HNA-1 and/or HNA-2 and recombinant proteins or peptides corresponding to the HNA-1 and HNA-2 epitopes. Furthermore, the invention provides for kits for detecting HLA in a biological sample in addition to HNA, which will contain antibodies specific for HLA and recombinant protein or peptides that correspond to the HLA epitope.

[00200] Kits useful for detecting HNA-3a or HNA-3b and optionally other HNA and/or HLA antigens may further comprise any components necessary to carry out the detection assays that are conventional in the art. For example, the kits may comprise buffers, loading dyes, gels such as polyacrylamide gels and molecular weight markers preparing SDS-PAGE gels to carry out Western blots. The kits may also comprise filters, membranes blocking buffers, control buffers, isotype control antibodies, wash buffers or buffers and reagents for detection to carry out immunoblotting or dot blotting analysis such as labeled secondary antibodies. The kit may also comprise fixing reagents, blocking buffers, control buffers, wash buffers, staining dyes and detection reagents including anti-idiospecific antibodies to carry out immunocytochemistry or immunohistochemistry. Furthermore, the kits may comprise the necessary reagents and tools to carryout flow cytometry, ELISA assays, RIA assays or microtoxicity assays.

[00201] Kits according to the invention comprise components for detecting HNA-3a or HNA-3b nucleic acid in a biological sample. The kit will comprise oligonucleotide probes that hybridize to a fragment of HNA-3a nucleic acid of SEQ ID NO: 3 and a fragment of the nucleic acid of SEQ ID NO: 3 that hybridizes to the oligonucleotide probes to use as a positive control. Alternatively, the kit will comprise oligonucleotide probes that hybridize to a fragment of HNA-3b nucleic acid of SEQ ID NO: 4 and a fragment of the nucleic acid of SEQ ID NO: 4 that hybridizes

to the oligonucleotide probes to use as a positive control. The invention further provides for kits to detect HNA-1 and HNA-2 nucleic acid, in addition to HNA-3a or HNA-3b nucleic acid in a biological sample, which will contain oligonucleotide probes that are specific for HNA-1 and HNA-2, and corresponding fragments of the HNA-1 and HNA-2 nucleic acids as positive controls. In addition, the invention provides for kits for detecting HLA nucleic acid in addition to HNA nucleic acid in a biological sample, which will contain oligonucleotide probes specific for HLA nucleic acid and corresponding fragments of HLA nucleic acid as positive controls.

[00202] Alternatively, the kits for detecting HNA-3a nucleic acids will comprise oligonucleotide primers for amplifying a fragment of the HNA-3a nucleic acid of SEQ ID NO: 3, and a fragment of the HNA-3a nucleic acid that is known to be amplified by the oligonucleotide primers to serve as a positive control. The kits for detecting HNA-3b nucleic acids will comprise oligonucleotide primers for amplifying a fragment of the HNA-3b nucleic acid of SEQ ID NO: 4, and a fragment of the HNA-3b nucleic acid that is known to be amplified by the oligonucleotide primers to serve as a positive control. The invention further provides for kits that comprise oligonucleotide primers specific for HNA-1 and HNA-2 nucleic acids, and the fragments of the nucleic acids of HNA-1 and HNA-2 that are known to be amplified by the oligonucleotide primers. In addition, the invention provides for kits containing oligonucleotide primers specific for HLA nucleic acid in addition to oligonucleotide primers specific for HNA nucleic acids and a fragment of the HLA nucleic acid that is amplified by the oligonucleotide primers.

[00203] The kits of the invention may also comprise the components necessary to carry out PCR or other amplification methods. For example, the kit may contain one or more of the following: Taq polymerase or another thermostable polymerase, ATP, suitable amounts of each of the four deoxyribonucleoside triphosphates (dNTPs), and buffers, salts such as MgCl2, preservatives, reducing agents or water.

[00204] Kits useful for detecting HNA-3a or HNA-3b nucleic acids and optionally other HNA and/or HLA nucleic acids may further comprise any components necessary to carry out the detection assays that are conventional in the art. For example, the kits may comprise the reagents necessary for extracting the nucleic acids from the biological sample. The kits may comprise buffers, loading

dyes, gels, molecular weight markers, membranes, filters, blocking buffers and detection reagents for Northern Blot analysis, Southern Blot analysis, slot-blot analysis or *in situ* hybridization analysis and any other methods convention in the art, such as those techniques.

