

Transfusion-transmitted infectious diseases

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Abstract

A spectrum of blood-borne infectious agents is transmitted through transfusion of infected blood donated by apparently healthy and asymptomatic blood donors. The diversity of infectious agents includes hepatitis B virus (HBV), hepatitis C virus (HCV), human immunodeficiency viruses (HIV-1/2), human T-cell lymphotropic viruses (HTLV-I/II), Cytomegalovirus (CMV), Parvovirus B19, West Nile Virus (WNV), Dengue virus, trypanosomiasis, malaria, and variant CJD. Several strategies are implemented to reduce the risk of transmitting these infectious agents by donor exclusion for clinical history of risk factors, screening for the serological markers of infections, and nucleic acid testing (NAT) by viral gene amplification for direct and sensitive detection of the known infectious agents. Consequently, transfusions are safer now than ever before and we have learnt how to mitigate risks of emerging infectious diseases such as West Nile, Chikungunya, and Dengue viruses.

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1. Introduction

Transfusion-transmitted infectious diseases remain a major subject of interest for blood safety. The introduction of Nucleic Acid Testing (NAT) in 2000 for HCV then HIV-1 in 2003 was finally followed by HBV in 2006. In order to reduce costs, manufacturers assembled NAT for all three viruses into single ‘Triplex’ assays. The previously accepted strategy of testing in pools of various sizes that had been devised to reduce costs while detecting rapidly replicating viruses during the window period was shown to be a limiting factor to the efficacy of NAT when applied to slower replicating viruses such as HBV or

viruses with a relatively low peak of viral load such as West Nile virus (WNV). In addition, the detection of viral genome in the presence of antibodies in individuals having previously recovered from the infection such as HBV or parvovirus B19 infection raised the issue of infectivity of such blood units particularly when transfused to immunodeficient patients.

The immune status of transfused patients is an issue of increasing importance, since, in developed countries, immunodeficient recipients through age, chemotherapy for malignancies or immunosuppressive treatment for bone marrow or organ transplantation has become the majority. To complicate the issue, immunodeficient patients are exposed to more donors hence at higher risk of infection, are susceptible to lower infectious doses and, when infected, develop more severe clinical symptoms. In addition they tend to reactivate common viruses from which infection they may have recovered from for many years, raising the difficult diagnostic issue of differentiating between transfusion-transmitted infection and reactivation.

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In this context, emerging viruses, either previously considered innocuous but made more aggressive by immunodeficiency such as WNV or newly discovered or spread out viruses in relation to the circulation of goods and humans, such as SARS, have become a concern in transfusion safety.

2. Transfusion-transmission threats from emerging infectious diseases

According to the International Society for Infectious Diseases, more than 40 diseases exist today that were unknown a generation ago, and about 1100 epidemic events were verified by the WHO in the past five years (Promed May 5, 2008). According to the Institute of Medicine (IOM), emerging infectious diseases are defined as those whose incidence in humans have increased within the past two decades or threaten to increase in the near future. Emergence may be due to the spread of a new agent, the recognition of an infection that has been present in the population but gone undetected, or to the realization that an established disease has an infectious origin. Emergence may also be used to describe the reappearance or re-emergence of a known infection after a decline in incidence.

The AABB's Transfusion Transmitted Diseases committee has undertaken a project to identify, describe and prioritize emerging infectious disease agents that are known or suspected to be transfusion-transmitted and for which there is no currently implemented intervention existing in the United States or Canada. A total of 69 such agents have been identified and categorized into three levels of concern in a watch list. For example, *Babesia*, dengue virus, and the prion responsible for variant Creutzfeldt-Jakob disease represent agents of high threat and while the agents of Chagas disease, *Trypanosoma cruzi* and malaria have interventions, these agents have been included due to the implementation of donation screening being very recent or the intervention potentially being inadequate.

