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(72) Inventeurs/Inventors:
MAINE, GREGORY T., US;
HSU, STEPHEN C., US;
SMITH, DARWIN D., JR., US;
PUCCI, DOMINICK L., US;
HERZOGENRATH, JOERG, DE;
CURDT, INGO, DE;
CHRIST, HEIKE MARIA, DE

(73) Propriétaire/Owner:
ABBOTT LABORATORIES, US

(74) Agent: NORTON ROSE FULBRIGHT CANADA
LLP/S.E.N.C.R.L., S.R.L.

(54) Titre : PROCEDES PERMETTANT DE DETERMINER L'AVIDITE D'UN ANTICORPS IGG EN COMPARANT
L'AVIDITE EN PHASE LIQUIDE A L'AVIDITE EN PHASE SOLIDE

(54) Title: METHODS FOR THE DETERMINATION OF ANTIBODY IGG AVIDITY, BY COMPARING LIQUID TO SOLID
PHASE AVIDITY

(57) **Abrégé/Abstract:**

The present invention relates to methods of determining anti-infectious agent IgG avidity, for example, human anti-cytomegalovirus and human anti-toxoplasma IgG, using a competitive assay format. The methods include the steps of adding a purified antigen from the infectious agent to a solution to create a liquid phase antigen, and coating the purified antigen onto a solid phase to create a solid phase antigen; assaying separately the liquid and solid phase antigens with test samples from the patient and determining the formation of antibody/antigen complexes; and determining the ratio of anti-infectious agent antibody present in the test sample when assayed by the liquid phase antigen compared to the solid phase antigen, wherein the ratio is proportional to the level of antibody present in the patient.

ABSTRACT

The present invention relates to methods of determining anti-infectious agent IgG avidity, for example, human anti-cytomegalovirus and human anti-toxoplasma IgG, using a competitive assay format. The methods include the steps of adding a purified antigen from the infectious agent to a solution to create a liquid phase antigen, and coating the purified antigen onto a solid phase to create a solid phase antigen; assaying separately the liquid and solid phase antigens with test samples from the patient and determining the formation of antibody/antigen complexes; and determining the ratio of anti-infectious agent antibody present in the test sample when assayed by the liquid phase antigen compared to the solid phase antigen, wherein the ratio is proportional to the level of antibody present in the patient.

METHODS FOR THE DETERMINATION OF ANTIBODY IgG AVIDITY, BY COMPARING LIQUID TO SOLID PHASE AVIDITY

BACKGROUND OF THE INVENTION

Technical Field

5 The present invention relates to methods of determining anti-infectious agent IgG antibody avidity, for example, human anti-cytomegalovirus and human anti-toxoplasma IgG antibody avidity.

10 Background Information

Toxoplasma gondii is an obligate intracellular parasite which is classified among the Coccidia. This parasite has relatively broad host range infecting both mammals and birds. The organism is ubiquitous in nature
15 and exists in three forms: tachyzoite, cyst, and oocyst (Remington, J.S., McLeod, R., Desmonds, G., Infectious Diseases of the Fetus and Newborn Infant (J.S. Remington and J.O. Klein, Eds.), pp. 140-267, Saunders, Philadelphia (1995)). Tachyzoites, found during acute
20 infection, are the invasive form capable of invading all nucleated mammalian cells. After the acute stage of infection, tissue cysts called bradyzoites are formed within host cells and persist within the host organism for the life of the host. Cysts are important in
25 transmission of infection, especially in humans, as the ingestion of raw or undercooked meat can result in the ingestion of bradyzoites, which can infect the individual resulting in an acute infection. Oocysts represent a stage of sexual reproduction, which occurs only in the
30 intestinal lining of the cat family from which they are excreted in the feces.

 A T. gondii infection acquired through contaminated meat or cat feces in a healthy adult is often

asymptomatic. In pregnant women and immunosuppressed patients, the clinical outcome can be very serious. An acute infection with T. gondii acquired during pregnancy, especially during the first trimester, can result in
5 intrauterine transmission to the unborn fetus resulting in severe fetal and neonatal complications, including mental retardation and fetal death. Recrudescence of a previous T. gondii infection or an acute infection in an immunosuppressed individual can be pathogenic.

10 Toxoplasmic encephalitis is a major cause of morbidity and mortality in AIDS patients. Toxoplasma infection has also been shown to be a significant cause of chorioretinitis in children and adults.

Diagnosis of infection with T. gondii may be
15 established by the isolation of T. gondii from blood or body fluids, demonstration of the presence of the organism in the placenta or tissues of the fetus, demonstration of the presence of antigen by detection of specific nucleic acid sequences (e.g., DNA probes), or
20 detection of T. gondii specific immunoglobulins synthesized by the host in response to infection using serologic tests.

The detection of T. gondii specific antibodies and determination of antibody titer are important tools used
25 in the diagnosis of toxoplasmosis. The most widely used serologic tests for the diagnosis of toxoplasmosis are the Sabin-Feldman dye test (Sabin, A.B. and Feldman, H.A. (1948) Science 108, 660-663), the indirect hemagglutination (IHA) test (Jacobs, L. and Lunde, M.
30 (1957) J. Parasitol. 43, 308-314), the IFA test (Walton, B.C. et al. (1966) Am. J. Trop. Med. Hyg. 15, 149-152), the agglutination test (Fondation Mérieux, Sérologie de l'Infection Toxoplasmique en Particulier à Son Début:

Méthodes et Interprétation des Résultats, Lyon, 182 pp. (1975)) and the ELISA (Naot, Y. and Remington, J.S. (1980) J. Infect. Dis. 142, 757-766). The ELISA test is one of the easiest tests to perform, and many automated

5 serologic tests for the detection of Toxoplasma specific IgM and IgG are commercially available.

The current tests for the detection of IgM and IgG antibodies in infected individuals can vary widely in their ability to detect serum antibody. Hence, there is
10 significant inter-assay variation seen among the commercially available kits. The differences observed between the different commercial kits are caused primarily by the preparation of the antigen used for the serologic test. Most kits use either whole or sonicated
15 tachyzoites grown in tissue culture or in mice, which contain a high proportion of extra-parasitic material, for example, mammalian cells, tissue culture components, etc. Due to the lack of a purified, standardized antigen or standard method for preparing the tachyzoite antigen,
20 it is not surprising that inter-assay variability exists resulting in different assays having different performance characteristics in terms of assay sensitivity and specificity.

Given the limitations of serologic tests employing
25 the tachyzoite antigen, as described above, as well as the persistent problems regarding determination of onset of infection, purified recombinant antigens obtained by molecular biology are an attractive alternative in that they can be purified and standardized. In the
30 literature, a number of Toxo genes have been cloned and expressed in a suitable host to produce immunoreactive, recombinant Toxo antigens. For example, the Toxo P22 (SAG2), P24 (GRA1), P25, P28 (GRA2), P29 (GRA7), P30

(SAG1), P35 (GRA 8), P41 (GRA4), P54 (ROP2), P66 (ROP1), and the Toxo P68 antigens have been described (Prince et al. (1990) Mol. Biochem. Parasitol 43, 97-106; Cesbron-Delauw et al. (1989) Proc. Nat. Acad. Sci. 86, 7537-7541; Johnson et al. (1991) Gene 99, 127-132; Prince et al. (1989) Mol. Biochem. Parasitol. 34, 3-13; Bonhomme et al. (1998) J. Histochem. Cytochem. 46, 1411-1421; Burg et al. (1988) J. Immunol. 141, 3584-3591; Knapp et al. (1989) EPA 431541A2; Carey et al. (2000) Molec. Biochem. Parasitol. 105, 25-37; Mevelec et al. (1992) Mol. Biochem. Parasitol. 56, 227-238; Saavedra et al. (1991) J. Immunol. 147, 1975-1982); EPA 751 147).

Additionally, it should be noted that the presence of IgG antibodies in a single sample of serum is sufficient to establish that the patient has been infected but does not give an indication as to when the infection occurred. However, in the United States, there is no systematic serological screening program in pregnant women, whereas in countries such as France and Austria, sera are obtained at regular intervals throughout gestation in women who are seronegative when first tested. In the United States, a decision regarding whether the woman was recently infected, thereby placing her fetus at risk, is often made from results in a single sample of serum. However, it is critical in pregnant women to determine as accurately as possible if they acquired their infection just prior to or during gestation. For this reason, the presence of IgG antibodies in a pregnant woman often leads to additional serological testing to attempt to determine if the infection was acquired during pregnancy or in the distant past (Remington et al., 1995, Toxoplasmosis, 4th ed., Coord. Ed., Remington, J.S., W.B. Saunders, Philadelphia,

PA). Of the recommended additional serological tests, those that demonstrate the presence of IgM antibodies are most frequently used. However, since IgM antibodies may remain detectable for more than one year after initial
5 infection, demonstration of these antibodies cannot be used to prove recently acquired infection (Liesenfeld et al., Journal of Clinical Microbiology 35:174-78 (1997); Wilson et al., Journal of Clinical Microbiology 35:3112-15 (1997); Wong et al., Clinical Infectious Diseases
10 18:853-62 (1994)). Because accurate diagnosis of the recently acquired infection in pregnant women is important for clinical management of both the mother and her fetus, a search has continued for better diagnostic methods (Remington et al., 1995, *Toxoplasmosis*, 4th ed.,
15 Coord. Ed., J.S. Remington, W.B. Saunders, Philadelphia, PA; Wong et al., supra).

Human Cytomegalovirus (HCMV) is a member of the group of herpes viruses, is a ubiquitous agent, and is responsible for a broad spectrum of disease affecting
20 humans in many different clinical settings. It is rarely pathogenic in healthy adults but is associated with several diseases in immunocompromised individuals (such as HIV-infected people and transplant recipients). Furthermore, HCMV is the most common cause of congenital
25 infection, occurring in approximately 1% of all live births (Britt, W.J. and Alford, C.A. (1996) Cytomegalovirus, In *Fields Virology*, 3rd ed., Fields et al. (eds.), Lippincott-Raven Publishers, Philadelphia, PA, 2493-2523; Stagno, S. (1995) Cytomegalovirus. In
30 *Infectious Diseases of the Fetus and Newborn Infant* (4th ed.) Remington, J.S. and Klein, J.O. (eds.), W.B. Saunders, Philadelphia, PA, 312-353). Since HCMV infections in pregnant women are asymptomatic or

accompanied by non-specific symptoms, laboratory methods including serology and virology are used to diagnose HCMV infection.

Diagnosis of HCMV infection can be obtained by
5 direct demonstration of the virus in various body fluids or indirectly through serology. In order for the physician to accurately assess the risk of a pregnancy potentially complicated by maternal HCMV infection, it is important to distinguish between primary and non-primary
10 HCMV infection. Intrauterine transmission of primary HCMV infection (ca. 40%) in the first trimester of pregnancy has the potential to cause significant fetal damage, including fetal death (Boppana, S. et al. (1992) *Pediatr. Infect. Dis. J.* 11,93-99). Intrauterine
15 transmission of non-primary HCMV infection occurs at a much lower rate (ca. 0.2-1%) and is generally but not always asymptomatic in the developing newborn (Boppana, S. et al. (1999) *Pediatr.* 104,55-60).

The diagnosis of primary HCMV infection in patients
20 is confirmed if seroconversion to HCMV-specific IgG and IgM antibodies is detected. However, since there are currently no treatment options available for primary HCMV infection in pregnant women, seroconversion to HCMV-specific antibodies is detected rarely as pre-
25 gestational, and pregnant women are not routinely screened for HCMV antibodies. The detection of HCMV-specific IgM has been used as a marker of active or recent HCMV infection (Nielsen, S.L. (1988) *J. Clin. Microbiol.* 26,654-661) and its detection varies widely
30 with poor agreement among commercial tests (Lazzarotto, T. et al. (1992) *J. Clin. Lab. Anal.* 6,216-218). Unfortunately, HCMV-specific IgM can be produced during both primary and non-primary HCMV infections, and hence

this test serves only as a marker to flag pregnancies at risk for potential congenital HCMV infection that require additional clinical testing and follow-up.

Serological tests for the detection of Toxo-specific
5 IgM antibodies and HCMV-specific IgM antibodies in pregnant women serve as markers for pregnancies at risk for congenital infection. However, these tests are not able to discriminate between an acute and chronic toxoplasmosis or a primary and non-primary HCMV
10 infection, respectively. Since an acute maternal toxoplasmosis or a primary maternal HCMV infection during the first trimester poses the greatest risk for fetal damage, additional testing is required to more accurately assess the risk and potential impact the maternal
15 infection has on the developing fetus and newborn. In particular, a test is needed which can aid in the determination of whether the maternal infection was acquired during gestation or whether the infection occurred sometime in the distant past, i.e., prior to
20 conception. If the infection occurred prior to conception, maternal immunity would be sufficient to protect the developing fetus in utero and no further testing or intervention would be required. On the other hand, if the infection occurred during gestation,
25 obstetric counseling would be given to pregnant women and in the case of a suspected acute toxoplasmosis, therapeutic intervention could begin to attempt to prevent intrauterine transmission of the parasite.

It is known that the functional binding affinity or
30 avidity of IgG antibodies increases progressively with time after immunization of animals, also known as maturation of the humoral immune response (Inouye et al. (1984) J. Clin. Microbiol. 20, 525-529). Conventional

affinity assays, for example, equilibrium dialysis using
Scatchard analysis, are not suitable for the measurement
of the polyclonal responses elicited by large and complex
microbial, viral and parasitic antigens (Hedman, K. and
5 Rousseau, S.A. (1989) J. Virol. 27, 288-292).