[00205] The present invention is illustrated by the following examples that are not intended to limit the invention. Example 1 describes isolation of granulocytes from donor blood. Example 2 described the method used to obtain HNA-3a positive and negative plasma. Example 3 describes biotinylation of granulocyte surface proteins. Example 4 describes a method of incubating granulocytes with plasma. Example 5 describes fluorescence activated cell sorting using flow cytometry. Example 6 describes a method of carrying out immunoprecipitation using magnetic beads. Example 7 describes a method of carrying out SDS-PAGE and Western blotting. Example 8 describes a method of using Fourier transform ion cyclotron resonance mass spectrometry (FTICR-MS). The experiments described in Examples 1-8 were used to identify the amino acid sequences of HNA-3a and HNA-3b, and these methods may be used to carry out the methods of the invention. Example 9 describes the heterologous expression of HNA-3a and HNA-3b, and these polypeptides may be used in the methods of the invention. Example 10 describes heterologous expression of HNA-3a peptide fragments, and these peptide fragments were used to map the epitope of HNA-3a, and these peptides may be used in the methods of the invention. Example 11 describes affinity purification of HNA-3a antibodies from human blood plasma. Example 12 described identification of antigenic fragments of HNA-3a, and these fragments may be used to carry out the methods of the invention. Example 13 describes a method of genotyping for HNA-3a and HNA-3b, which may be used to carry out the methods of the invention. Lastly, Example 14 describes methods of making anti-HNA-3 antibodies, and these antibodies may be used to carry out the methods of the invention.

EXAMPLES

Example 1
Granulocyte Isolation

[00206] Selected donor blood was mixed with 1.25% EDTA and 0.5% dextran. After sedimentation, the supernatant was further used for Ficoll density centrifugation. After washing of the obtained pellet, a haemolysis of the erythrocytes

took place. Remaining granulocytes were washed and served in various cell concentrations as starting material.

Example 2
Obtaining HNA-3a Positive and Negative Plasma

[00207] Selected donor blood was mixed with 1.25% EDTA, then the cells were separated by centrifugation. The supernatant served as corresponding plasma.

Example 3
Biotinylation of Granulocyte Surface Proteins

[00208] For the analysis by Western blots, the purified granulocytes were biotinylated using the EZ-Link Sulfo-NHS-LC-LC-biotin (PIERCE; Rockford, IL).

Example 4
Incubation of the Granulocytes with Plasma

[00209] Granulocytes (biotinylated or non-biotinylated) were incubated with HNA-3a-positive or –negative plasma for at least 30 minutes at 37°C. After washing the batch, either a FACS analysis of whole cells took place, or the cell lysis by means of buffer containing Triton-X100 was carried out. After centrifuging off the cell debris, the supernatant containing protein was analyzed.

Example 5
Fluorescence Activated Cell Sorting (FACS analysis) Flow Cytometry

[00210] Isolated granulocytes of HNA-3a-positive and -negative donors were incubated with plasma (with and without anti-HNA-3a antibodies) and washed. Subsequently, the cells were incubated with fluorescein isothiocyanate (FITC) labeled rabbit F(ab')2-anti-human IgG. After washing, the cell suspension was examined with FACS to determine for the fluorescence intensity of the granulocytes. High intensities pointed to HNA-3a-positive results.

Example 6
Immunoprecipitation by means of magnetic beads

[00211] Protein-G coated magnetic beads were coupled with anti-human IgG (Fc specific). After washing, the beads were incubated with the supernatant containing protein, as described in Example 4. After renewed washing and demagnetizing of the beads, the proteins were eluted using sample buffer containing SDS, (for analysis via SDS-PAGE and Western blot) or digested directly in buffer

containing trypsin (for analysis via Fourier transform ion cyclotron resonance mass spectrometry (FTICR-MS)).

Example 7
SDS-PAGE / Western Blot

[00212] The eluent of the immunoprecipitation (biotinylated batches) was separated by SDS-PAGE (7.5% separation gels) and blotted on nitrocellulose membrane. For coupling to the biotinylated proteins, the membrane, after blocking and washing steps, was incubated with alkaline phosphatase (AP) bonded to streptavidin. The detection took place by the addition of NBT (Nitro-Blue Tetrazolium Chloride)/BCIP (5-Bromo-4-Chloro-3'-Indolyphosphate p-Toluidine Salt) for 1-15 minutes.

Example 8
Fourier Transform Ion Cyclotron Resonance (FTICR-MS)

[00213] The tryptic digestion of the immunoprecipitated proteins (not biotinylated batches) was pre-cleaned using C18 material (ZipTip™) and analyzed by MS. The evaluation of the peptide spectra took place by data bank comparisons using of SEQUEST Sorcerer- and Scaffold2 software (Data bank: uniprot-sprot-human_re154).

Example 9
Heterologous Expression of HNA-3a and HNA-3b

[00214] A cDNA clone having a DNA sequence encoding the HNA-3a protein (SEQ ID NO: 1) was expressed in *E. coli* and in CHO cells. The synthesized protein was separated with SDS-PAGE gel electrophoresis (as described in Example 7) and the specificity was shown by binding of human anti-HNA-3a antibodies in Western blot. An analogous procedure was carried out for a cDNA clone with the DNA sequence for the expression of the protein HNA-3b (SEQ ID NO: 2).