West Nile virus (WNV) entered the US in 1999 and was first described infecting humans in New York City resulting in cases of meningoencephalitis. Since that time, the agent and disease in humans has spread across the entire US and has entered Canada, Mexico and Central and South America [1]. WNV is now the most significant arboviral infection in the US with the 2002–2003 epidemics ranking among the highest for such an agent in the US with close to 11,000 cases of West Nile neuro-invasive disease reported to 2007. To date, 58 mosquito and 288 avian species may be infected as part of the amplification cycle with *Culex* mosquito species and corvids, sparrows and finches among the most important mosquito and bird groups perpetuating the cycle. The 18 mammalian species that may be infected represent dead end hosts. The only human to human mode of transmission is via blood transfusion or organ transplantation. In 2002, 23 transfusion-transmitted cases were described which established the agent as transfusion transmitted [1], and since blood donor screening was initiated in 2003, another nine cases have been described due to low viral loads and false negative results in minipool

nucleic acid testing (NAT) screening. In order to enhance the detection of donors having low viral loads, conversion from minipool to individual unit screening is performed during times of high WNV activity [2]. Approximately 25–30% of more than 2000 infected blood donors identified required individual donation NAT for detection.

Dengue ranks as the most important mosquito born viral agent in the world, and in the past 50 years its incidence has increased 30-fold. Its similarity to WNV, a related Flavivirus, raises the question of the ability of dengue virus to be transfusion transmitted. The two clusters of reported cases (Hong Kong and Singapore) confirm that the agent may be transfusion transmitted [3]; however, many more cases of blood born dengue inevitably occur but are unrecognized and not described as transfusion transmitted against a background of epidemic dengue. In contrast to WNV, the major mosquito vectors are *Aedes aegyptii* and *Aedes albopictus*; the latter being responsible for the spread of another viral epidemic, Chikungunya virus which has caused significant morbidity and mortality in the islands of the East Indian Ocean involving infection rates of over one-third of the population [4]. WNV and Chikungunya virus are similar in the resulting clinical disease of severe arthralgias, but differ since the latter is an Alphavirus. Also in contrast to WNV, no non-human host is required as part of the amplification/transmission cycle. The American Red Cross in Puerto Rico, in collaboration with the Centers for Disease Control and Prevention and Gen-Probe, has investigated the prevalence of viremia in blood donors during the 2005 outbreak in Puerto Rico. The study, which tested 16,521 blood donations found 12 positive units, or a frequency of 0.73 per 1000. Two of the four dengue serotypes, which were the same as those in circulation at the time, were identified with viral loads ranging from 2 to 7 logs. Of the 12 positives, infectious virus was recovered from three units as defined by infection of mosquito monolayers and inoculated mosquitoes [5]. Similar results have been obtained in Honduras and Brazil where frequencies of 3 and 0.62 per 1000, respectively, were described. Studies performed in Northern Queensland, Australia however, failed to detect any viremic donors [6].

Chagas disease, caused by the protozoan parasite *T. cruzi* has been known in the Americas since it was first described by Carlos Chagas in 1909. Infection in the US and Canada is rare but has been described in six autochthonous (or domestic) cases in the US, seven transfusion cases and three transplant clusters since the 1990s. Concern exists for this transfusion-transmitted agent since the disease is endemic in Latin America with estimates from PAHO of 7.7 million infected persons. Immigration to the US from Latin America now makes Latins the largest minority group in the US with estimates of 17.9 million born in Latin America with another 35 million in the US of Latin heritage. Blood donor screening was voluntarily introduced in the US in early 2007 following the licensure of a blood donor screening test (Ortho) with anywhere from 75% to 90% of the nation's blood being screened. Canada has not yet implemented and is looking at a number of alternate strategies including questioning of

donors for birth, residence or travel risk and testing those who respond affirmatively to those questions, or not using the platelets from such donors until a test platform of choice has been approved. Such selective strategies are used successfully in France, Spain and England. Experience in the US using the Ortho ELISA and radioimmune precipitation as the supplemental test has shown a frequency of 1 in 28,500 donations with over 12 million donations screened in the first year [7]. The screening test performance has been excellent with a repeat reactive rate of 0.01% and rate of RIPA positivity among repeat reactive donors at 31%.