Competitive binding assays have been used to assess
antibody affinity following vaccination and maternal
protective immunity to congenital HIV infection (Devey,
M.E. et al. (1988) J. Immunol. Methods 106, 119-
10 125; Devash, Y. et al. (1990) Proc. Nat. Acad. Sci. USA
87, 3445-3449). However, competitive binding assays have
not been described that discriminate between an acute
infection and an infection acquired in the distant past.

Further, it is well established that IgG avidity
15 assays utilizing chaotropic reagents can be used at the
diagnostic level to discriminate between an acute
infection (low avidity IgG antibodies predominantly
present) and an infection acquired in the distant past
(high avidity IgG antibodies predominantly present) for a
variety of infectious agents including HCMV (Bodéus, M.
20 et al. (1998) Clin. Diagn. Virol. 9,9-16), T. gondii
(Lappalainen, M. et al. (1993) J. Infect. Dis. 167, 691-
697), Human Immunodeficiency Virus (HIV) (Suligoi, B. et
al. (2002) J. Clin. Microbiol. 40,4015-4020), Parvovirus
25 B19 (Gray, J.J. et al. (1993) J. Virol. Meth. 44,11-23),
Herpesvirus 6 and 7 (Ward, K.N. et al. (2001) J. Clin.
Microbiol. 39,959-963), Hepatitis A, B, C, E virus
(Roque-Afonso, A.-M. et al. (2004) J. Clin. Microbiol.
42,5121-5124; Thomas, H.I.J. (1997) J. Med. Virol.
30 51,189-197; Ward, K.N. et al. (1994) J. Med. Virol.
43,367-372; Zhang, J.-Z. et al. (2002) J. Med. Virol.
66,40-48), Epstein-Barr Virus (EBV) (Weissbrich, B.
(1998) J. Med. Virol. 54,145-153), Actinobacillus

actinomycetemcomitans (juvenile periodontitis) (O'Dell, D.S. et al. (1995) Clin. Exp. Immunol. 101,295-301), Herpes Simplex Virus Type 2 (Ashley, R. et al. (2004) Sexual. Transmitt. Dis. 31,508-515), Severe Acute Respiratory Syndrome (SARS) (Chan, P.K.S. et al. (2005) J. Infect. Dis. 192,166-169), Fascioliasis (liver flukes) (Abou-Basha, L.M. et al. (2000) East. Mediterr. Health J. 6,919-925), Tick-Borne Encephalitis Virus (TBEV) (Gassman, C.G. and Bauer, G. (1997) J. Med. Virol. 51,242-251), Rubella (Hedman, K. and Rousseau, S.A. (1989) J. Med. Virol. 27,288-292), Lyme borreliosis (Rauer, S. et al. (2001) Scand. J. Infect. Dis. 33,809-811), Varicella Zoster Virus (VZV) (Erika, O. (2004) Revista do Instituto de Medicina Tropical de Sao Paulo 46,165-168), Dengue Virus (Fick, de Souza V.A.U. et al. (2004) J. Clin. Microbiol. 42,1782-1784), Schistosomiasis (blood flukes) (J. Egypt. Soc. Parasitol. 32,979-985), Porphyromonas gingivalis (periodontitis) (Benjamin, P.A. et al. (1997) J. Period. Res. 32,31-39), Aspergillus umbrosus (farmer's lung disease) (Clin. Exp. Immunol. 95,162-165), Puumala Virus (Hedman, K. et al. (1991) Lancet. 338,1353-1356), and Brucellosis (Gutierrez, J. et al. (1995) Revista Medica de Chile 123,819-822). Current "home brew" and commercial IgG avidity assays employ the use of chaotropic reagents (e.g., urea, diethylamine, thiocyanate, guanidium, etc.) to distinguish between antibodies of high and low avidity (see U.S. Patent No. 6,372,426B1; Hedman, K. and Seppala, I. (1988) J. Clin. Immunol. 8, 214-221; Hedman et al. (1989) J. Infect. Dis. 4, 736-740; Thomas, H.I.J. and Morgan-Capner, P. (1988) Epidem. Inf. 101, 591-598; Thomas, H.I.J. and Morgan-Capner, P. (1991) J. Virol. Methods 31, 219-228; Montoya, J.G. et al. (2002) J. Clin. Microbiol. 40, 2504-2508;

Pfrepper, K. -I. et al. (2005) Clin. Diagn. Labora. Immunol. 12, 977-982; Petersen, E. et al. (2005) J. Clin. Microbiol. 43, 1570-1574; Baccard-Longere, M. et al. Clin. Diagn. Labora. Immunol. 8, 429-431). The
5 chaotropic reagent can be added to the patient sample to inhibit the binding of low avidity antibodies to the "solid phase antigen" during incubation with the "solid phase antigen". Alternatively, the chaotropic agent can be used to wash the "solid phase antigen" after
10 incubation of the patient sample with the "solid phase antigen". Low avidity IgG antibodies are then stripped from the "solid phase antigen" by the chaotropic reagent. The ratio of the signal in the avidity assay is determined with an anti-human IgG conjugate containing a
15 signal-generating compound in the presence and in the absence of the chaotropic reagent (added either to the sample or used to wash the "solid phase antigen") and is proportional to the level of high avidity IgG present in the patient sample. However, chaotropic reagents can be
20 hazardous or corrosive to an automated immunoassay instrument platform and may also cross-contaminate other assays thereby causing aberrant results. Consequently, there is a current and significant need for an automated IgG avidity immunoassay that does not utilize chaotropic
25 reagents.

SUMMARY OF THE INVENTION

30 The present invention includes a method of determining the level of human anti-infectious agent IgG antibody avidity in a patient suspected of having been infected by the infectious agent. This method comprises

the steps of: a) adding at least one purified antigen from the infectious agent to a solution to create a liquid phase antigen and coating the at least one purified antigen onto a solid phase to create a solid phase antigen; b) in a first assay, contacting a test sample from the patient with a liquid phase comprising no infectious antigen and contacting a test sample from the patient with the coated solid phase of step a) for a time and under conditions sufficient for formation of antibody/antigen complexes; c) washing the coated solid phase of step b); d) in a second assay, contacting a test sample from the patient with the liquid phase antigen and contacting a test sample from the patient with the solid phase antigen for a time and under conditions sufficient for formation of antibody/antigen complexes; e) washing the contacted solid phase antigen of step d); f) adding a conjugate to the first and second assays for a time and under conditions sufficient for formation of anti-IgG/antibody/antigen complexes in the first and second assays, wherein the conjugate comprises an anti-IgG antibody attached to a signal-generating compound capable of generating a detectable signal; g) detecting a signal generated by the signal-generating compound in the first and second assay; and h) determining the ratio between the signal obtained in the second assay to the signal obtained in the first assay, wherein the ratio is proportional to the level of human anti-infectious agent low avidity IgG antibody present in the patient. The infectious agent may be, for example, a virus, a parasite, a fungus or a bacteria. Further, the patient sample may be pretreated with solution prior to addition of the coated solid phase. Also, the solid phase may be, for example, a porous material, a non-porous material, a

latex particle, a magnetic particle, a microparticle, a bead, a membrane, a microtiter well or a plastic tube.

Further, the present invention encompasses a method of determining the level of human anti-toxoplasma low avidity IgG antibody in a patient. This method comprises the steps of: a) adding at least one purified antigen from *Toxoplasma gondii* (*T. gondii*) to a solution (e.g., diluent) to create a liquid phase antigen and coating the at least one purified antigen onto a solid phase to create a solid phase antigen; b) in a first assay, contacting a test sample from the patient with a liquid phase comprising no *T. gondii* antigen and contacting a test sample from the patient with the coated solid phase of step a) for a time and under conditions sufficient for formation of antibody/antigen complexes; c) washing the coated solid phase of step b); d) in a second assay, contacting a test sample from the patient with the liquid phase antigen and contacting a test sample from the patient with the solid phase antigen for a time and under conditions sufficient for formation of antibody/antigen complexes; e) washing the contacted solid phase antigen of step d); f) adding a conjugate to the first and second assays for a time and under conditions sufficient for formation of anti-IgG/antibody/antigen complexes in the first and second assays, wherein the conjugate comprises an anti-IgG antibody attached to a signal-generating compound capable of generating a detectable signal; g) detecting a signal generated by the signal-generating compound in the first and second assays; and h) determining the ratio between the signal obtained in the second assay to the signal obtained in the first assay, wherein the ratio is proportional to the level of human anti-Toxo low avidity IgG antibody present in the

patient. This method may further comprise the step of:

i) multiplying the ratio of step h) by 100 and

subtracting the multiplied ratio from 100 in order to

determine an Avidity Index, an Avidity Index of <30%

5 indicating the patient has low avidity Toxo IgG, an

Avidity Index of $\geq 40\%$ indicating the patient has high

avidity Toxo IgG, and an Avidity Index of 30% to 39%

indicating the patient is equivocal for Toxo IgG antibody

avidity. Alternatively, the method may further comprise

10 the step of multiplying the ratio of step h) by 100 and

subtracting the multiplied ratio from 100 in order to

determine an Avidity Index, an Avidity Index of <20%

indicating said patient has low avidity Toxo IgG, an

Avidity Index of $\geq 50\%$ indicating said patient has high

15 avidity Toxo IgG, and an Avidity Index of 20% to 49%

indicating said patient is equivocal for Toxo IgG

antibody avidity. (An "equivocal" result is one that is

uncertain and necessitates that another sample be taken

from the patient (e.g., 2-3 weeks subsequent to the first

20 test) and tested using the methods described herein. It

is neither a low or high avidity IgG result. Further, an

"equivocal" result may also be referred to as a

"borderline", "grayzone", "mean" or "moderate" result.)

A low avidity Toxo IgG result indicates the patient may

25 or may not have acute toxoplasmosis, and a high avidity

Toxo IgG result indicates the patient has not had acute

toxoplasmosis within approximately 4 months prior to

testing.

The "at least one purified antigen" in the method

30 may be, for example, P22, P24, P25, P28, P29, P30, P35,

P41, P54, P66 and P68. (The purified or isolated antigen

may be created by recombinant means, by synthetic means

or extracted from *T. gondii* subsequent to transcription

and translation of the organism's genome.) Further, the patient test sample may be pretreated with solution prior to addition of the coated solid phase. Again, the solid phase may be, for example, a porous material, a non-porous material, a latex particle, a magnetic particle, a microparticle, a bead, a membrane, a microtiter well or a plastic tube.

Additionally, the present invention includes a method of determining the level of human anti-cytomegalovirus IgG antibody avidity in a patient. This method comprises the steps of: a) adding at least one purified antigen from human cytomegalovirus (HCMV) to a solution to create a liquid phase antigen and coating the at least one purified antigen onto a solid phase to create a solid phase antigen; b) in a first assay, contacting a test sample from the patient with a liquid phase comprising no HCMV antigen and contacting a test sample from the patient with the coated solid phase of step a) for a time and under conditions sufficient for formation of antibody/antigen complexes; c) washing the coated solid phase of step b); d) in a second assay, contacting a test sample from the patient with the liquid phase antigen and contacting a test sample from the patient with the solid phase antigen for a time and under conditions sufficient for formation of antibody/antigen complexes; e) washing the contacted solid phase antigen of step d); f) adding a conjugate to the first and second assays for a time and under conditions sufficient for formation of anti-IgG/antibody/antigen complexes in the first and second assays, wherein the conjugate comprises an anti-IgG antibody attached to a signal-generating compound capable of generating a detectable signal; g) detecting a signal generated by the signal-generating

compound in the first and second assays; and h)
determining the ratio between the signal obtained
in the second assay and the signal obtained in the first
assay, wherein said ratio is proportional to the level of
5 human anti-HCMV low avidity IgG antibody present in
patient sample. The method may further comprise the step
of: i) multiplying said ratio of step h) by 100 and
subtracting the multiplied ratio from 100 in order to
determine an Avidity Index, an Avidity Index of <50%
10 indicating said patient has low avidity CMV IgG, an
Avidity Index of $\geq 60\%$ indicating said patient has high
avidity CMV IgG, and an Avidity Index of 50% to 59%
indicating the patient is equivocal for CMV IgG antibody
avidity. Alternatively, the method may further comprise
15 the step of: i) multiplying said ratio of step h) by 100
and subtracting the multiplied ratio from 100 in order to
determine an Avidity Index, an Avidity Index of <40%
indicating the patient has low avidity CMV IgG, an
Avidity Index of $\geq 70\%$ indicating the patient has high
20 avidity CMV IgG, and an Avidity Index of 40% to 69%
indicating the patient is equivocal for CMV IgG antibody
avidity. (Again, an "equivocal" result is one that is
uncertain and necessitates that another sample be taken
from the patient (e.g., 2-3 weeks subsequent to the first
25 test) and tested using the methods described herein. It
is neither a low or high avidity IgG result. Further, an
"equivocal" result may also be referred to as a
"borderline", "grayzone", "mean" or "moderate" result.)
A CMV low avidity IgG result indicates the patient has a
30 primary CMV infection, and a CMV high avidity IgG result
indicates the patient has a non-primary CMV infection.

The "at least one purified antigen" of the method
may be, for example, pp38, pp53, pp65, p130 or pp150.

(The purified or isolated antigen may be created by recombinant means, synthetic means or extracted from HCMV subsequent to transcription and translation of the proteins encoded by the organism's genome.) Further, the
5 patient sample may be pretreated with solution prior to addition of the coated solid phase. Again, the solid phase may be, for example, a porous material, a non-porous material, a latex particle, a magnetic particle, a microparticle, a bead, a membrane, a microtiter well or a
10 plastic tube.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a schematic of the operation of Assay No. 1 and Assay No. 2 for the ARCHITECT® CMV IgG Avidity assay.