[00215] The HNA-3a protein was expressed with a His-tag to allow for purification. In addition, solid phase ELISA was used to demonstrate binding of the recombinant human anti-HNA-3a or HNA-3b protein with its respective antibody.

Example 10
Heterologous Expression of Peptide Fragments

[00216] HNA-3a DNA fragments were cloned using the pGEX-2TK vector (GE Healthcare, Chalfont St Giles, UK) and the restriction enzymes BamHI and HindII (Roche, Basel, Switzerland). The cDNA clone NM_020428.2 (OriGene, Rockville, MD) was used as template DNA to generate Glutathione S-Transferase gene region (GST) fusions. DNA fragments encoding amino acids 22-231 of SEQ ID NO: 1 (denoted as "HNA-3a(22-231)"), and amino acids 145-167 of SEQ ID NO: 1 (denoted as "HNA-3a(145-167)") were inserted into the vector JHC27 to encode GST-HNA-3a fusion peptides. DNA fragments encoding amino acids 114-164 of SEQ ID NO: 1 (denoted as "HNA-3a(114-164)") were inserted into the pTB25 vector to encode the GST fusion peptide GST-HNA-3a(114-164).

[00217] *E. coli* BL21-Gold(DE3) cells (Stratagene, La Jolla, CA) were transformed with the above described vectors and grown at 37 C in YTG medium containing 100 µg/ml ampicillin to an OD600=0.7. Subsequently, the cells were incubated with Isopropyl β-D-1-thiogalactopyranoside (IPTG) (1 mM; 1 h), followed by centrifugation (7,000g; 10 min) and washing in ice-cold PBS. The cells were then sonicated in denaturing buffer (8 M Urea), centrifuged (12,000g) and the supernatant was dialyzed against denaturing-buffer (Tris-glycerin). The fusion protein supernatants were loaded onto a glutathione sepharose column and washed with PBS. A solution of 50 mM Tris-HCl (pH 8) containing 10 mM reduced glutathione was used for clution of the GST-HNA-3a fusion peptides.

Example 11
Affinity Purification of HNA-3a Antibodies from Human Blood Plasma

[00218] For affinity purification of HNA-3a antibodies from human blood plasma, GST- HNA-3a(114-164) was produced as described in Example 10), concentrated and dialyzed against coupling buffer (0.2 M $NaHCO_3$, 0.5 M NaCl, pH 8.3). A HiTrap™ NHS-activated HP column (GE Healthcare, Uppsala, Sweden) was equilibrated with 6 ml ice-cold 1 mM HCl; and subsequently, 1 ml of the concentrated GST-HNA-3a(114-164) peptide was injected (3 mg / ml) onto the column. After 30 minutes incubation at 25°C, the column was washed according to manufacturer's instructions.

[00219] Human plasma known to be positive for HNA-3a antibodies was diluted in wash buffer (1:25) (20 mM NaH2PO4, 150 mM NaCl, pH 7.4) and 50 ml was loaded onto the column at a flow rate of 0.8 ml / min. After washing with

washing buffer, the antibodies were eluted from the column using 10 ml 0.1 M glycine buffer (pH 2.7). Aliquots of the collected fractions (750 µl) were mixed with 250 µl neutralization buffer (1 M Tris-HCl, pH 9). Fractions containing a protein concentration greater than 50 µg/ml were pooled and dialyzed against wash buffer.

[00220] A Granulocyte Activation Assay was used to test whether HNA-3a induced granulocyte aggregation. Granulocytes isolated from HNA-3a positive donors (as described in Example 1) were incubated with human plasma (30 min, 37°C) known to contain anti-HNA-3a antibodies, and subsequently washed (140g, 5 min). Bound antibodies were obtained using system for acid elution according to the manufacturer's instructions (BAG, Lich, Germany).

[00221] The HNA-3a specific antibodies, of the eluted antibodies obtained by affinity purification in combination with the GST- HNA-3a(114-164) peptide in the Granulocyte Activation Assay. The negative controls for this assay were the GST-fusion protein alone, a control serum containing HNA-3b antibodies and a negative control antibody (no HNA-3 antibodies). HNA-3a antibodies activated granulocytes to aggregation only in its native form and had little effect in denatured formed. Fixed granulocyte agglutinates were not positive.