Malaria, caused by the protozoan parasite, *Plasmodium* and its five species (including the recent recognition of *Plasmodium knowlesi* as a human pathogen) is recognized as the most significant transfusion-transmitted disease agent worldwide. The agent's vector is the anophelene mosquito with the transmission cycle involving only the female anophelene and humans. WHO estimates include 350–500 million cases annually with greater than 1 million deaths mostly in children in sub-Saharan Africa. Like dengue, data indicate that the worldwide distribution of malaria is increasing. Due to climate change, malaria is occurring at greater elevations than previously found including areas of Africa that have never experienced disease outbreaks and where the population is therefore susceptible. Donor questioning to exclude donors who have had malaria, or resided in, or traveled to malarious areas is the preventive measure used in nonendemic areas. Although these strategies appear to be effective, as measured by a rate of less than 1 case per year in the US over the past ten years (i.e., only three cases since 1999) [8], these strategies are complex and nonspecific and result in the deferral of more than 100,000 donors in the US per year. Each year at the American Red Cross, past malaria, residence or travel deferrals to malarious endemic areas represent close to 5% of the total deferrals. Those deferrals related to travel (typically to countries not having had a history of importing transfusion-transmitted malaria, such as Mexico) are increasing while those related to residence or having had malaria are decreasing. For example from 2000 to 2005, the number of travel deferrals totaled approximately 250,000, while the number of individuals having malaria was 495 [9]. Several countries such as France, the UK and Australia rely on "testing in" strategies to recover lost donors more rapidly by re-entering them after a 4–6 month deferral (country dependent) if they test non-reactive on a commercial antibody test that contains antigens to two of the five malaria species (*Plasmodium falciparum* and *Plasmodium vivax*). A permutation of this algorithm occurs in Australia where the donor is not deferred but is flagged by the computer system to discard the donor's cellular components until the donor is cleared by the Newmarket test [10]. A study by American Red Cross used the Newmarket test to look for evidence of malarial infection in deferred donors. Reactive rates of 0.34% and 1.23% were observed in a control group and in deferred donors, respectively. Of note, in the control group, most reactive donors had travel history or a history of prior malaria infection that occurred outside of the deferral period (1 and 3 years,

respectively). In the deferred group, most deferrals were due to travel (1 year), but many of those also had a history of residence and/or malaria (3 year deferral), which was not necessarily reported as a result of questioning sequence [11].

Babesia is a protozoan parasite commonly present in the north-eastern part of the US with a seroprevalence of about 1.5%. Like the agent of malaria, it is an obligate intra-erythrocytic parasite; the two can be distinguished by blood smear. *Babesia* is transmitted by ticks; *Babesia microti*, the most common species in the US, by *Ixodes* ticks; the natural host is the white-footed mouse. Deer are not infected, but do transport the ticks. The resulting disease, babesiosis, may be an acute illness and is readily treatable by antibiotics if recognized; however, most cases are asymptomatic. Those recipients with the worst outcome are those that are elderly, immunosuppressed or asplenic. Since the agent has been recognized in the US, estimates of approximately 70 transfusion-transmitted cases have been reported. There is currently no intervention via effective donor question or screening test; being bitten by a tick is nonspecific and insensitive as most individuals bitten by these small ticks are unaware of their having been bitten. Research studies employ IFA as a screening test and PCR or hamster inoculation as confirmation of infectivity. In studies performed by the American Red Cross, infected donors have been shown to clear infection as documented by repeated PCR negativity and seroreversion whereas others remain PCR positive and retain high IFA titers for years [12].