5 FIGURE 2 is a schematic of the operation of Assay No. 1 and Assay No. 2 for the ARCHITECT® Toxo IgG Avidity assay.

DETAILED DESCRIPTION OF THE INVENTION

10 The difficulties of known assays using chaotropic agents for the determination of human anti-CMV and human anti-Toxo IgG antibody avidity have been described, in detail, above. In contrast, the methods of the present invention do not use chaotropic reagents. In particular, 15 the methods of the present invention utilize the discovery that low avidity IgG antibodies produced during acute infection have a low affinity for "liquid phase antigen" and a high affinity for same "solid phase antigen". High avidity IgG antibodies produced during 20 chronic infection, in contrast, have a preferential affinity for "liquid phase antigen" under optimal assay conditions, including optimal dilution of the patient sample. Thus, the methods of the present invention use the differential affinity of low and high avidity 25 antibodies to "solid phase antigen" and same "liquid phase antigen" in order to distinguish between antibodies of low and high avidity and thereby discriminate at the diagnostic level between an acute infection and an infection acquired in the distant past (i.e., chronic 30 infection, non-acute or non-primary infection). In terms of use, the avidity assays of the present invention may be used to aid in the diagnosis of CMV infection in

pregnant women, for example, or to aid in the diagnosis of toxoplasmosis in pregnant women.

For purposes of the present invention, "antibody avidity" is defined as the sum of the binding affinities of the two Fab domains present on each IgG molecule and the antigen to which it binds.

A "liquid phase antigen" is defined as an antigen in solution, which comprises one or more epitopes that bind to an antibody also freely mobile within a solution. In contrast, a "solid phase antigen" is defined as an antigen that is attached to a solid phase, which comprises one or more epitopes that can capture an antibody in solution.

A "solid phase" may be a porous or non-porous material, a latex particle, a magnetic particle, a microparticle (see U.S. Patent No. 5,705,330), a bead, a membrane, and a microtiter well or a plastic tube. The choice of solid phase material as well as method of labeling the antigen, if desired, is determined based upon desired assay format performance characteristics.

"Low avidity antibodies" are defined as those antibodies that are produced between 0 and 4 months post-infection. "High avidity antibodies" are defined as those antibodies that are produced greater than 4 months post-infection. During the course of infection, the overall avidity of the IgG antibodies produced in response to infection increases with time.

The "Avidity Index" for an avidity assay is defined as the proportion of high avidity IgG antibodies present in the patient sample times 100.

Examples of biological fluids which may be tested using the method of the present invention include whole

blood, plasma, serum, cerebrospinal fluid, saliva, tears, nasal washes or aqueous extracts of tissues and cells.

An "infectious agent" is defined as an organism (e.g., bacteria, fungus, virus or parasite) that is
5 capable of producing disease in a susceptible host.

The "conjugate" or "indicator reagent" will comprise an antibody or anti-antibody, attached to a "signal-generating compound" or "label". This "signal-generating compound" or "label" is in itself detectable or may be
10 reacted with one or more additional compounds to generate a detectable product (see e.g., U.S. Patent No. 6,395,472 B1). Examples of signal-generating compounds include chromogens, radioisotopes (e.g., ^{125}I , ^{131}I , ^{32}P , ^3H , ^{35}S and ^{14}C), fluorescent compounds (e.g., fluorescein or
15 rhodamine), chemiluminescent compounds (e.g., acridinium), particles (visible or fluorescent), nucleic acids, complexing agents, or catalysts such as enzymes (e.g., alkaline phosphatase, acid phosphatase, horseradish peroxidase, beta-galactosidase and
20 ribonuclease). In the case of enzyme use (e.g., alkaline phosphatase or horseradish peroxidase), addition of a chromo-, fluoro- or lumino-genic substrate results in generation of a detectable signal. Other detection systems such as time-resolved fluorescence, internal-
25 reflection fluorescence, amplification (e.g., polymerase chain reaction) and Raman spectroscopy are also useful.

The "solution" of the present invention is defined as an aqueous liquid between 0°C and 37°C . Examples include buffers and diluents.

30 As noted above, one method of the present invention is a competitive antigen format for the determination of human anti-HCMV IgG antibody avidity. First, a HCMV antigen must be prepared that is capable of binding human

anti-HCMV IgG antibodies in solution and when coated onto a solid phase. This viral antigen can be prepared by infection of mammalian cells in tissue culture with HCMV obtained from a clinical isolate or from a commercial
5 stock of HCMV strain AD169, Towne, or Toledo (Trincado, D.E. et al. (2000) J. Med. Virol. 61, 481-487; Chee, M.S. et al. (1990) Curr. Top. Microbiol. Immunol. 154, 125-169; Lehner, R. et al. (1991) J. Clin. Microbiol. 29, 2494-2502) followed by purification of the virus from the
10 infected cells. Alternatively, purified recombinant HCMV antigens can be prepared that are capable of binding human anti-HCMV IgG antibodies in solution and when coated onto a solid phase. These recombinant HCMV antigens can include but are not limited to pp38 (UL80a),
15 pp52 (UL44), pp65 (UL83), p130 (UL57), pp150 (UL32) (Maine et al. (2001) Expert Rev. Molec. Diagn. 1, 19-29; U.S. Patent No. 6,074,817).

The purified HCMV viral lysate, synthetic or recombinant antigens are then diluted into a solution
20 (e.g., buffered antigen diluent) ("liquid phase antigen") and also coated onto a solid phase ("solid phase antigen"). Two assays are then performed in the competitive antigen avidity assay format in order to determine the Avidity Index. In ASSAY No. 1 of the
25 present invention (no HCMV soluble antigen), the patient sample is diluted with sample solution (e.g., diluent) and incubated with buffered antigen solution (e.g., diluent) containing no HCMV antigen and with the HCMV antigen coated solid phase. Alternatively, the diluted
30 sample can be "pretreated" with the solution (e.g., buffered antigen diluent) containing no HCMV antigen prior to addition of the HCMV antigen coated solid phase. In this assay, both low and high avidity human anti-HCMV

IgG antibodies bind to the "solid phase antigen". In parallel, in ASSAY No. 2 of the present invention (soluble HCMV antigen), the patient sample is diluted with sample solution (e.g., diluent) and incubated with 5 buffered antigen solution (e.g., diluent) containing the HCMV antigen and with the HCMV antigen coated solid phase. Alternatively, the diluted sample can be "pretreated" with the buffered antigen solution containing the HCMV antigen prior to addition of the HCMV 10 antigen coated solid phase. In this assay, low avidity human anti-HCMV IgG antibodies bind to the "solid phase antigen" whereas high avidity human anti-HCMV IgG antibodies bind to the "liquid phase antigen". After incubation of the patient sample with the buffered 15 antigen solution (with or without soluble HCMV antigen) and HCMV antigen coated solid phase, a wash step is performed to remove human IgG antibodies not bound to the solid phase HCMV antigen. In ASSAY No. 1, only human IgG antibodies not specific for HCMV are removed. In ASSAY 20 No. 2, the wash step removes human IgG antibodies not specific for HCMV and human anti-HCMV IgG high avidity antibodies bound to the "liquid phase antigen". Subsequently in both assays, an anti-human IgG conjugate containing a signal-generating compound is added and the 25 signal obtained is proportional to the amount of human anti-HCMV IgG bound to the solid phase. Since the wash step following primary antibody incubation removes high avidity human anti-HCMV IgG, the ratio of the signal obtained in ASSAY No. 2 over the signal in ASSAY No. 1 is 30 proportional to the level of human anti-HCMV low avidity IgG present in the sample. This is in contrast to the chaotropic avidity assay format, where the ratio of the signals obtained is proportional to the level of human

anti-HCMV high avidity IgG present in the sample. This is due to the fact that the chaotropic avidity assay wash step removes IgG antibodies of low avidity, whereas the competitive antigen format of the present invention removes IgG antibodies of high avidity. Since the "Avidity Index" for an avidity assay is defined as the proportion of high avidity IgG antibodies present in the patient sample times 100, the results of the competitive antigen avidity assay are transformed mathematically as follows:

$$\text{Avidity Index (\%)} = 100 - \left[\frac{\text{Signal ASSAY No. 2}}{\text{Signal ASSAY No. 1}} \right] \times 100$$

Further, as noted above, another method of the present invention is a competitive antigen format for the determination of human anti-Toxo IgG antibody avidity. First, a T. gondii antigen must be prepared that is capable of binding human anti-Toxoplasma IgG antibodies in solution and when coated onto a solid phase. This parasite antigen can be prepared by infection of mice or mammalian cells in tissue culture with T. gondii obtained from a clinical isolate or from a commercial stock of strain RH, BK or C-56 (Reiter-Owona et al. (1999) Bull. World Health Org. 77, 929-935) followed by purification of the parasite antigen from mice or infected cells. Alternatively, purified recombinant T. gondii antigens can be prepared that are capable of binding human anti-Toxo IgG antibodies in solution and when coated onto a solid phase. These recombinant T. gondii antigens can include but are not limited to P22 (SAG2), P24 (GRA1), P25, P28 (GRA2), P29 (GRA7), P30 (SAG1), P35 (GRA8), P41

(GRA4), P54 (ROP2), P66 (ROP1), P68 (Prince et al. (1990) Mol. Biochem. Parasitol 43, 97-106; Cesbron-Delauw et al. (1989) Proc. Nat. Acad. Sci. 86, 7537-7541; Johnson et al. (1991) Gene 99, 127-132; Prince et al. (1989) Mol. Biochem. Parasitol. 34, 3-13; Bonhomme et al. (1998) J. Histochem. Cytochem. 46, 1411-1421; Burg et al. (1988) J. Immunol. 141, 3584-3591; Knapp et al. (1989) EPA 431541A2; Carey et al. (2000) Molec. Biochem. Parasitol. 105, 25-37; Mevelec et al. (1992) Mol. Biochem. Parasitol. 56, 227-238; Saavedra et al. (1991) J. Immunol. 147, 1975-1982); EPA 751 147). The purified parasite, synthetic or recombinant T. gondii antigens are then diluted into a solution (e.g., buffered antigen diluent) ("liquid phase antigen") and also coated onto a solid phase ("solid phase antigen"). Two assays are then performed in the competitive antigen avidity assay format in order to determine the Avidity Index. In ASSAY No. 1 (no T. gondii soluble antigen), the patient sample is diluted with sample solution (e.g., diluent) and incubated with buffered antigen solution (e.g., diluent) containing no T. gondii antigen and with the T. gondii antigen coated solid phase. Alternatively, the diluted sample can be "pretreated" with the buffered antigen diluent containing no T. gondii antigen prior to addition of the T. gondii antigen coated solid phase. In this assay, both low and high avidity human anti-Toxo IgG antibodies bind to the "solid phase antigen". In parallel, in ASSAY No. 2 (soluble T. gondii antigen) the patient sample is diluted with sample solution (e.g., diluent) and incubated with buffered antigen solution (e.g., diluent) containing the T. gondii antigen and with the T. gondii antigen coated solid phase. Alternatively, the diluted sample can be "pretreated" with the buffered

antigen solution (e.g., diluent) containing the T. gondii antigen prior to addition of the T. gondii antigen coated solid phase. In this assay, low avidity human anti-Toxo IgG antibodies bind to the "solid phase antigen" whereas
5 high avidity human anti-Toxo IgG antibodies bind to the "liquid phase antigen". After incubation of the patient sample with the buffered antigen solution (with or without soluble T. gondii antigen) and T. gondii antigen coated solid phase, a wash step is performed to remove
10 human IgG antibodies not bound to the solid phase T. gondii antigen. In ASSAY No. 1 only human IgG antibodies not specific for T. gondii are removed. In ASSAY No. 2, the wash step removes human IgG antibodies not specific for T. gondii and human anti-Toxo IgG high avidity
15 antibodies bound to the "liquid phase antigen". Subsequently in both assays, an anti-human IgG conjugate containing a signal-generating compound is added, and the signal obtained is proportional to the amount of human anti-Toxo IgG bound to the solid phase. Since the wash
20 step following primary antibody incubation removes high avidity human anti-Toxo IgG, the ratio of the signal obtained in ASSAY No. 2 over the signal in ASSAY No. 1 is proportional to the level of human anti-Toxo low avidity IgG present in the sample. This is in contrast to the
25 chaotropic avidity assay format, where the ratio of the signals obtained is proportional to the level of human anti-Toxo high avidity IgG present in the sample. This is due to the fact that the chaotropic avidity assay wash step removes IgG antibodies of low avidity whereas the
30 competitive antigen format of the present invention removes IgG antibodies of high avidity. Since the "Avidity Index" for an avidity assay is defined as the proportion of high avidity IgG antibodies present in the

patient sample times 100, the results of the competitive antigen avidity assay are transformed mathematically as follows:

$$\text{Avidity Index (\%)} = 100 - \frac{\text{Signal ASSAY No. 2}}{\text{Signal ASSAY No. 1}} \times 100$$

As noted above, low avidity IgG antibodies produced during primary CMV infection or during acute toxoplasmosis have a low binding affinity for "liquid phase antigen" but a high binding affinity for "solid phase antigen" (e.g., antigen-coated microparticles or microtiter plates). In contrast, high avidity IgG antibodies produced during non-primary CMV infection or during a chronic toxoplasmosis preferentially bind "liquid phase antigen" and not "solid phase antigen" provided the "liquid phase antigen" is present in sufficient amounts to bind all high avidity anti-CMV or anti-Toxo IgG antibodies present in the patient sample of interest. This condition is met by diluting the patient sample as needed in the assay.