Example 12
Identification of Antigenic Fragments of HNA-3a

[00222] In order to map the epitope of the HNA-3a amino acids sequence (SEQ ID NO: 1), recombinant peptides comprising extracellular fragments of the HNA-3a amino acid sequence were generated as GST-fusion peptides as described in Example 10. Reactivity of these peptides with HNA-3a sera as determined by Western blot is provided in Table 1 below

SEQ ID NO:	Amino acids of HNA-3a (SEQ ID NO: 1)	Reactivity with HNA-3a
27	55-231	++
14	55-183	++
28	55-105	--
29	105-153	--
30	155-200	--
31	190-231	--
32	150-159	--
33	144-167	(+)
34	134-174	++
35	124-183	++

36	114-194	++
37	105-200	++
38	94-214	++
39	84-220	++
40	44-164	++
41	75-164	++
42	94-164	++
16	114-164	++
43	134-164	(+)
44	142-183	--
45	142-200	--
46	142-222	--
47	142-231	--

[00223] Isolated granulocytes from a representative HNA-3a positive (HNA-3a+) donor and a representative HNA-3a negative donor (HNA-3a-) were incubated with plasma known to contain HNA-3a antibodies (+) and with plasma known to be free of HNA-3a antibody (-). HNA-3a protein was then immunoprecipitated using anti-human IgG, coupled with Protein G coupled magnetic beads. For each donor / plasma combination was a sample was deglycosylated with Peptide-N-Glycosidase F (PNGase F).

[00224] The immunoprecipitated proteins were separated by SDS-PAGE and transferred to nitrocellulose using procedures well known in the art, and analyzed by imunoblotting with a HNA-3a+ and HNA-3a- plasma. The proteins were initially visualized using alkaline phosphatase conjugated to streptavidin (a) or anti-human IgG (b) and then incubated with NBT/BCIP for detection.

[00225] The GST-fusion peptides comprising amino acids 145-167 of SEQ ID NO: 1 (HNA-3a(145-167); SEQ ID NO: 48) and amino acids 55-231 of SEQ ID NO: 1 (HNA-3a(55-231); SEQ ID NO: 27) were analyzed using an immunoblot. A 50 kDa band represents the GST-HNA-3a(55-231) peptide bound to an antibody present in HNA-3a positive sera. A smaller band of 36 kDa represents the GST-HNA-3a(145-167) peptide bound to an antibody present in HNA-3a positive sera. Only antibodies from HNA-3+ plasma reacted with the HNA-3a fusion peptides. Antibodies from the HNA-3a – plasma did not react with the HNA-3a fusion proteins. The binding to the longer HNA-3a amino acids 55-231 peptide is shown for two HNA-3a positive plasmas and the binding for the smaller fragment HNA-3a amino acids 145-167 is displayed for HNA-3a positive plasma.

[00226] The GST-fusion peptide HNA-3a amino acids 145 -167 also induced aggregation in HNA-3a positive granulocytes.

[00227] This analysis demonstrated that the critical minimum antigenic fragment of the HNA-3a polypeptide sequence is amino acids 154-164 of SEQ ID NO: 1 (SEQ ID NO: 25).

[00228] This method may be used to identify the antigenic fragments of HNA-3a or any other antigen such as HNA-1, HNA-2, HNA-5 or HLA.

Example 13
Genotyping for HNA-3a and HNA-3b

[00229] PCR for HNA-3 polymorphisms were carried out as follows. Aliquots of 50-100 ng DNA were amplified using 0.5 pmol allele-specific sense primers (5'-AGT GGC TGA GGT GCT TCG-3;SEQ ID NO: 49; HNA-3a) or 5'-GAG TGG CTG AGG TGC TTC A-3'; SEQ ID NO: 50; HNA-3b)) and a partial intronic antisense primer (5'-GTG CGC CAA TAT CCT CAC TTG-3'(SEQ ID NO: 51)). Polymerase chain reaction (PCR) was performed with 0.2 mmol deoxyribonucleotide triphosphate and 2.0 units Hot Start Taq DNA Polymerase (GeneCraft, Germany) on a Thermal Cycler (GeneAmp™ PCR System 2700, Applied Biosystems, Germany) in a total volume of 20 µL. After heating at 95°C for 10 minutes, 2-step PCR was performed under the following conditions: denaturing (30 seconds, 95° C), annealing (40 seconds, 64° C), extension (30 seconds, 72° C) for 10 cycles, denaturing (30 seconds, 95° C), annealing (30 seconds, 61° C), extension (30 seconds, 72° C) for 20 cycles, and final extension (5 minutes, 72° C). As internal positive control, 0.0625 pmol human growth hormone (hGH) primers amplifying a 439-bp fragment of the *hGH* gene were used (5'-CAG TGC CTT CCC AAC CAT TCC CTT A-3' (SEQ ID NO: 52), 5'-ATC CAC TCA CGG ATT TCT GTT GTG TTT C-3' (SEQ ID NO: 53)). PCR products (291 bp) were analysed on 1.5% agarose gels using Tris borate EDTA buffer (TBE-buffer; 5 Prime, Germany).

[00230] This method may be used to genotype for any antigen allele such as HNA-1, HNA-2, HNA-4, HNA-5 or HLA.