To date, there have been 166 reported cases of variant Creutzfeldt-Jakob (vCJD) disease reported in the UK and 39 cases reported elsewhere in the world (next highest after the UK is France followed by Ireland). Ingestion of tissues from cattle infected with bovine spongiform encephalopathy (BSE) is almost certainly the cause of human disease. The disease agent is a nucleic acid absent form of protein referred to as a prion. In the UK, there have been four reports of transfusion-transmitted cases occurring at 6.5–8.5 years after receipt of the implicated component (non-leukoreduced red cells) [15]. Three of the four had symptomatic vCJD and the fourth with evidence of infection found when spleen and cervical lymph nodes were examined at autopsy [13,14]. The linked donors in these cases developed vCJD relatively close, 17–40 months, to the time of the presumed transmitting donation. Components from 31 individuals in the UK who developed vCJD and who had donated blood prior to their disease have been traced; of the 66 resulting recipients, 40 have died of causes unrelated to vCJD (including the one with asymptomatic vCJD infection) and the remaining 23 are alive after greater than 5 years without any vCJD-related symptoms. Although these four transfusion-transmission events would suggest a relatively high risk of recipient infection in the UK, the actual transfusion-transmission risk from donors who have ingested contaminated beef is unknown. Studies using the number of prion-positive excised tonsils and appendices project that anywhere from 49 to 690 individuals per million in the UK may be infected [16]. However, the number of vCJD cases reported annually in the UK has declined from the mid 1990s, suggesting that there may ultimately only be a few hundred

cases. In contrast, look back studies performed at the American Red Cross on donors reporting sporadic CJD demonstrate that this agent has a much lower risk of transmission, if at all. These look back studies include 408 recipients of blood from 33 donors whose last donation occurred during the year prior to the onset of CJD symptoms of which 31 have survived without symptoms for 15 years or more [14]. Interventions used in the US to prevent vCJD transfusion transmission include deferral for travel to, or residence in, the UK and Western Europe, or for receipt of transfusion in the UK or France. Although tests for evidence of vCJD infection are being developed, the most promising strategy appears to be prion removal using affinity filters in combination with leukoreduction.

3. Ten years of follow-up of the GIPH HTLV cohort study - lessons from a blood center

Fundação Hemominas is a public blood center located in Minas Gerais State and covers 90% of the need of blood transfusion in the state. It collects over 260 thousand blood bags/year and is a reference for the treatment of hemophilia and sickle cell anemia.

The natural history of HTLV infection is not well known, and may vary with viral and host factors, as well as geographical origin of the infected subjects. The type 1 is associated to disabling and fatal diseases, yet there is no satisfactory treatment and ways of assessing prognosis and likelihood of diseases are limited. Cohort studies are useful to address these questions, especially if they are multicentric. Although cohort studies are very expensive and of long duration, they provide answers that would not be feasible otherwise.

Blood donors in Brazil have been routinely screened for the Human T-cell lymphotropic virus (HTLV-1/2) since 1993 [17]. The HTLV-1/2 serostatus is confirmed using enzymatic assays (EIA), Western blot (WB) and polymerase chain reaction (PCR) [18].

The Interdisciplinary HTLV Research Group (GIPH) is an open prevalent cohort started at Fundação Hemominas in March 1997. 570 blood donors with HTLV-1/2 positive ($n = 333$, 58.4%) or indeterminate (237, 41.6%) serological results are followed, as well as their seropositive or seroindeterminate relatives ($n = 97$) and a group of seronegative blood donors ($n = 166$), as a control. The aim of this study is to determine and quantify epidemiological, clinical and laboratory features that may be associated with HTLV-1/2 infection in a low risk population (blood donors). Every two years the participating individuals are evaluated concerning these aspects. As part of the study, patients with HAM/TSP ($n = 160$) are followed up in Sarah Hospital, a rehabilitation hospital participating in GIPH.

During the past ten years (1997–2007), it was observed: (1) high rates of intrafamilial transmission of HTLV-1 (36%); (2) possible association of HTLV-1 infection with various skin abnormalities, fibromyalgia and psychic depression; (3) immunological markers of HAM/TSP were defined; (4) a considerable rate of seroconversion of HTLV-1 indeterminate

subjects; (5) identification of risk factors in this population, such as less years of formal education, past blood transfusion, IDU, a seropositive relative; (6) development of HAM/TSP in 14/431 (3.24%), more frequent than ATL (7/431, 1.62%); (7) presence of uveitis in 4/419 (1.93%); (8) presence of familial clusters of HTLV-1 associated diseases. Vertical transmission could be avoided in all 18 children born from cohort participants in the period.