In order to ensure that the CMV and Toxo IgG avidity assays in the competitive antigen format described above perform as intended, assay-specific controls for CMV and Toxo, containing high and low avidity IgG, are run periodically to assess avidity assay validity. In order to manufacture these controls, source plasma must be obtained for control manufacture. High avidity IgG source plasma for CMV and Toxo is readily obtainable due to the seroprevalence for these diseases in the general population, i.e., healthy CMV or Toxo immune individuals

can donate plasma containing high avidity IgG that can be used to manufacture high avidity IgG controls. In contrast, individuals in the acute phase of a CMV or Toxo infection, whose plasma contains low avidity IgG, may not
5 be healthy and unable to donate their plasma for the manufacture of low avidity IgG controls. Furthermore, the acute phase of infection is relatively short and the incidence of infection for CMV and Toxo is relatively low, making it extremely difficult to source adequate
10 amounts of low avidity IgG plasma for CMV and Toxo that are necessary for the manufacture of these important assay validity controls. Since the CMV and Toxo avidity assays described above require the proper dilution of patient samples to provide valid assay results, a high
15 avidity IgG control, containing high-titer high avidity IgG, can "mimic" a low avidity control when run in a dilution protocol that does not dilute the control into the correct dilution range. Hence, another aspect of this invention is the development of "simulated" low
20 avidity IgG controls for CMV and Toxo, wherein the IgG titer of said controls when run in the alternate protocol dilution for the low avidity control, overcomes the "blocking" by the "liquid phase antigen" resulting in a low avidity IgG result.

25 The present invention may be illustrated by use of the following non-limiting examples:

EXAMPLE 1

General Methodology

30 Materials and Sources

Tris- (hydroxymethyl)-aminomethane (TRIS), TRIS-HCL, sodium chloride, EDTA, sucrose, Quinolone (A56620), Nipasept* (Sodium alkyl paraben), ProClin* 300, ProClin*

*Trade-mark

950, Bovine Serum Albumin (BSA), sodium hydroxide, hydrochloric acid, CAPS, CHAPS, azide, 2-(N-morpholino) ethanesulfonic acid (MES), sodium dodecyl sulfate (SDS), paramagnetic polystyrene microparticles, CMV antigen
5 pool, Antifoam, Triton X-405, Triton X-100, Phenylmethylsulfonylchloride (PMSF), Lysozyme, Benzonase, magnesium chloride, maltose, Bovine Albumin Fraction V, Calf serum, Polysorbate 20, Sarafloxacin hydrochloride, Tween 20, Carnation non-fat dry milk, mouse
10 immunoglobulin IgG, CKS antigen ammonium precipitated, 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide (EDAC), CMV IgG positive high avidity recalcified human plasma, Toxo IgG positive high avidity recalcified human plasma, CMV IgG positive low avidity recalcified human plasma, CMV
15 IgG negative recalcified human plasma, lamb serum, yeast extract, tryptone, glycerin, monobasic potassium phosphate, dibasic potassium phosphate, ampicillin, Defoamer Mazu DF-60, ammonium hydroxide, casamino acids, 6 N sulfuric acid, 6 N hydrochloric acid, 6 N sodium
20 hydroxide, 0.5 M EDTA solution, pH 9, isopropyl- β -D-thiogalactoside (IPTG), phosphate buffered saline (PBS), Diethylaminoethyl (DEAE) Sepharose Fast Flow slurry, Amylose slurry, ARCHITECT® anti-human IgG acridinium-labeled conjugate concentrate, ARCHITECT® instrument,
25 ARCHITECT® Line Diluent, Pre-Trigger Solution, Trigger Solution, and ARCHITECT® commodities were obtained from Abbott Manufacturing, Inc. (Abbott Park, IL). Radim CMV IgG avidity kits were purchased from Radim SpA (Rome, Italy). Vidas Toxo* IgG avidity kits were purchased from
30 BioMérieux SA (Lyon, France). Human anti-Toxoplasma P30 IgG monoclonal antibody was obtained from Celliance Corp. (Norcross, GA). The pMALTM Protein Fusion and Purification System were purchased from New England

*Trade-mark

Biolabs, Inc. (Beverly, MA). New England BioLabs' protocols were followed for the transformation of DNA into E. coli and for purification of maltose binding protein (MBP). EPICURIAN ColiTM XL-1 BLUE (recA1 endA1
5 gyrA96 thi-1 hsdR17 supE44 relA1 lac [F' proAB lacI^q ZDM15 Tn10 (Tet^r)] supercompetent E. coli cells were obtained from Stratagene Cloning Systems, Inc. (La Jolla, CA).

Media, Buffers and General Reagents

10 "ARCHITECT[®] CMV IgG Avidity Microparticle Diluent" and "ARCHITECT[®] CMV IgG Avidity Pretreatment 1 Buffer" contained 4.44 g/L TRIS, 2.65 g/L TRIS-HCL, 5 g/L sodium chloride, 3 g/L EDTA, 100 g/L sucrose, 0.01 g/L Quinolone (A56620), 1 g/L Nipasept (Sodium alkyl paraben), 1 g/L
15 ProClin 300, 10 g/L BSA, adjusted pH to 8.4 with sodium hydroxide or hydrochloric acid. "ARCHITECT[®] CMV IgG Avidity Microparticle Coating Buffer" contained 22.14 g/L CAPS, 4.38 g/L sodium chloride, 1 g/L CHAPS, 1 g/L azide, adjusted pH to 11.0 with sodium hydroxide or hydrochloric
20 acid. "ARCHITECT[®] CMV IgG Avidity Microparticle Concentrate Buffer" contained 2 L "ARCHITECT[®] CMV IgG Avidity Microparticle Coating Buffer", 3 L 50 mM MES buffer, pH 6.2, 0.2 L CMV antigen coated microparticles, and 1 L "ARCHITECT[®] CMV IgG Avidity Assay Microparticle
25 Diluent". "ARCHITECT[®] CMV IgG Avidity Microparticle Bulk" contained 0.1 L "ARCHITECT[®] CMV IgG Microparticle Concentrate", 0.9 L "ARCHITECT[®] CMV IgG Avidity Microparticle Diluent", and 0.1 mL Antifoam. "ARCHITECT[®] CMV IgG Avidity Conjugate Diluent" contained 9.8 g/L MES,
30 29 g/L sodium chloride, 20 g/L BSA, 30 ml/L Triton X-405, 10 ml/L Quinolone (A56620), 1 g/L Nipasept (Sodium alkyl paraben), adjusted pH to 6.6 with sodium hydroxide or hydrochloric acid. "ARCHITECT[®] CMV IgG Avidity Conjugate

Bulk" contained 0.03-0.06 mg/L ARCHITECT® anti-human IgG conjugate concentrate, 0.05 ml/L Antifoam, in "ARCHITECT® CMV IgG Avidity Conjugate Diluent". "ARCHITECT® CMV IgG Avidity Pretreatment 2 Blocker" contained 4.44 g/L TRIS, 2.65 g/L TRIS-HCL, 5 g/L sodium chloride, 3 g/L EDTA, 100 g/L sucrose, 0.01 g/L Quinolone (A56620), 1 g/L Nipasept (Sodium alkyl paraben), 1 g/L ProClin 300, 10 g/L BSA, 33.3-100 ml/L CMV antigen pool, adjusted pH to 8.4 with sodium hydroxide or hydrochloric acid. "ARCHITECT® CMV IgG High Avidity Control" contained CMV IgG positive high avidity recalcified plasma (Avidity Index range = 70-100%), CMV IgG negative recalcified plasma, 1 g/L azide, and 15 ml/L 9.5% ProClin 950. "ARCHITECT® CMV IgG Low Avidity Control" contained CMV IgG positive low avidity recalcified plasma (Avidity Index range = 10-30%), CMV IgG negative recalcified plasma, 1 g/L azide, and 15 ml/L 9.5% ProClin 950. "ARCHITECT® CMV IgG Avidity Background Calibrator" contained 0.25 L/L CMV IgG negative recalcified plasma, 0.75 L/L lamb serum, 15 ml/L 9.5% ProClin 950, and 1 g/L azide. "MBP Inoculum Media" contained 24 g/L yeast extract, 12 g/L tryptone, 5 ml/L glycerin, 1.7 g/L Potassium phosphate monobasic, 11.4 g/L potassium phosphate dibasic, 0.05 g/L ampicillin. "MBP Fermentation Media" contained 24 g/L yeast extract, 12 g/L tryptone, 10 ml/L glycerin, 1.7 g/L potassium phosphate monobasic, 11.4 g/L potassium phosphate dibasic, 0.05 g/L ampicillin, 0.5 ml/L Defoamer, Mazu DF-60. "CKS Fermentation Media" contained 24 g/L yeast extract, 12 g/L tryptone, 15 ml/L glycerin, 1.7 g/L potassium phosphate monobasic, 11.4 g/L potassium phosphate dibasic, 10 g/L casamino acids, 0.05 g/L ampicillin, 0.5 ml/L Defoamer, Mazu DF-60. "MBP Lysis

Buffer" contained 50 mM phosphate buffer, pH 7.5, 0.05% Triton X-100, 50 mM NaCl, and 1 mM EDTA.

"ARCHITECT® Toxo IgG Avidity Microparticle Diluent" contained 2.11 g/L TRIS, 11.43 g/L TRIS-HCL, 8 g/L sodium chloride, 3.72 g/L EDTA, 132.5 g/L sucrose, 0.005 g/L Quinolone (A56620), 1 g/L Nipasept (Sodium alkyl paraben), 18 ml/L Polysorbate 20, 102.5 g/L calf serum, adjusted pH to 7.5 with sodium hydroxide or hydrochloric acid. "ARCHITECT® Toxo IgG Avidity Pretreatment 1 Buffer" contained 2.13 g/L TRIS, 11.46 g/L TRIS-HCL, 9.87 g/L sodium chloride, 4.65 g/L EDTA, 0.005 g/L Quinolone, (A56620), 1 g/L Nipasept (Sodium alkyl paraben), 0.01% Antifoam, 0.1 g/L mouse IgG, adjusted pH to 7.5 with sodium hydroxide or hydrochloric acid. "ARCHITECT® Toxo IgG Avidity Pretreatment 2 Blocker" contained 2.13 g/L TRIS, 11.46 g/L TRIS-HCL, 9.87 g/L sodium chloride, 4.65 g/L EDTA, 0.005 g/L Quinolone, (A56620), 1 g/L Nipasept (Sodium alkyl paraben), 0.01% Antifoam, 0.1 g/L mouse IgG, 50-200 mg/L rpMBP-ToxoP30MIX1, adjusted pH to 7.5 with sodium hydroxide or hydrochloric acid. "ARCHITECT® Toxo IgG Avidity Microparticle Coating Buffer" contained 50 mM MES, 0.0005% Triton X-100, pH 6.2. "ARCHITECT® Toxo IgG Avidity Conjugate Diluent" contained 9.8 g/L MES, 29 g/L sodium chloride, 20 g/L Bovine Albumin Fraction V, 30 ml/L Triton X-405, 10 ml/L Quinolone (A56620), 1 g/L Nipasept (Sodium alkyl paraben), 0.8 g/L sodium azide, adjusted pH to 6.6 with sodium hydroxide or hydrochloric acid. "ARCHITECT® Toxo IgG Avidity Conjugate Bulk" contained 0.015-0.09 mg/L ARCHITECT® anti-human IgG conjugate concentrate, 1 ml/L Antifoam, in "ARCHITECT® Toxo IgG Avidity Conjugate Diluent". "ARCHITECT® Toxo IgG Avidity Assay Specific Diluent" contained 2.13 g/L TRIS, 11.43 TRIS-HCL g/L, 9.87 g/L sodium chloride, 300 ml/L

calf serum, 4.65 g/L EDTA, 1 g/L Nipasept (Sodium alkyl paraben), 0.005 g/L Sarafloxacin Hydrochloride, 1.8 ml/L Tween 20, 10 g/L Carnation Non-Fat Dry Milk, 100 mg/L MBP lysate, 100 mg/L rpCKS ammonium sulfate precipitated, 100
5 mg/L mouse IgG, 1 ml/L Antifoam, adjusted pH to 7.5 with sodium hydroxide or hydrochloric acid. "ARCHITECT® Toxo IgG High Avidity Control" contained Toxo IgG positive high avidity recalcified plasma (Avidity Index range = 60-100%), Toxo IgG negative recalcified plasma, 1 g/L
10 azide, and 15 ml/L 9.5% ProClin 950. "ARCHITECT® Toxo IgG Low Avidity Control" contained human anti-Toxo P30 IgG low avidity monoclonal antibody (Avidity Index range = 10-20%), BSA 10 g/L, 1 g/L azide, and 15 ml/L 9.5% ProClin 950. "ARCHITECT® CMV IgG Avidity Background
15 Calibrator" contained ARCHITECT® Line Diluent.

EXAMPLE 2

Manufacture of the ARCHITECT® CMV IgG Avidity Assay Reagent Kit, Calibrator, Controls, and Assay Software

20 Step A: Coating of CMV Viral Antigen onto Microparticles and Manufacture of Microparticle Bulk Reagent

Paramagnetic polystyrene microparticles were washed once with "ARCHITECT® CMV IgG Avidity Microparticle
25 Coating Buffer" and then resuspended to a final concentration of 1% in coating buffer. The CMV antigen pool was thawed at room temperature, sonicated with 6 x 5 second bursts with pause amplitude of 30%, and then centrifuged at 500 x g for 30 minutes to separate the
30 virus from residual cell debris. The viral antigen supernatant was added to the coating buffer containing microparticles at a concentration of approximately 1-25 ml viral antigen supernatant per liter of coating buffer and incubated for 30 minutes with stirring. The viral

antigen coated microparticles were washed three times with 50 mM MES buffer, pH 6.2, and resuspended to a final concentration of 1% solids in "ARCHITECT® CMV IgG Avidity Microparticle Concentrate Buffer" and stored at 2-8°C. The microparticle concentrate was then diluted 1:10 with "ARCHITECT® CMV IgG Avidity Microparticle Diluent", antifoam was added and the "ARCHITECT® CMV IgG Avidity Microparticle Bulk" reagent was filled into reagent bottles and stored at 2-8°C.