Example 14
Methods of Making anti-HNA-3 Antibodies

[00231] Antibodies specific for HNA-3a or HNA-3b protein may be obtained by immunization with peptide comprising a particular HNA-3 epitope. Suitable procedures for generating antibodies include those described in Hudson and Hay, Practical Immunology, 2nd Edition, Blackwell Scientific Publications (1980). Exemplary antigenic fragments that may be used to generate HNA-3a specific antibodies include SEQ ID NO: 13, SEQ ID NO: 14, SEQ ID NO: 15, SEQ ID NO: 16, SEQ ID NO: 17, SEQ ID NO: 18, SEQ ID NO: 25, SEQ ID NO: 27, SEQ ID NO: 34, SEQ ID NO: 35, SEQ ID NO: 36, SEQ ID NO: 37, SEQ ID NO: 38, SEQ ID NO: 39, SEQ ID NO: 40, SEQ ID NO: 41 and SEQ ID NO: 42. Exemplary antigenic fragments that may be used to generate HNA-3b specific antibodies include SEQ ID NO: 19, SEQ ID NO: 20, SEQ ID NO: 21, SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24 and SEQ ID NO: 26.

[00232] In one procedure for the production of antibodies, animals (typically mice or rabbits) are injected with a HNA-3a or HNA-3b epitope containing peptide and the resulting polyclonal antibodies in the serum are isolated. In addition, those animals with sufficient serum titer levels as determined by ELISA are selected for hybridoma production. Spleens of immunized animals are collected and prepared as single cell suspensions from which splenocytes are recovered. The splenocytes are fused to mouse myeloma cells (such as Sp2/0-Ag14 cells; ATCC no. CRL-1581), allowed to incubate in DMEM with 200 U/ml penicillin, 200 g/ml streptomycin sulfate, and 4 mM glutamine, and then incubated in HAT selection medium (Hypoxanthine; Aminopterin; Thymidine). After selection, the tissue culture supernatants are taken from each well containing a hybridoma and tested for anti-HNA-3a or HNA-3b antibody production by ELISA.

[00233] Alternative procedures for obtaining anti-HNA-3a or anti-HNA-3b antibodies may also be employed, such as the immunization of transgenic mice harboring human Ig loci for the production of human antibodies, and the screening of synthetic antibody libraries, such as those generated by mutagenesis of an antibody variable domain.

[00234] Furthermore, human antibodies can be produced from phage-display libraries (Hoogenboom *et al., J. Mol. Biol.* 227:381 (1991); Marks *et al., J. Mol. Biol.* 222:581 (1991). These processes mimic immune selection through the display of antibody repertoires on the surface of filamentous bacteriophage, and

subsequent selection of phage by their binding to an antigen of choice. One such technique is described in PCT Application no. PCT/US98/17364, which describes the isolation of high affinity and functional agonistic antibodies for MPL- and msk-receptors using such an approach.

[00235] These methods are used to generate antibodies specific for any antigenic protein such as HNA-1, HNA-2, HNA-4, HNA-5 or HLA.

[00236] Numerous modifications and variations in the practice of the invention are expected to occur to those skilled in the art upon consideration of the presently preferred embodiments thereof. Consequently, the only limitations which should be placed upon the scope of the invention are those which appear in the appended claims.

WE CLAIM:

1. A method of determining whether a donor tissue intended for transplant or transfusion will induce transfusion related acute lung injury (TRALI) or graft versus host disease (GVHD) in a human recipient wherein the human recipient expresses the HNA-3a antigen, comprising

    a. contacting a sample of tissue intended for transplant or transfusion in the human subject with a polypeptide comprising the amino acid sequence of SEQ ID NO: 1 or an antigenic fragment thereof comprising arginine at amino acid 154 to form a complex with HNA-3a specific antibodies in the sample, and

    b. detecting the complex, wherein the presence of the complex indicates that the donor tissue is likely to induce TRALI or graft versus host disease (GVHD) in a human recipient that expresses an HNA-3a antigen.

2. A method of determining whether a donor tissue intended for transplant or transfusion will induce transfusion related acute lung injury (TRALI) or graft versus host disease (GVHD) in a human recipient wherein the human recipient expresses the HNA-3b antigen, comprising

    a. contacting a sample of tissue intended for transplant or transfusion in the human subject with a polypeptide comprising the amino acid sequence of SEQ ID NO: 2 or an antigenic fragment thereof comprising glutamine at amino acid 154 to form a complex with HNA-3b specific antibodies in the sample, and

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b. detecting the complex, wherein the presence of the complex indicates that the donor tissue is likely to induce TRALI or graft versus host disease (GVHD) in a human recipient that expresses an HNA-3b antigen.