As part of the activities of this research group inserted in a blood center, are the actions of hemovigilance for HTLV, with look back studies of recipients of blood transfusion from donors who seroconverted for HTLV-1/2 or repeat donors who were positive when the screening was first started in 1993. Receptors are traced back and, if found, are offered the test for the virus.

The multidisciplinary approach of GIPH, which is coordinated by a blood center, enables the study of the multiple aspects of HTLV-1/2 infection, including disease associations, infection progression markers and should impact on health policies to foster prevention of HTLV spread. It illustrates the benefits of cohort studies, and this approach applicable to other centers, especially those located in higher prevalence areas in South and Central America.

4. Hepatitis B blood safety: old virus, new questions

Hepatitis B virus has been identified forty years ago and HBsAg screening has been part of blood screening since 1972. However, with the development, and recently the implementation, of HBV nucleic acid testing (NAT) in blood for transfusion, new data have been generated that need to be taken into consideration and integrated into our knowledge of the virus and approach to HBV blood safety.

HBV is one of the most widespread and pathogenic viruses in the world, causing liver cirrhosis and hepatocellular carcinoma after years or decades of chronic infection. HBsAg prevalence ranges between 1:1000 and 25% in populations of blood donors, the highest being found in West Africa, the lowest in Western Europe and North America. Evidence of contact with the virus ranges from >80% in West Africa to 60% in the Far East and <0.5% in the UK. Transmission occurs at a young age (vertically or horizontally) in Africa and Asia, with the attached high prevalence of chronic infection, while most people infected sexually or through blood recover and develop a solid neutralizing immune response.

This diversity is also present with the viral genome distributed geographically into 7 main genotypes (A–G) with some diversity in infectivity and pathogenicity mostly related to different levels of viral load. Blood screening needs to be adapted to these epidemiological parameters in order to reach maximum efficacy. The sensitivity of HBsAg screening assays has enormously improved over time reaching 0.1 IU/ml but remains unable to detect the pre-seroconversion window period or samples with very low viral load after decades of chronicity or clinical recovery [19]. The debate is how to improve on the blood safety provided by HBsAg screening [20].

HBV DNA screening is the only means of covering the window period [21]. This is the main concern of countries where infection occurs sexually or through IV drug abuse after age 15, at which people become blood donors. In contrast, anti-HBc screening can eliminate nearly all HBV present in chronically infected or recovered individuals, although only a small fraction of anti-HBc-positive donations also carries detectable HBV DNA. However, in areas where anti-HBc prevalence is >2–5%, the deficit in blood donations that would be created by deferring anti-HBc-positive donors is considered too high to maintain sufficient blood supply. In these areas, HBV DNA screening is the main option, although the generally very low viral load of the potentially infectious units forces to screen in very small pools (<10 plasmas) or in individual units [21,22].

NAT screening, particularly in individual unit samples, has revealed an entity called ‘occult’ HBV infection (OBI) or carriage that is defined as the presence of HBV DNA without detectable HBsAg outside the window period [19]. In a population screened with both HBsAg and HBV NAT, approximately 85% are positive with both assays but approximately 5% are HBsAg positive but HBV DNA negative (occult HBsAg), while 5–9% are DNA positive/HBsAg negative or OBI [23]. OBIs are found in older male donors (>45 y). Nearly 100% carry anti-HBc and approximately 50% also carry anti-HBs suggesting that OBIs occur largely in individuals having recovered from the infection but unable to totally control viral replication [24]. The viral load median level is 25 IU/ml, with nearly all cases <1000 IU/ml. Genome sequencing of OBIs of genotypes A2, B, C and D revealed high frequency of amino acid substitutions in the HBV envelope proteins affecting both humoral and cellular epitopes, suggesting a considerable role played by the host immune pressure selecting variants escaping detection by the immune system. However, in Africa where genotypes A1 and E are prevalent, very few aa substitutions are found indicating that other mechanisms than host immune control are involved. Evidence of lack of pre-core expression and stop codons in the core gene suggest that the low viral load found in OBIs might be related to abnormal viral replication [25].