10 Step B: Manufacture of Conjugate Bulk Reagent

ARCHITECT® anti-human IgG acridinium-labeled conjugate was diluted to a final concentration of 30-60 ng/ml in "ARCHITECT® CMV IgG Avidity Conjugate Diluent" to yield the "ARCHITECT® CMV IgG Avidity Conjugate Bulk" which was then filled into reagent bottles and stored at 2-8°C.

Step C: Manufacture of Pretreatment 1 Buffer

"ARCHITECT® CMV IgG Avidity Pretreatment 1 Buffer" was prepared using the recipe in Example 1, which was then filled into reagent bottles and stored at 2-8°C.

Step D: Manufacture of Pretreatment 2 Blocker

"ARCHITECT® CMV IgG Avidity Pretreatment 2 Blocker" was prepared using the recipe in Example 1, which was then filled into reagent bottles and stored at 2-8°C. The "ARCHITECT® CMV IgG Reagent Pack" is defined as the reagents described in Examples 2A-2D.

Step E: Manufacture of Background Calibrator

"ARCHITECT® CMV IgG Avidity Background Calibrator" was prepared using the recipe in Example 1, which was then filled into reagent bottles and stored at 2-8°C.

Step F: Manufacture of Controls

"ARCHITECT® CMV IgG High Avidity Control" and "ARCHITECT® CMV IgG Low Avidity Control" were prepared

Step G: Manufacture of Assay Software

The assay software required to run the ARCHITECT®
5 CMV IgG Avidity assay on the ARCHITECT® instrument is
provided on a CD-ROM to be loaded on the ARCHITECT®
instrument prior to running the assay. The assay
software controls the pipetting, dispensing, and mixing
steps of all the reagents in the required sequence on the
10 instrument in order to perform the assay as described
below and as shown in Figure 1.

Operation of the ARCHITECT® CMV IgG Avidity Assay

15 Step A: Configuration of the ARCHITECT® Instrument and
Loading of the Reagent Pack

The operator configures the ARCHITECT® instrument to perform the assay by loading the assay software from the CD-ROM (Abbott Laboratories, Abbott Park, IL). The software required to perform the assay contains two assay files, ASSAY no. 1 and ASSAY no. 2. ASSAY No. 1 and ASSAY No. 2 must be performed on each sample in order to calculate the Avidity Index as shown below. The operator also configures an additional assay file using the ARCHITECT® instrument user interface, which calculates the Avidity Index, according to the following formula:

$$\text{Avidity Index (\%)} = 100 - \frac{\text{Sample RLU} - \text{Calibrator RLU}}{\text{Sample RLU} - \text{Calibrator RLU}} \times 100$$

(Assay No. 2)

(Assay No. 1)

"Sample RLU" is defined as the assay result of the patient sample expressed in Relative Light Units (RLU);

5 "Calibrator RLU" is defined as the assay result in RLU using the "ARCHITECT® CMV IgG Avidity Background Calibrator"; "ASSAY No. 2" is defined as the assay which pretreats the sample, control, or calibrator with the "ARCHITECT® CMV IgG Avidity Pretreatment 2 Blocker";

10 "ASSAY No. 1" is defined as the assay which pretreats the sample, control, or calibrator with the "ARCHITECT® CMV IgG Avidity Pretreatment 1 Buffer"; and the "Avidity Index" is defined by the equation above and expressed in percent is proportional to the level of human anti-HCMV

15 high avidity IgG present in the sample. Samples which have an Avidity Index value of < 50% contain low avidity CMV IgG, $\geq$ 60% contain high avidity CMV IgG, and between 50 to 59% are equivocal for CMV IgG antibody avidity.

The operator loads the "ARCHITECT® CMV IgG Reagent

20 Pack" on the ARCHITECT® instrument as follows:

"ARCHITECT® CMV IgG Avidity Pretreatment 1 Buffer" is loaded into Position No. 1, color coded yellow;

"ARCHITECT® CMV IgG Avidity Microparticle Bulk" is loaded into Position No. 2, color coded pink; "ARCHITECT® CMV

25 IgG Avidity Conjugate Bulk" is loaded into Position No. 3, color coded black; and "ARCHITECT® CMV IgG Avidity Pretreatment 2 Blocker" is loaded into Position No. 5, color coded pink.

Step B: Ordering the ARCHITECT® CMV IgG Avidity Test

30 Prior to running the ARCHITECT® CMV IgG avidity test, the operator must select the appropriate dilution protocol for ASSAY Nos. 1 and 2 based on the CMV IgG titer of each sample expressed in AU/ml from the

ARCHITECT® CMV IgG assay as follows: Dilution Protocol No. 1, 5-16 AU/ml; Dilution Protocol No. 2, 16-50 AU/ml; Dilution Protocol No. 3, 50-150 AU/ml; Dilution Protocol No. 4, 150-500 AU/ml; for samples with a CMV IgG titer > 500 AU/ml, the sample is manually diluted to a titer of 10 AU/ml and Dilution Protocol No. 1 is run. The samples are then loaded onto to the instrument. The "ARCHITECT® CMV IgG Avidity Background Calibrator" is loaded onto to the instrument for calibration of the assay and the "ARCHITECT® CMV IgG High Avidity Control" and "ARCHITECT® CMV IgG Low Avidity Control" is loaded to ensure the assay results are valid.

Step C: Description of the ARCHITECT® CMV IgG Avidity Assay

Approximately 10-72 µl of each sample is needed for ASSAY Nos. 1 and 2 depending on the dilution protocol requested by the operator. The following steps for ASSAY Nos. 1 and 2 are identical except for the pretreatment step: The pipetting probe aspirates the amount of sample required for each assay and performs the appropriate sample dilution with ARCHITECT® Line Diluent; in the pretreatment step for ASSAY No. 2, the pipetting probe dispenses "ARCHITECT® CMV IgG Avidity Pretreatment 2 Blocker", which contains the HCMV viral antigen present in the liquid phase and which binds human anti-HCMV high avidity IgG, into the diluted sample; in the pretreatment step for ASSAY No. 1, the pipetting probe dispenses "ARCHITECT® CMV IgG Avidity Pretreatment 1 Buffer", which contains buffer only, into the diluted sample; the pretreated samples incubate for 7 minutes; the pipetting probe then dispenses 50 µl of "ARCHITECT® CMV IgG Avidity Microparticle Bulk" into the "pretreated samples" and the samples are incubated for 18 minutes; human anti-HCMV IgG

antibodies of low avidity bind to the solid phase coated HCMV viral antigen in ASSAY No. 2 whereas human anti-HCMV IgG antibodies of high and low avidity bind to the solid phase coated HCMV viral antigen in ASSAY No.1; the
5 microparticles are then washed with ARCHITECT® Line Diluent and then the pipetting probe dispenses 50 µl of the "ARCHITECT® CMV IgG Avidity Conjugate Bulk" and the microparticles are incubated with the conjugate for 4 minutes; the microparticles are washed again with
10 ARCHITECT® Line Diluent and then treated with ARCHITECT® Pre-Trigger and Trigger reagent; the resulting chemiluminescence signal generated is read by the ARCHITECT® instrument and displayed as RLU for each sample and stored for ASSAY No. 1 and ASSAY No.2; after
15 the run is complete the instrument subtracts the "ARCHITECT® CMV IgG Avidity Background Calibrator" RLU from each sample for ASSAY No. 1 and ASSAY No. 2 and calculates the Avidity Index as described above; next to the Avidity Index result the interpretation of the result
20 is also displayed according to the following algorithm; samples which have an Avidity Index value of < 50% contain low avidity CMV IgG; $\geq 60\%$ contain high avidity CMV IgG; and between 50 to 59% are equivocal for CMV IgG antibody avidity.

25

EXAMPLE 4

Evaluation of the ARCHITECT® CMV IgG Avidity Assay

Step A: Human Sera for Testing

Three groups of sera were tested in this evaluation:
30 Group 1 (n = 256) consisted of random blood donor sera (n = 126) and pregnant women (n = 130) that were negative for CMV IgM antibody and positive for CMV IgG antibody; Group 2 (n = 35) consisted of serial bleeds from three

individuals with primary HCMV infection as documented by seroconversion (n = 2) or by the presence of CMV IgM antibodies and low avidity CMV IgG (n = 1); Group 3 (n = 37) consisted of serial bleeds from 20 pregnant women with primary HCMV infection as documented by seroconversion (n = 18) or by the presence of CMV IgM antibodies and low avidity CMV IgG (n = 2).

Step B: Comparison of the Performance of the ARCHITECT® CMV IgG Avidity Assay to the Radim CMV IgG Avidity Assay and Clinical Data

The Radim CMV IgG avidity assay (Radim SpA, Rome, Italy) consists of two CMV IgG assays run in duplicate and distinguishes between specimens containing low and high avidity by incorporating a chaotropic wash step with urea after primary antibody incubation in one of the two CMV IgG assays. The Avidity Index for the Radim CMV IgG avidity assay (Radim SpA, Rome, Italy) was calculated as follows per the manufacturer's package insert using Optical Density (O.D.):

$$\text{Avidity Index (\%)} = \frac{\text{O.D. with Dissoc. Reagent (Urea)}}{\text{O.D. with Sample Diluent}} \times 100$$

Results for this assay were interpreted according to the Radim package insert (Radim SpA, Rome, Italy).

Samples from Group 1 (CMV IgM- IgG+) were used to assess the clinical specificity of the avidity assays. Samples that are negative for CMV IgM and positive for CMV IgG antibody should contain high avidity IgG as this population is immune to HCMV and does not have an active HCMV infection. The results with samples from Group 1 are shown below in Table 1:

TABLE 1

Evaluation of the ARCHITECT® CMV IgG Avidity Assay on
Samples from Group 1 (CMV IgG+ IgM-)

		Radim CMV IgG Avidity			
		LOW	EQV	HIGH	TOTAL
ARCHITECT® CMV IgG Avidity	LOW	1	0	0	1
	EQV	0	0	4	4
	HIGH	1	0	250	251
TOTAL		2	0	254	256

ARCHITECT®/Radim Relative Agreement: $251/252 = 99.6\%$

ARCHITECT® Clinical Specificity: $251/252 = 99.6\%$

Radim Clinical Specificity: $254/256 = 99.2\%$

Radim (Radim SpA, Rome, Italy)

As can be seen from Table 1, the ARCHITECT® and Radim avidity assay (Radim SpA, Rome, Italy) sample results are in excellent agreement, i.e. samples with low and high avidity results in the ARCHITECT® assay also have corresponding low and high avidity results, respectively, in the Radim assay (Radim SpA, Rome, Italy). Both assays also demonstrate high clinical specificity, i.e. almost all samples that were negative for CMV IgM and positive for CMV IgG antibody contained high avidity CMV IgG.

Samples from Group 2 and Group 3 were used to assess the clinical sensitivity of the avidity assays. These samples were from individuals with primary HCMV infection. A cutoff of 4 months was chosen for the evaluation of clinical sensitivity and is based on the

ability of an avidity assay to exclude a primary HCMV infection in pregnant women during the first trimester of gestation (3 months). The results with samples from Group 2 and Group 3 are shown in Table 2:

5

TABLE 2

Evaluation of the ARCHITECT® CMV IgG Avidity Assay on Samples from Group 2 and Group 3

		Radim CMV IgG Avidity			TOTAL
		LOW	EQV	HIGH	
ARCHITECT® CMV IgG Avidity	LOW	59	8	3	70
	EQV	0	0	0	0
	HIGH	0	1	1	2
TOTAL		59	9	4	72

10 ARCHITECT®/Radim Relative Agreement: $60/63 = 95.2\%$
 ARCHITECT® Clinical Sensitivity: $70/72 = 97.2\%$
 Radim Clinical Sensitivity: $59/63 = 93.7\%$
 Radim (Radim SpA, Rome, Italy)

As can be seen from Table 2, the ARCHITECT® and
 15 Radim assays (Radim SpA, Rome, Italy) are in good
 agreement with one another, i.e. samples with low and
 high avidity results in the ARCHITECT® assay also have
 corresponding low and high avidity results, respectively,
 in the Radim assay (Radim SpA, Rome, Italy). Both assays
 20 also demonstrate good clinical sensitivity. The rate of
 maturation of avidity appears to be slower for the
 ARCHITECT® assay relative to the Radim assay (Radim SpA,
 Rome, Italy) as shown by the 11 samples that were low
 avidity by the ARCHITECT® assay and equivocal ($n = 8$) or
 25 high ($n = 3$) by the Radim assay (Radim SpA, Rome, Italy).

Based on these data the ARCHITECT® CMV IgG avidity assay is more sensitive for the detection of primary HCMV infection.

The correlation between the ARCHITECT® and Radim CMV IgG avidity assay (Radim SpA, Rome, Italy) results was evaluated across samples from Groups 1-3 (n = 215) and a correlation coefficient of $r = 0.88$ was obtained. This was a surprising and unexpected result for two reasons: first, the avidity assays are qualitative and hence quantitative agreement would not necessarily be expected; and second, they use very different assay formats, i.e., the competitive antigen format selectively removes high avidity IgG from the patient sample whereas the chaotropic format removes low avidity IgG in a wash step.