3. A method of determining the susceptibility of a human transplant or transfusion recipient for rejecting transplanted or transfused tissue, wherein the donor tissue contains HNA-3a polypeptide or an antigenic fragment thereof comprising arginine at amino acid 154, comprising

a. contacting a biological sample from the human transplant or transfusion recipient prior to transplant with a polypeptide comprising the amino acid sequence of SEQ ID NO: 1 or an antigenic fragment thereof comprising arginine at amino acid 154 to form a complex with HNA-3a specific antibodies in the biological sample, and

b. detecting the complex, wherein the presence of the complex in the biological sample indicates that the human transplant or transfusion recipient is susceptible for rejecting the transplanted or transfused tissue.

4. A method of determining the susceptibility of a human transplant or transfusion recipient for rejecting transplanted or transfused tissue, wherein the donor tissue contains HNA-3b polypeptide or an antigenic fragment thereof comprising glutamine at amino acid 154, comprising

a. contacting a biological sample from the human transplant or transfusion recipient prior to transplant with a polypeptide comprising the amino acid sequence of SEQ ID NO: 2 or an antigenic fragment thereof comprising glutamine at amino acid 154 to form a complex with HNA-3b specific antibodies in the biological sample, and

b. detecting the complex, wherein the presence of the complex in the biological sample indicates that the human transplant or transfusion recipient is susceptible for rejecting the transplanted or transfused tissue.

5. The method of claim 1 or 2 further comprising one or more of the steps of

c) contacting the sample with Fc-γ receptor IIIb polypeptide to form a complex with HNA-1 specific antibodies in the sample,

d) contacting the sample with CD177 polypeptide to form a complex with HNA-2 specific antibodies in the sample,

e) contacting the sample with CD11b polypeptide or to form a complex with HNA-4 specific antibodies in the sample,

f) contacting the sample with CD11a polypeptide to form a complex with HNA-5 specific antibodies in the sample, or

g) contacting the sample with an HLA antigen to form a complex with HLA specific antibodies in the sample, and

h) detecting the complex, wherein the presence of one or more of the complexes of (d) to (g) and a complex comprising i) a polypeptide comprising the amino acid sequence of SEQ ID NO: 2 or an antigenic fragment thereof comprising glutamine at amino acid 154 and an HNA-3b specific antibodies indicates that the sample is likely to induce TRALI or GVHD in a human recipient.

6. The method of claim 3 or 4 further comprising one or more of the steps of

c) contacting the sample with Fc-γ receptor IIIb polypeptide to form a complex with HNA-1 specific antibodies in the sample,

d) contacting the sample with CD177 polypeptide to form a complex with HNA-2 specific antibodies in the sample,

e) contacting the sample with CD11b polypeptide or to form a complex with HNA-4 specific antibodies in the sample,

f) contacting the sample with CD11a polypeptide to form a complex with HNA-5 specific antibodies in the sample, or

g) contacting the sample with an HLA antigen to form a complex with HLA specific antibodies in the sample, and

h) detecting the complex, wherein the presence of one or more of the complexes of (d) to (g) and a complex comprising i) a polypeptide comprising the amino acid sequence of SEQ ID NO: 2 or an antigenic fragment thereof comprising glutamine at amino acid 154 and an HNA-3b specific antibodies indicates that the human transplant or transfusion recipient is susceptible for rejecting the transplanted or transfused tissue

7. A method of determining the susceptibility of a human transplant or transfusion recipient for developing transfusion related acute lung injury (TRALI), wherein the donor tissue contains anti-HNA-3a specific antibodies or HNA-3b specific antibodies, comprising

a) contacting a biological sample from a human transplant or transfusion recipient prior to transplantation or transfusion with an antibody that specifically binds to a polypeptide comprising the amino acid sequence of SEQ ID NO: 1 or an antigenic fragment thereof comprising arginine at amino acid 154 to form a complex with HNA-3a in the biological sample or an antibody that specifically binds to a polypeptide comprising the amino acid sequence of SEQ ID NO: 2 or antigenic fragment thereof comprising glutamine at amino acid 154 to form a complex with HNA-3b in the biological sample, and

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b) detecting the complex, wherein the presence of the complex indicates that the human transplant or transfusion recipient is susceptible for developing TRALI.

8. The method of claim 7 further comprising one or more of the steps of

c) contacting the sample with an antibody that specifically binds to HNA-1 to form a complex with HNA-1 in the sample,

d) contacting the sample with an antibody that specifically binds to HNA-2 to form a complex with HNA-2 in the sample,

e) contacting the sample with an antibody that specifically binds to HNA-4 to form a complex with HNA-4 in the sample,

f) contacting the sample with an antibody that specifically binds to HNA-5 to form a complex with HNA-5 in the sample, or

g) contacting the sample with an antibody that specifically binds to HLA antigen to form a complex with HLA in the sample, and

h) detecting the complex, wherein the presence of one or more of the complexes of (d) to (g) and a complex comprising an antibody that specifically binds to a polypeptide comprising the amino acid sequence of SEQ ID NO: 1 or an antigenic fragment thereof comprising arginine at amino acid 154 and HNA-3a or a complex comprising in an antibody that specifically binds to a polypeptide comprising the amino acid sequence of SEQ ID NO: 2 or antigenic fragment thereof comprising glutamine at amino acid 154 and HNA-3b_indicates the human transplant or transfusion recipient is susceptible for developing TRALI.