At present, the main question in transfusion regards the infectivity of OBIs for blood recipients. It appears generally low and almost exclusively with donations carrying only anti-HBc, although cases of fulminant hepatitis post-OBI transfusion have been reported [26,27]. Recent cases of transmissions of HBV by an OBI also carrying anti-HBc have been reported. More look back data need to be collected to further assess this issue [28].

Finally, short of long term follow-up data, there is no evidence that the status of OBI in the donor corresponds to a higher risk of liver disease. Deferred donors should be reassured of the likelihood of a good prognosis.

At this stage of knowledge, it is uncertain whether or not HBV NAT screening is cost-effective in the variety of epidemiological and economic circumstances of countries of the world. Many countries are currently implementing HBV NAT and it is only with accumulation of data that evidence-based screening decisions can be made.

5. Impact of recipient immune status and infection risks of transfusion and transplantation

In this overview of the immune status of the recipient and the risk of infections via blood products and transplantation, only viruses transmitted by blood and organs will be discussed, i.e. hepatitis B virus (HBV), hepatitis C virus (HCV), cytomegalovirus (CMV), West Nile virus (WNV), human T-cell leukemia/lymphoma virus I/II (HTLV-I/II) and Parvovirus B19 virus. Although human immunodeficiency virus (HIV) can be transmitted by blood and organs, this virus will not be discussed.

5.1. Hepatitis B virus

Several studies indicated that recipients of anti-hepatitis B core (anti-HBc) positive livers developed hepatitis B infection after transplantation. When the recipient was hepatitis B surface antigen (HBsAg) negative before transplantation, HBsAg became demonstrable in 18/21 (86%) [29] and 18/25 (72%) [30] of patients after transplantation. Even when recipients were anti-HBs positive (HB vaccinated as well as not vaccinated), they also developed acute hepatitis B in a high proportion. When the donor was anti-HBc and anti-HBs positive still 15/18 (83%) of recipients developed acute hepatitis B post-transplantation. When donor livers were anti-HBc negative only 3/651 (0.5%) developed acute hepatitis B [29]. Four year follow-up of recipients who received anti-HBc-positive donor livers showed that survival was 2.4 fold diminished as compared to recipients of anti-HBc negative livers [29]. Several studies demonstrated that the administration of hepatitis B immunoglobulin (HBIG) and lamivudine [31] or lamivudine monotherapy [32] could prevent acute hepatitis B in these recipients.

Reactivation of HBV is a well-described event in HBsAg positive, as well as HBsAg negative patients undergoing immune suppression. One study showed that in anti-HBc positive, HBsAg negative recipients of solid organs 15/34 (44%) had reactivation as indicated by presence of HBV DNA [33]. Any patient with past HBV infection undergoing immune suppression can develop reactivation of HBV infection. Dependent on the degree of T-cell depletion, the risk is low, as demonstrated in solid organ recipients, or high in patients treated for graft-versus-host disease (GVHD) or undergoing allogeneic bone marrow or stem cell transplantation or treatment with aggressive chemotherapy or monoclonal antibodies against T- or B-cells. Prevention of HBV reactivation is important. It is advised to screen all patients for HBV-markers pre-treatment and to vaccinate all patients who are HBsAg negative. When patients are HBV-marker positive, careful monitoring of the HBV-status and/or administration of anti-viral therapy (e.g. lamivudine) or HBIG should be considered.