There are several advantages of the competitive antigen format of the ARCHITECT® CMV IgG avidity of the present invention over the chaotropic format of other CMV IgG avidity assays. First, no chaotropic reagents are required to perform the assay. Chaotropic reagents can be hazardous or corrosive to an automated immunoassay instrument platform and may also cross-contaminate other assays thereby causing aberrant results. Second, it is known that the Avidity Index is affected to some extent by the anti-human IgG concentration against an infectious agent (Hedman, K. and Seppala, I., *supra*). Most conventional avidity assays employing chaotropic reagents do not compensate for this effect whereas the present invention utilizes a series of dilution protocols to dilute samples in the appropriate range, thus ensuring that the Avidity Index result is not confounded by the anti-IgG titer present in patient samples. Finally, the competitive antigen format of the present invention

demonstrated better detection of specimens from patients with primary HCMV infection.

EXAMPLE 5

5 Manufacture of MBP Lysate and rpMBP-ToxoP30MIX1

The E. coli maltose binding protein (MBP) fusion and purification system described in U.S. Patent No.

5,643,758 has been found to be useful for the production and purification of soluble fusion proteins in E. coli.

10 The plasmid pMAL-c2X was obtained from New England BioLabs, Inc. and transformed into E. coli supercompetent cells EPICURIAN ColiTM XL-1 BLUE using supplier protocols. This strain was subsequently used for the production of MBP lysate. The EPICURIAN ColiTM XL-1 BLUE E. coli strain
15 containing the pMBP-c2X-ToxoP30MIX1 construct described in U.S. serial 10/263,153 was used for the production of purified rpMBP-ToxoP30. The EPICURIAN ColiTM XL-1 BLUE E. coli strain containing the CKS-ToxoP35-CKS construct described in U.S. Patent No. 6,329,157 B1 was used for
20 the production of purified rpCKS-ToxoP35 protein.

Step A: Preparation of MBP lysate

E. coli strain containing plasmid pMAL-c2X was inoculated into a flask with "MBP Inoculum Media" and grown at 37°C with shaking to an O.D. at 600nm of 0.8-1.2.

25 This culture was used to inoculate a 10L fermentor containing "MBP Fermentation Media" and grown at 37°C, agitation at 500 rpm, aeration at 15 slpm, and pressure at 345 mbar. The fermentation culture was grown to an O.D. at 600nm of 6.0-8.0 and then induced with 50 mg/L
30 IPTG. After 4 hours post induction, the fermentor harvest was concentrated by diafiltration against PBS and centrifuged at 14,000 x g for 25 minutes at 2-8°C. The fermentor cell paste was aliquoted and then stored at

-70°C until production of lysate.

The cell paste was thawed and transferred to 10 ml "MBP Lysis Buffer" per gram of cell paste containing 0.2 ml/L Benzonase solution, 6.2 g/L magnesium chloride, and 2 g/L Lysozyme and homogenized. PMSF solution was added (1 ml/g cell paste), homogenized, and incubated for 60 minutes at 37°C with shaking. An equal volume of cold distilled water was then added and incubated for 15 minutes at 37°C with shaking. The lysed cell paste was centrifuged at 15,000 x g for 45 minutes at 2-8°C. The supernatant was recovered, clarified by filtration through a 0.2 µ filter, and stored at -70°C.

Step B: Purification of rpMBP-ToxoP30MIX1

E. coli strain containing plasmid pMBP-c2X-ToxoP30MIX1 was inoculated into a flask with "MBP Inoculum Media" and grown at 36°C with shaking to an O.D. at 600 nm of 0.8-1.2. This culture was used to inoculate a 10L fermentor containing "MBP Fermentation Media" and grown at 36°C, agitation at 500 rpm, aeration at 15 slpm, and pressure at 345 mbar. The fermentation culture was grown to an O.D. at 600 nm of 6.0-8.0 and then induced with 50 mg/L IPTG. After 4 hours post induction, the fermentor harvest was concentrated by diafiltration against PBS and centrifuged at 14,000 x g for 25 minutes at 2-8°C. The fermentor cell paste was aliquoted and then stored at -70°C until purification of the protein.

The cell paste was thawed and transferred to 10 ml "MBP Lysis Buffer" per gram of cell paste containing 0.2 ml/L Benzonase solution, 6.2 g/L magnesium chloride, and 2 g/L Lysozyme and homogenized. PMSF solution was added (1 ml/g cell paste), homogenized, and incubated for 60 minutes at 37°C with shaking. An equal volume of cold distilled water was then added and incubated for 15

minutes at 37°C with shaking. The lysed cell paste was centrifuged at 15,000 x g for 45 minutes at 2-8°C. The supernatant was recovered and clarified by filtration through a 0.2 µ filter.

5 The supernatant was then applied to a DEAE Sepharose Fast Flow column equilibrated with 50 mM phosphate buffer, pH 7.4, 25 mM NaCl, and 1 mM EDTA. The column was extensively washed with this buffer and then eluted with 50 mM phosphate buffer, pH 7.4, 200 mM NaCl, 1 mM
10 EDTA and the eluted peak pool was stored for 12 to 24 hours at 2-8°C.

The peak pool protein fraction from the DEAE column was applied to an Amylose resin column equilibrated with 50 mM phosphate buffer, pH 7.4, 50 mM NaCl, 1 mM EDTA.
15 The column was washed extensively with this buffer and the rpMBP-ToxoP30 protein was then eluted with 50 mM NaCl, 10 mM maltose, 0.2% azide. The eluted peak pool was recovered and clarified by filtration through a 0.2 µ filter and stored at -70°C until microparticle coating.

20

EXAMPLE 6

Manufacture of the ARCHITECT® Toxo IgG Avidity Assay Reagent Kit, Calibrator, Controls, and Assay Software

25 Step A: Coating of rpMBP-ToxoP30 Antigen Onto Microparticles and Manufacture of Microparticle Bulk Reagent

The rpMBP-ToxoP30MIX1 antigen was thawed at ambient
30 temperature and diluted to a final concentration of 1 mg/ml in 50 mM phosphate, 50 mM sodium chloride, 1 mM EDTA, 10 mM maltose, 0.2% azide, pH 7.5 and incubated for 5 days at 37°C to refold the antigen. The antigen was

then stored at 2-8 °C for 1 day prior to coating microparticles.

Paramagnetic polystyrene microparticles were washed twice with "ARCHITECT® Toxo IgG Avidity Microparticle Coating Buffer" and then resuspended to a final concentration of 1.33% in coating buffer. The refolded rpMBP-ToxoP30MIX1 antigen was then added to the washed microparticles at a final protein concentration of 100 µg/ml and mixed for 10 minutes at 15-30°C. EDAC was then added to the microparticle coating reaction at a final concentration of 1 mg/ml and incubated with mixing for 30 minutes at 15-30°C. A 1 M TRIS buffer, pH 8.0 was added to the microparticle coating reaction to a final concentration of 0.1 M and incubated with mixing for an additional 30 minutes at 15-30°C. The coated microparticles were then washed with 50 mM MES, pH 6.2 to remove unbound antigen, reactants, and resuspended to a final concentration of 1% solids in "ARCHITECT® Toxo IgG Avidity Microparticle Diluent." The "ARCHITECT® Toxo IgG Avidity Microparticle Bulk Reagent" was prepared by diluting the microparticle concentrate to a final concentration of 0.1% solids with "ARCHITECT® Toxo IgG Avidity Microparticle Diluent", which was then filled into reagent bottles and stored at 2-8°C.

25 Step B: Manufacture of Conjugate Bulk Reagent

ARCHITECT® anti-human IgG acridinium-labeled conjugate was diluted to a final concentration of 15-90 ng/ml in "ARCHITECT® Toxo IgG Avidity Conjugate Diluent" to yield the "ARCHITECT® Toxo IgG Avidity Conjugate Bulk" which was then filled into reagent bottles and stored at 2-8°C.

30 Step C: Manufacture of Pretreatment 1 Buffer

"ARCHITECT® Toxo IgG Avidity Pretreatment 1 Buffer" was prepared using the recipe in Example 1, which was then filled into reagent bottles and stored at 2-8°C.

Step D: Manufacture of Pretreatment 2 Blocker

5 "ARCHITECT® Toxo IgG Avidity Pretreatment 2 Blocker" was prepared using the recipe in Example 1, which was then filled into reagent bottles and stored at 2-8°C.

Step E: Manufacture of Assay Specific Diluent

10 "ARCHITECT® Toxo IgG Avidity Assay Specific Diluent" was prepared using the recipe in Example 1, which was then filled into reagent bottles and stored at 2-8°C. The "ARCHITECT® Toxo IgG Reagent Pack" is defined as the reagents described in Examples 6A-6E.

Step F: Manufacture of Background Calibrator

15 "ARCHITECT® Toxo IgG Avidity Background Calibrator" was prepared using the recipe in Example 1, which was then filled into reagent bottles and stored at 2-8°C.

Step G: Manufacture of Controls

20 "ARCHITECT® Toxo IgG High Avidity Control" and "ARCHITECT® Toxo IgG Low Avidity Control" were prepared using the recipes in Example 1, which were then filled into reagent bottles and stored at 2-8°C.

Step H: Manufacture of Assay Software

25 The assay software required to run the ARCHITECT® Toxo IgG Avidity assay on the ARCHITECT® instrument is provided on a CD-ROM to be loaded on the ARCHITECT® instrument prior to running the assay (Abbott Laboratories, Abbott Park, IL). The assay software controls the pipetting, dispensing, and mixing steps of
30 all the reagents in the required sequence on the instrument in order to perform the assay as described below and as shown in Figure 2.

EXAMPLE 7Operation of the ARCHITECT® Toxo IgG Avidity AssayStep A: Configuration of the ARCHITECT® Instrument and Loading of the Reagent Pack

5 The operator configures the ARCHITECT® instrument to perform the assay by loading the assay software from the CD-ROM. The software required to perform the assay contains two assay files, ASSAY no. 1 and ASSAY no. 2.

10 ASSAY No. 1 and ASSAY No. 2 must be performed on each sample in order to calculate the Avidity Index as shown below. The operator also configures an additional assay file using the ARCHITECT® instrument user interface, which calculates the Avidity Index, according to the

15 following formula:

$$\begin{array}{l}
 \text{Avidity} \\
 \text{Index (\%)} = 100 - \left[\frac{\text{Sample RLU} - \text{Calibrator RLU}}{\text{Sample RLU} - \text{Calibrator RLU}} \right] \times 100
 \end{array}$$

(Assay No. 2)

(Assay No. 1)

"Sample RLU" is defined as the assay result of the patient sample expressed in Relative Light Units (RLU);

"Calibrator RLU" is defined as the assay result in RLU using the "ARCHITECT® Toxo IgG Avidity Background Calibrator"; "ASSAY No. 2" is defined as the assay which pretreats the sample, control, or calibrator with the

30 "ARCHITECT® Toxo IgG Avidity Pretreatment 2 Blocker"; "ASSAY No. 1" is defined as the assay which pretreats the sample, control, or calibrator with the "ARCHITECT® Toxo IgG Avidity Pretreatment 1 Buffer"; and the "Avidity Index" is defined by the equation above and expressed in

percent is proportional to the level of human anti-Toxo high avidity IgG present in the sample. Samples which have an Avidity Index value of $< 30\%$ contain low avidity Toxo IgG, $\geq 40\%$ contain high avidity Toxo IgG, and
5 between 30 to 39% are equivocal for Toxo IgG antibody avidity.

The operator loads the "ARCHITECT® Toxo IgG Reagent Pack" on the ARCHITECT® instrument as follows:

"ARCHITECT® Toxo IgG Avidity Assay Specific Diluent" is
10 loaded into Position No. 1, color coded yellow;

"ARCHITECT® Toxo IgG Avidity Microparticle Bulk" is loaded into Position No. 2, color coded pink; "ARCHITECT® Toxo IgG Avidity Conjugate Bulk" is loaded into Position No. 3, color coded black; "ARCHITECT® Toxo IgG Avidity
15 Pretreatment 1 Buffer" is loaded into Position No. 4, color coded yellow; and "ARCHITECT® Toxo IgG Avidity Pretreatment 2 Blocker" is loaded into Position No. 5, color coded pink.

Step B: Ordering the ARCHITECT® Toxo IgG Avidity Test

20 Prior to running the ARCHITECT® Toxo IgG avidity test, the operator must select the appropriate dilution protocol for ASSAY Nos. 1 and 2 based on the Toxo IgG titer of each sample expressed in IU/ml from the ARCHITECT® Toxo IgG assay as follows: Dilution Protocol
25 No. 1, 3-20 IU/ml; Dilution Protocol No. 2, 21-200 IU/ml; Dilution Protocol No. 3, 201-2000 IU/ml; for samples with a Toxo IgG titer > 2000 IU/ml, the sample is manually diluted to a titer of 10 IU/ml and Dilution Protocol No. 1 is run. The samples are then loaded onto to the
30 instrument. The "ARCHITECT® Toxo IgG Avidity Background Calibrator" is loaded onto to the instrument for calibration of the assay and the "ARCHITECT® Toxo IgG High Avidity Control" and "ARCHITECT® Toxo IgG Low

Avidity Control" is loaded to ensure the assay results are valid.