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9. The method of any one of claims 1-7, wherein the antibody comprises a label selected from the group consisting of a radioactive label, fluorescent label, enzymatic label, avidin label and biotin label.

10. A method of determining whether a donor tissue intended for transplant or transfusion is likely to be rejected in a human recipient wherein the human recipient expresses HNA-3a specific antibodies or HNA-3b specific antibodies, comprising

a) extracting nucleic acids from a sample of tissue intended for transplant or transfusion,

b) contacting the nucleic acids with an oligonucleotide probe that hybridizes to a sequence within SEQ ID NO: 3 that encodes an arginine at position 154 of the amino acid sequence of SEQ ID NO: 1 or to a sequence within SEQ ID NO: 4 that encodes a glutamine at position 154 of the amino acid sequence of SEQ ID NO: 2 under stringent hybridization condition wherein the conditions comprise hybridization in 0.02 M – 0.15 M NaCl at about 50°C to 70°C, or amplifying a sequence within SEQ ID NO: 3 that encodes an arginine at position 154 of the amino acid sequence of SEQ ID NO: 1 or a sequence within SEQ ID NO: 4 that encodes a glutamine at position 154 of the amino acid sequence of SEQ ID NO: 2 from the extracted nucleic acids using at least one oligonucleotide primer specific for an HNA-3a or HNA-3b nucleic acid, and

c) detecting the presence of HNA-3a or HNA-3b nucleic acid in the sample or detecting hybridization of the probe to the nucleic acids, wherein hybridization of the probe indicates the presence of an HNA-3a nucleic acid or HNA-3b nucleic acid in the sample, and wherein the presence of HNA-3a or HNA-3b nucleic acid in the sample indicates that the sample is likely to be rejected in a human recipient that expresses HNA-3a or HNA-3b specific antibodies.

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11. A method of determining the susceptibility of a human transplant or transfusion recipient for developing transfusion related acute lung injury (TRALI), wherein the donor tissue contains HNA-3a specific antibodies, comprising

a) extracting nucleic acids from a biological sample from a human transplant or transfusion recipient prior to transplantation or transfusion,

b) contacting the nucleic acids with an oligonucleotide probe that hybridizes to a sequence within SEQ ID NO: 3 that encodes an arginine at position 154 of the amino acid sequence of SEQ ID NO: 1 under stringent hybridization condition wherein the conditions comprise hybridization in 0.02 M – 0.15 M NaCl at about 50°C to 70°C, or amplifying a sequence within SEQ ID NO: 3 that encodes an arginine at position 154 of the amino acid sequence of SEQ ID NO: 1 using at least one oligonucleotide primer specific for a HNA-3a nucleic acid in the biological sample, and

c) detecting the presence of a fragment of the HNA-3a nucleic acid in the biological sample or detecting hybridization of the probe to the nucleic acid wherein hybridization of the probe to the nucleic acids indicates the presence of HNA-3a nucleic acid in the biological sample and wherein the presence of HNA-3a nucleic acid in the biological sample indicates that a human transfusion or transplant recipient is susceptible for developing TRALI.

12. A method of determining the susceptibility of a human transplant or transfusion recipient for developing transfusion related acute lung injury (TRALI), wherein the donor tissue contains HNA-3b specific antibodies, comprising

a) extracting nucleic acids from a biological sample from a human transplant or transfusion recipient prior to transplantation or transfusion,

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b) contacting the nucleic acids with an oligonucleotide probe that hybridizes to a sequence within SEQ ID NO: 4 that encodes a glutamine at position 154 of the amino acid sequence of SEQ ID NO: 2 under stringent hybridization condition wherein the conditions comprise hybridization in 0.02 M – 0.15 M NaCl at about 50°C to 70°C, or amplifying a sequence SEQ ID NO:4 that encodes a glutamine at position 154 of the amino acid sequence of SEQ ID NO: 2 from the extracted nucleic acids using at least one oligonucleotide primer specific for a HNA-3a or HNA-3b nucleic acid in the biological sample, and

c) detecting the presence of a fragment of the HNA-3b nucleic acid in the biological sample or detecting hybridization of the probe to the nucleic acid wherein hybridization of the probe to the nucleic acids indicates the presence of HNA-3b nucleic acid in the biological sample and wherein the presence HNA-3b nucleic acid in the biological sample indicates that a human transfusion or transplant recipient is susceptible for developing TRALI.