5.2. Hepatitis C virus

No reactivation of HCV is reported in immunosuppressed patients who cleared HCV-RNA by natural course or by

antiviral therapy. Patients who are HCV-RNA positive develop a more aggressive course of their liver disease after renal transplantation [34] or when co-infected with HIV [35]. Also HCV/HIV co-infected individuals form an increased risk for perinatal and sexual transmission of HCV due to higher viral load levels than in immune competent individuals [35,36].

5.3. Cytomegalovirus

CMV can easily (30–60% incidence) be transmitted by fresh whole blood to seronegative recipients [37]. The infection rate decreased significantly (1% incidence) when red blood cell concentrates were stored at 4 °C before transfusion. When blood products were leukoreduced by filtration or negative for CMV-antibodies, the risk was almost non-existent anymore [38]. In solid organ transplant recipients and bone marrow or stem cell recipients, primary infection by the transplant in a CMV seronegative recipients is common. Also reactivation of a latent CMV infection in individuals undergoing immune suppression is well known. Patients at risk for CMV infection are: premature infants; the fetus of pregnant women; transplant recipients; HIV infected individuals and oncology patients undergoing immunosuppressive therapy. The degree of T-cell depletion determines the clinical outcome of CMV reactivation, especially since 70–80% of individuals are CMV seropositive.

In one study in immune suppressed CMV-seropositive patients, CMV reactivation was observed in 45–86% of the patients and 20–30% of those developed CMV related clinical disease [39]. Manifestations of clinical disease are pneumonitis, gastro-intestinal tract infections, retinitis and idiopathic thrombocytopenia; some of these infections are associated with a high mortality.

Preventive measures are the use of barrier contraceptives, in case the partner is CMV seropositive or the CMV status is unknown and the use of leukoreduced or CMV seronegative blood products. In immune suppressed patients weekly monitoring by PCR or pp65 antigen is recommended to trigger antiviral therapy. Prophylactic antiviral therapy is not generally recommended. If HCV primo infection or reactivation is established ganciclovir, valganciclovir or foscarnet can be administered.

5.4. West Nile virus

Since 1999 an epidemic of WNV in North America is reported. In immune competent individuals WNV infection causes in 20% a self-limited febrile illness and in approximately 0.7% meningoencephalitis. However, in immune suppressed patients WNV infection results in 40% in meningoencephalitis [40]. WNV can be transmitted by blood transfusion and organ transplantation [41]. All donors in North America are now screened for WNV infection from spring to autumn. The epidemic seems to level off and the blood supply is safe for WNV transmission at present.

5.5. Human T-cell leukemia/lymphoma virus III

There is very limited literature about the risk of HTLV-I/II infection in immunosuppressed patients. In one study it was shown that in HTLV-I infected renal transplant patients ($n = 15$) no myelopathy or adult T-cell lymphoma developed during follow-up for 1–10 years [42]. Also in HTLV-II infected individuals, no significant disease is reported in immune competent as well as immune suppressed individuals. In HIV infected patients HTLV-II is not associated with disease; HTLV-II/HIV co-infection may even protect against disease progression in HIV infected patients [43].

5.6. Parvovirus (B19v) virus

In immune competent individuals (B19v) virus infection is a self-limited disease. Very few cases of (B19v) infection are reported by blood product transmission or by solid organ, bone marrow or stem cell transplantation. Viremia of (B19v) lasts 2–6 months, but maybe prolonged to 40 months in immune suppressed patients [44]. In HIV infected patients prolonged aplastic anemia is reported. No specific measures are necessary to prevent (B19v) infection in immune suppressed individuals.

5.7. Conclusion

From all viruses that can be transmitted by blood products or transplants, HBV and CMV are of most importance for the immune suppressed patient. Also HBV and CMV can reactivate in immune suppressed patients causing significant disease. By screening all blood products for all significant viral markers, and by the removal of white blood cells, the blood supply is safe at present for immune competent as well as immune suppressed patients. The immune suppressed patient should be carefully screened and monitored for reactivation of significant viral markers (HBV, CMV) and if necessary they should receive antiviral therapy.

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