Step C: Description of the ARCHITECT® Toxo IgG Avidity Assay

5 Approximately 5-80 µl of each sample is needed for ASSAY Nos. 1 and 2 depending on the dilution protocol requested by the operator. The following steps for ASSAY Nos. 1 and 2 are identical except for the pretreatment step: The pipetting probe aspirates the amount of sample
10 required for each assay and performs the appropriate sample dilution with ARCHITECT® Line Diluent; in the pretreatment step for ASSAY No. 2, the pipetting probe dispenses "ARCHITECT® Toxo IgG Avidity Pretreatment 2 Blocker", which contains the rpMBP-ToxoP30MIX1 antigen
15 present in the liquid phase and which binds human anti-Toxo high avidity IgG, into the diluted sample; in the pretreatment step for ASSAY No. 1, the pipetting probe dispenses "ARCHITECT® Toxo IgG Avidity Pretreatment 1 Buffer", which contains buffer only, into the diluted
20 sample; the pretreated samples incubate for 7 minutes; the pipetting probe then dispenses 90 µl "ARCHITECT® Toxo IgG Avidity Assay Specific Diluent" and 50 µl of "ARCHITECT® Toxo IgG Avidity Microparticle Bulk" into 23 µl of the pretreatment reaction and the samples are
25 incubated for 18 minutes; human anti-Toxo IgG antibodies of low avidity bind to the solid phase coated rpMBP-ToxoP30MIX1 antigen in ASSAY no. 2 whereas human anti-Toxo IgG antibodies of high and low avidity bind to the solid phase coated rpMBP-ToxoP30MIX1 antigen in ASSAY no.
30 1; the microparticles are then washed with ARCHITECT® Line Diluent and then the pipetting probe dispenses 50 µl of the "ARCHITECT® Toxo IgG Avidity Conjugate Bulk" and the microparticles are incubated with the conjugate for 4

minutes; the microparticles are washed again with ARCHITECT® Line Diluent and then treated with ARCHITECT® Pre-Trigger and Trigger reagent; the resulting chemiluminescence signal generated is read by the ARCHITECT® instrument and displayed as RLU for each sample and stored for ASSAY No. 1 and ASSAY No.2; after the run is complete the instrument subtracts the "ARCHITECT® Toxo IgG Avidity Background Calibrator" RLU from each sample for ASSAY No. 1 and ASSAY No. 2 and calculates the Avidity Index as described above; next to the Avidity Index result the interpretation of the result is also displayed according to the following algorithm; samples which have an Avidity Index value of < 30% contain low avidity Toxo IgG; $\geq$ 40% contain high avidity Toxo IgG; and between 30 to 39% are equivocal for Toxo IgG antibody avidity.

EXAMPLE 8

Evaluation of the ARCHITECT® Toxo IgG Avidity Assay

20 Step A: Human Sera for Testing

Two groups of sera were tested in this evaluation: Group 1 (n = 138) consisted of random individuals from France that were negative for Toxo IgM antibody and positive for Toxo IgG antibody; Group 2 (n = 23) consisted of serial bleeds from two individuals with an acute toxoplasmosis as documented by seroconversion; Group 3 (n = 24) consisted of selected individuals that were positive for Toxo IgG antibody.

30 Step B: Comparison of the Performance of the ARCHITECT® Toxo IgG Avidity Assay to the Vidas Toxo IgG Avidity Assay and Clinical Data

The Vidas Toxo IgG avidity assay (BioMérieux SA, Lyon, France) consists of two Toxo IgG assays run in

duplicate and distinguishes between specimens containing low and high avidity by incorporating a chaotropic wash step with urea after primary antibody incubation in one of the two Toxo IgG assays. The Avidity Index for the
 5 Vidas Toxo IgG avidity assay (BioMérieux SA, Lyon, France) was calculated as follows per the manufacturer's package insert using Relative Fluorescence Value (RFV):

$$\begin{array}{lcl} & \text{Test RFV with Dissoc. Reagent (Urea)} & \\ 10 \text{ Avidity} & = & \text{-----} \times 100 \\ \text{Index (\%)} & & \text{Reference RFV without Dissoc. Reagent} \end{array}$$

Results for this assay were interpreted according to the Vidas package insert (BioMérieux SA, Lyon, France).

15 Samples from Group 1 (Toxo IgM- IgG+) were used to assess the clinical specificity of the ARCHITECT® Toxo IgG avidity assay. Samples that are negative for Toxo IgM and positive for Toxo IgG antibody should contain high avidity IgG as this population is immune to T. gondii
 20 gondii and does not have an active T. gondii infection. The results with samples from Group 1 are shown below in Table 3:

TABLE 3

25 Evaluation of the ARCHITECT® Toxo IgG Avidity Assay on Samples from Group 1 (Toxo IgG+ IgM-)

ARCHITECT® Toxo IgG Avidity			
LOW	EQV	HIGH	TOTAL
1	1	136	138

ARCHITECT® Clinical Specificity: 136/137 = 99.3%

As can be seen from Table 3, the ARCHITECT® Toxo IgG avidity assay demonstrates high clinical specificity, i.e., almost all samples that were negative for Toxo IgM and positive for Toxo IgG antibody contained high avidity Toxo IgG.

Samples from Group 2 and Group 3 were used to assess the agreement and correlation between the ARCHITECT® Toxo IgG and Vidas Toxo IgG avidity assays (BioMérieux SA, Lyon, France). These samples were from individuals with acute toxoplasmosis as documented by seroconversion and from selected Toxo IgG positive individuals. The results with samples from Group 2 and Group 3 are shown in Table 4:

TABLE 4

Evaluation of the ARCHITECT® Toxo IgG Avidity Assay on Samples from Group 2 and Group 3

		Vidas Toxo IgG Avidity			
		LOW	EQV	HIGH	TOTAL
ARCHITECT® Toxo IgG Avidity	LOW	23	0	0	23
	EQV	0	0	0	0
	HIGH	0	1	23	24
TOTAL		23	1	23	47

ARCHITECT®/Vidas Relative Agreement: $46/46 = 100\%$
Vidas (BioMérieux SA, Lyon, France)

As can be seen from Table 4, the ARCHITECT® and Vidas (BioMérieux SA, Lyon, France) assays are in

excellent agreement with one another, i.e., samples with low and high avidity results in the ARCHITECT® assay also have corresponding low and high avidity results, respectively, in the Vidas assay (BioMérieux SA, Lyon, France). The correlation between the ARCHITECT® and Vidas Toxo IgG avidity assay (BioMérieux SA, Lyon, France) results was evaluated across samples from Groups 2 and 3 (n = 47) and a correlation coefficient of $r = 0.97$ was obtained. This was a surprising and unexpected result for two reasons: first, the avidity assays are qualitative and hence quantitative agreement would not necessarily be expected; and second, they use very different assay formats, i.e., the competitive antigen format selectively removes high avidity IgG from the patient sample whereas the chaotropic format removes low avidity IgG in a wash step.

There are several advantages of the competitive antigen format of the ARCHITECT® Toxo IgG avidity over the chaotropic format of other Toxo IgG avidity assays. First, no chaotropic reagents are required to perform the assay. Chaotropic reagents can be hazardous or corrosive to an automated immunoassay instrument platform and may also cross-contaminate other assays thereby causing aberrant results. Second, it is known that the Avidity Index is affected to some extent by the anti-human IgG concentration against an infectious agent (Hedman, K. and Seppala, I., *supra*). Most conventional avidity assays employing chaotropic reagents do not compensate for this effect whereas the present invention utilizes a series of dilution protocols to dilute samples in the appropriate range, thus ensuring that the Avidity Index result is not confounded by the anti-IgG titer present in patient samples.

Given the excellent agreement between the chaotropic method and the competitive antigen method of the present invention for the determination of antibody avidity, additional applications of the methods of the present invention are possible. For example, in addition to HCMV and T. gondii, the chaotropic method has been useful to discriminate between acute infection and infections acquired in the distant past for many infectious diseases. It is believed that the competitive antigen method described herein could also be used at the diagnostic level to discriminate between acute and chronic infection for a variety of diseases, including those for which the chaotropic method has not been described. Furthermore, the competitive antigen method, as was shown for HCMV, may provide superior assay performance over the chaotropic method without the accompanying drawbacks and hazards associated with the use of chaotropic reagents.

20

EXAMPLE 9"Simulated" Low Avidity Controls for CMV and ToxoStep A: Controls for Testing

The "ARCHITECT® CMV IgG High Avidity Control" described in EXAMPLE 1 contains high-titer (ca. 200 AU/ml) and high avidity CMV IgG (avidity index ca. 90%). The "ARCHITECT® Toxo IgG High Avidity Control" described in EXAMPLE 1 contains high titer (ca. 700 IU/ml) and high avidity Toxo IgG (avidity index ca. 70%).

Step B: "Simulated CMV IgG Low Avidity Control"

30

The ARCHITECT® CMV IgG avidity assay described in EXAMPLE 3 has four automated dilution protocols: Dilution Protocol No. 1, 5-16 AU/ml; Dilution Protocol No. 2, 16-50 AU/ml; Dilution Protocol No. 3, 50-150 AU/ml; Dilution

Protocol No. 4, 150-500 AU/ml. The "ARCHITECT® CMV IgG High Avidity Control", which contains ca. 200 AU/ml, should normally be run in Dilution Protocol No. 4 in order to obtain a valid avidity result. This control was
5 run in Dilution Protocol Nos. 1-4 with the following results.

TABLE 5

Evaluation of the ARCHITECT® CMV IgG High Avidity Control Across All Four Dilution Protocols in the ARCHITECT® CMV
10 IgG Avidity Assay

Protocol No.	Titer Range (AU/ml)	Avidity Index (%)	Interpretation
1	5-16	30.5	Low
2	>16-50	64.4	High
3	>50-150	80.2	High
4	>150-500	93.4	High

As can be seen from Table 5, the "ARCHITECT® CMV IgG High Avidity Control" "mimics" a low avidity IgG control when
15 run incorrectly in Protocol No. 1 instead of the correct Dilution Protocol No. 4. The dilution factor in Protocol No. 1 was not sufficient for this high titer high avidity control, resulting in the high titer IgG overcoming the "blocking" by the "liquid phase antigen", and thereby
20 binding to the "solid phase antigen". Hence, a "simulated" low avidity control for CMV IgG can simply be obtained by running the high avidity control in a dilution protocol that "under dilutes" the control in such a manner as resulting in the binding of high avidity
25 IgG to the "solid phase antigen" and thereby registering a low avidity IgG result in the assay.

Step C: "Simulated Toxo IgG Low Avidity Control"

The ARCHITECT® Toxo IgG avidity assay described in EXAMPLE 7 has three automated dilution protocols:

Dilution Protocol No. 1, 3-20 IU/ml; Dilution Protocol

No. 2, 21-200 IU/ml; Dilution Protocol No. 3, 201-2000

5 IU/ml. The "ARCHITECT® Toxo IgG High Avidity Control", which contains ca. 700 IU/ml, should normally be run in Dilution Protocol No. 3 in order to obtain a valid avidity result. This control was run in Dilution Protocol Nos. 1-3 with the following results.

10

TABLE 6

Evaluation of the ARCHITECT® Toxo IgG High Avidity Control Across All Three Dilution Protocols in the ARCHITECT® Toxo IgG Avidity Assay

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Protocol No.	Titer Range (IU/ml)	Avidity Index (%)	Interpretation
1	3-20	0.7	Low
2	>20-200	11.9	Low
3	>200-2000	65.1	High

As can be seen from Table 6, the "ARCHITECT® Toxo IgG High Avidity Control" "mimics" a low avidity IgG control when run incorrectly in Protocol No. 1 instead of the correct Dilution Protocol No. 3. The dilution factor in

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Protocol No. 1 was not sufficient for this high titer high avidity control, resulting in the high titer IgG overcoming the "blocking" by the "liquid phase antigen", and thereby binding to the "solid phase antigen". Hence, a "simulated" low avidity control for Toxo IgG can simply be obtained by running the high avidity control in a dilution protocol that "under dilutes" the control in such a manner as resulting in the binding of high avidity

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IgG to the "solid phase antigen" and thereby registering a low avidity IgG result in the assay.

The chaotropic method cannot use "simulated" low avidity controls. Thus, it is believed that the competitive antigen avidity assay of the present invention has several distinct advantages over the chaotropic method. First, high avidity IgG plasma is relatively easy to source thus ensuring that "simulated" low avidity IgG assay controls will be available to monitor avidity assay validity. Second, it will be easier to develop an avidity assay for known and new infectious diseases using the competitive antigen format than the chaotropic format, especially in cases where disease seroprevalence and incidence are low, i.e., cases where low avidity IgG patient samples or plasma for the disease of interest are unavailable or hazardous to individuals developing new avidity tests. The rapid development of diagnostic tests for newly emerging pathogens, especially the avidity assay, can be used as an aid to diagnose, treat, and quarantine individuals in the acute phase of the disease who may readily transmit the infection to naive individuals.

WHAT IS CLAIMED IS:

1. A method of determining the avidity of human anti-infectious agent IgG antibody in a patient sample, said patient suspected of having been infected by an infectious agent, comprising the steps of:

- a) adding at least one purified antigen from said infectious agent to a liquid phase solution to create a liquid phase antigen solution and coating said at least one purified antigen onto a solid phase to create a solid phase antigen;
- b) in a first assay, contacting a test sample from said patient with said liquid phase solution comprising no infectious antigen and contacting the contacted test sample and liquid phase solution with said coated solid phase of step a) for a time and under conditions sufficient for formation of antibody/antigen complexes;
- c) washing said coated solid phase of step b);
- d) in a second assay, contacting said test sample from said patient with said liquid phase antigen solution and contacting the contacted test sample and liquid phase antigen solution with said solid phase antigen for a time and under conditions sufficient for formation of antibody/antigen complexes;
- e) washing said contacted solid phase antigen of step d);
- f) adding a conjugate to said first and second assays for a time and under conditions sufficient for formation of anti-IgG/antibody/antigen complexes in said first and second assays, wherein said conjugate comprises an anti-IgG antibody attached to a signal-generating compound capable of generating a detectable signal;
- g) detecting a signal generated by said signal-generating compound in said first and second assays; and
- h) determining the ratio between said signal obtained in said second assay and said signal obtained in said first assay, wherein said ratio is proportional to the avidity of human anti-infectious agent IgG antibody present in said patient sample.

2. The method of claim 1 wherein said infectious agent is selected from the group consisting of a virus, a parasite, a fungus and a bacteria.