13. The method of any one of claims 10-12, wherein the oligonucleotide probes are affixed to a substrate selected from the group consisting of membranes, filters, beads and chips.

14. The method of any one of claims 1-13, wherein the tissue sample or biological sample is selected from the group consisting of blood, blood derivatives, plasma, and serum.

15. A kit comprising

a) a polypeptide comprising the amino acid sequence of SEQ ID NO: 2 or an antigenic fragment thereof that comprises a glutamine at amino acid 154,

b) one or more polypeptides or antigenic fragments thereof selected from the group consisting of HNA-3a polypeptide of SEQ ID NO: 1, Fc-γ receptor IIIb polypeptide

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(HNA-1), CD177 polypeptide (HNA-2), CD11b polypeptide (HNA-4), CD11a polypeptide (HNA-5) and HLA antigens.

16. A kit comprising

a) an antibody which specifically binds to_HNA-3b, and

b) one or more antibodies that specifically bind to a peptide comprising an antigen selected from the group consisting of HNA-1, HNA-2, HNA-4, HNA-5 or HLA. [

17. An isolated polypeptide comprising

a) the amino acid sequence SEQ ID NO: 2,

b) a fragment of the amino acid sequence of SEQ ID NO: 2, wherein the fragment is at least 7 amino acids in length, at least 10 amino acids in length, at least 20 amino acids in length or at least 50 amino acids in length and comprises amino acid residue 154 of SEQ ID NO: 2, or

c) the amino acid sequence selected from the group consisting of SEQ ID NO: 19, SEQ ID NO: 20, SEQ ID NO: 21, SEQ ID NO: 22, SEQ ID NO: 23, SEQ ID NO: 24 and SEQ ID NO: 26 and wherein the polypeptide specifically binds to_HNA-3b-specific alloantibodies.

18. An isolated polynucleotide comprising a nucleotide sequence encoding a polypeptide sequence of claim 17.

19. Use of a polypeptide or fragment thereof according to claim 18 for identification of HNA-3b-specific alloantibodies.

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20. Use of a polynucleotide of SEQ ID NO: 3 or a fragment thereof for determination of the HNA-3a genotype, wherein the fragment encodes an amino acid sequence that is at least 7 amino acids in length, at least 10 amino acids in length, at least 20 amino acids in length or at least 50 amino acids in length and comprises an arginine at position 154 of the amino acid sequence of SEQ ID NO: 1 and specifically binds to HNA-3a-specific alloantibodies.

21. The use of a polynucleotide of claim 18 or a fragment thereof for determination of the HNA-3b genotype, wherein the fragment encodes an amino acid sequence that is at least 7 amino acids in length, at least 10 amino acids in length, at least 20 amino acids in length or at least 50 amino acids in length and comprises a glutamine at position 154 of the amino acid sequence of SEQ ID NO: 2 and specifically binds to HNA-3b-specific alloantibodies.

22. A method of screening for HNA-3b genotype in a human subject comprising

a) extracting nucleic acids from a biological sample from the human subject, and

b) detecting a fragment of a nucleic acid sequence of SEQ ID NO: 4 in the biological sample, wherein the fragment comprises a sequence encoding a glutamine at position 154 of the amino acid sequence of SEQ ID NO: 2,

wherein the detection of fragment of SEQ ID NO: 4 indicates that the human subject has the HNA-3b genotype.

23. A method of detecting an HNA-3a specific antibody in a biological sample comprising

a) contacting the biological sample with a cell transformed or transfected to express the HNA-3a polypeptide of SEQ ID NO: 1 or a fragment thereof to form a complex with HNA-3a specific antibodies in the sample or contacting the biological sample with a cell transformed, wherein the fragment is at least 7 amino acids in length, at least 10 amino

acids in length, at least 20 amino acids in length or at least 50 amino acids in length and comprises an arginine at position 154 of the amino acid sequence of SEQ ID NO: 1, and

b) detecting the complex, wherein the presence of the complex indicates that the biological sample contains HNA-3a specific antibodies specific antibodies.

24. A method of detecting an HNA-3b specific antibody in a biological sample comprising

a) contacting the biological sample with a cell transformed or transfected to express the HNA-3b polypeptide of SEQ ID NO: 2 or a fragment thereof to form a complex with HNA-3b specific antibodies in the sample, wherein the fragment is at least 7 amino acids in length, at least 10 amino acids in length, at least 20 amino acids in length or at least 50 amino acids in length and comprises a glutamine at position 154 of the amino acid sequence of SEQ ID NO: 2, and

b) detecting the complex, wherein the presence of the complex indicates that the biological sample contains HNA-3b specific antibodies.