3. The method as claimed in claim 1 or claim 2 wherein said solid phase is selected from the group consisting of a porous material, a non-porous material, a latex particle, a magnetic particle, a microparticle, a bead, a membrane, a microtiter well and a plastic tube.

4. A method of determining the avidity of human anti-toxoplasma IgG antibody in a patient sample comprising the steps of:

- a) adding at least one purified antigen from *Toxoplasma gondii* (T.gondii) to a liquid phase solution to create a liquid phase antigen solution and coating said at least one purified antigen onto a solid phase to create a solid phase antigen;
- b) in a first assay, contacting a test sample from said patient with said liquid phase solution comprising no T.gondii antigen and contacting the contacted test sample and liquid phase with said coated solid phase of step a) for a time and under conditions sufficient for formation of antibody/antigen complexes;
- c) washing said coated solid phase of step b);
- d) in a second assay, contacting said test sample from said patient with said liquid phase antigen and contacting the contacted test sample and liquid phase antigen with said solid phase antigen for a time and under conditions sufficient for formation of antibody/antigen complexes.
- e) washing said contacted solid phase antigen of step d) ;
- f) adding a conjugate to said first and second assays for a time and under conditions sufficient for formation of anti-IgG/antibody/antigen complexes in said first and second assays, wherein said conjugate comprises an anti-IgG antibody attached to a signal-generating compound capable of generating a detectable signal;
- g) detecting a signal generated by said signal-generating compound in said first and second assays; and
- h) determining the ratio between said signal obtained in said second assay and said signal obtained in said first assay, wherein said ratio is proportional to the avidity of human anti-Toxo IgG antibody present in the patient sample.

5. The method of claim 4 further comprising the step of:

- i) multiplying said ratio of step h) by 100 and subtracting said multiplied ratio from 100 in order to determine an Avidity Index, an Avidity Index of <20% indicating said patient has low avidity Toxo IgG, an Avidity Index of $\geq 50\%$ indicating said patient has high avidity Toxo IgG, and an Avidity Index of 20% to 49% indicating said patient is equivocal for Toxo IgG antibody avidity.

6. The method of claim 4 further comprising the step of:
 - i) multiplying said ratio of step h) by 100 and subtracting said multiplied ratio from 100 in order to determine an Avidity Index, an Avidity Index of <30% indicating said patient has low avidity Toxo IgG, an Avidity Index of $\geq 40\%$ indicating said patient has high avidity Toxo IgG, and an Avidity Index of 30% to 39% indicating said patient is equivocal for Toxo IgG antibody avidity.
7. The method of claim 5 or claim 6 wherein a low avidity Toxo IgG result indicates said patient may or may not have acute toxoplasmosis and a high avidity Toxo IgG result indicates said patient has not had acute toxoplasmosis within 4 months prior to testing.
8. The method as claimed in any one of claims 4 to 7 wherein said at least one purified antigen is selected from the group consisting of P22, P24, P25, P28, P29, P30, P35, P41, P54, P66 and P68.
9. The method as claimed in any one of claims 4 to 8 wherein said solid phase is selected from the group consisting of a porous material, a non-porous material, a latex particle, a magnetic particle, a microparticle, a bead, a membrane, a microtiter well and a plastic tube.
10. A method of determining the avidity of human anti-cytomegalovirus IgG antibody in a patient sample comprising the steps of:
 - a) adding at least one purified antigen from human cytomegalovirus (HCMV) to a liquid phase solution to create a liquid phase antigen solution and coating said at least one purified antigen onto a solid phase to create a solid phase antigen;
 - b) in a first assay, contacting a test sample from said patient with said liquid phase solution comprising no HCMV antigen and contacting the contacted test sample and liquid phase with said coated solid phase of step a) for a time and under conditions sufficient for formation of antibody/antigen complexes;
 - c) washing said coated solid phase of step b);
 - d) in a second assay, contacting said test sample from said patient with said liquid phase antigen and contacting the contacted test sample and liquid phase antigen with said solid phase antigen for a time and under conditions sufficient for formation of antibody/antigen complexes;
 - e) washing said contacted solid phase antigen of step d);

- f) adding a conjugate to said first and second assays for a time and under conditions sufficient for formation of anti-IgG/antibody/antigen complexes in said first and second assays, wherein said conjugate comprises an anti-IgG antibody attached to a signal-generating compound capable of generating a detectable signal;
- g) detecting a signal generated by said signal-generating compound in said first and second assay; and
- h) determining the ratio between said signal obtained in said second assay and said signal obtained in said first assay, wherein said ratio is proportional to the avidity of human anti-HCMV IgG antibody present in said patient sample.

11. The method of claim 10 further comprising the step of:

- i) multiplying said ratio of step h) by 100 and subtracting said multiplied ratio from 100 in order to determine an Avidity Index, an Avidity Index of <40% indicating said patient has low avidity CMV IgG, an Avidity Index of $\geq 70\%$ indicating said patient has high avidity CMV IgG, and an Avidity Index of 40% to 69% indicating said patient is equivocal for CMV IgG antibody avidity.

12. The method of claim 10 further comprising the step of:

- i) multiplying said ratio of step h) by 100 and subtracting said multiplied ratio from 100 in order to determine an Avidity Index, an Avidity Index of <50% indicating said patient has low avidity CMV IgG, an Avidity Index of $\geq 60\%$ indicating said patient has high avidity CMV IgG, and an Avidity Index of 50% to 59% indicating said patient is equivocal for CMV IgG antibody avidity.

13. The method of claim 11 or claim 12 wherein a CMV low avidity IgG result indicates said patient has a primary CMV infection and a CMV high avidity IgG result indicates said patient has a non-primary CMV infection.

14. The method as claimed in any one of claims 10 to 13 wherein said at least one purified antigen is selected from the group consisting of pp38, pp53, pp65, p130 and pp150.

15. The method as claimed in any one of claims 10 to 14 wherein said solid phase is selected from the group consisting of a porous material, a non-porous material, a latex particle, a magnetic particle, a microparticle, a bead, a membrane, a microtiter well and a plastic tube.

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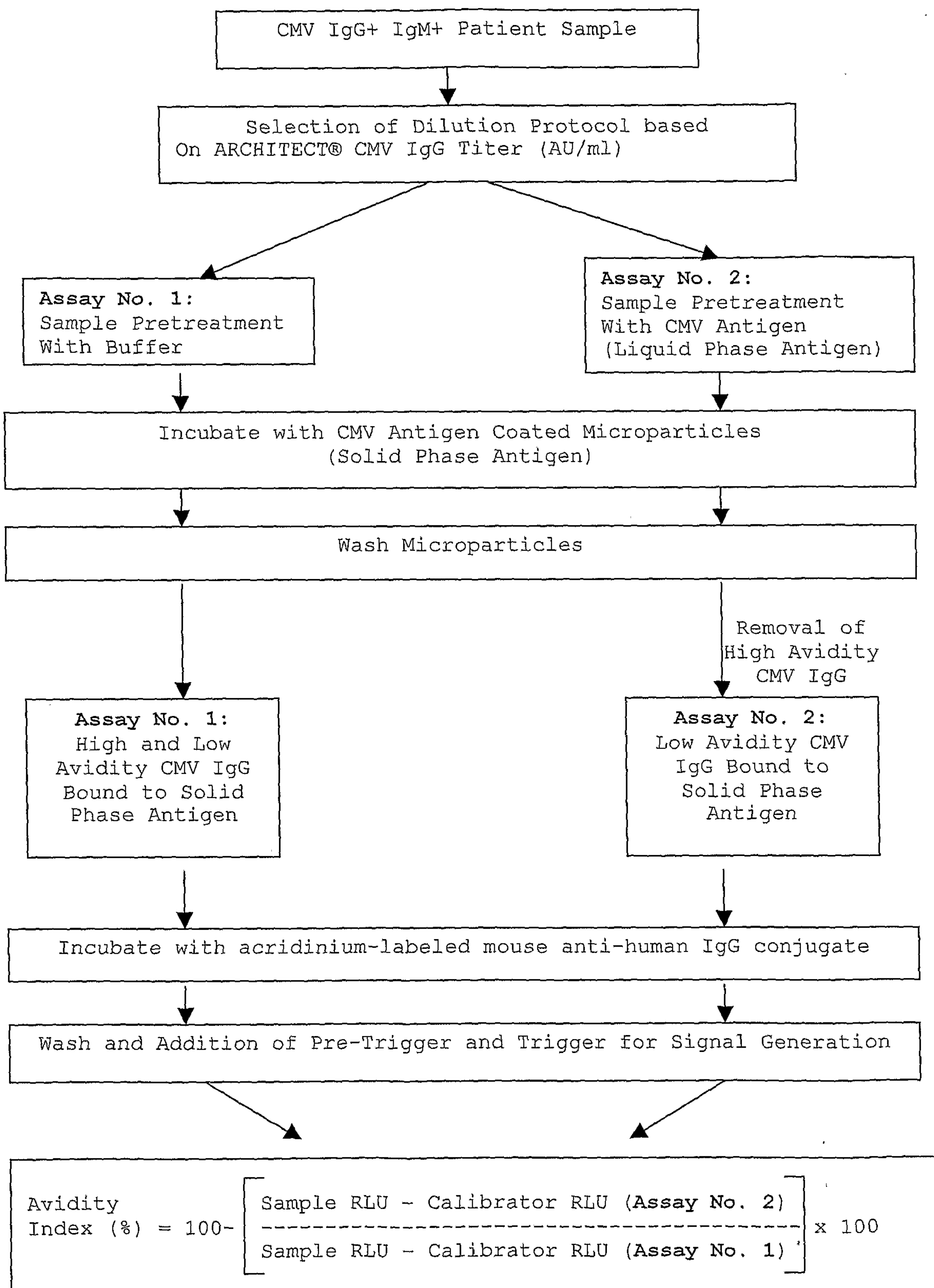


Figure 1

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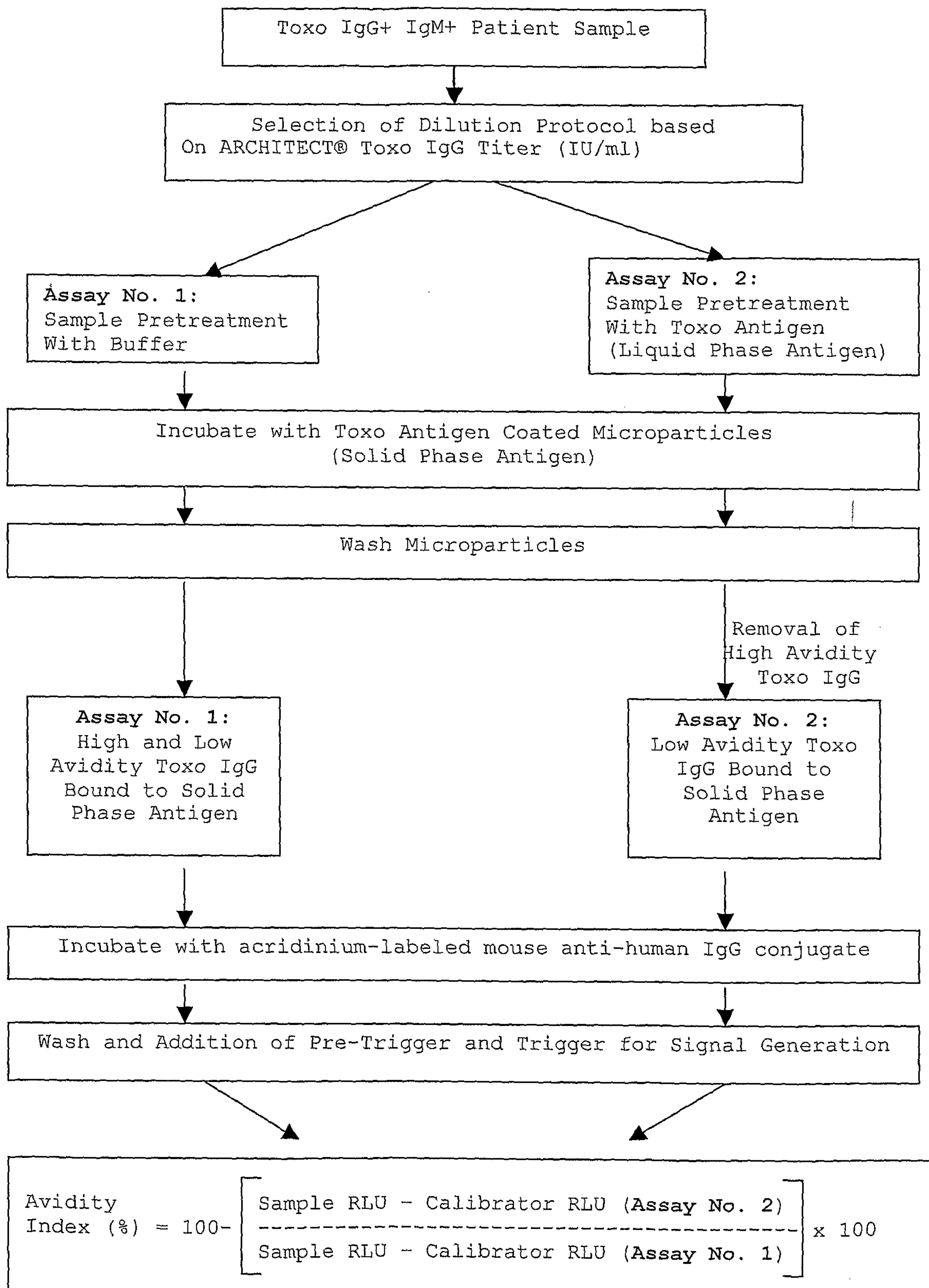


Figure 2