DISCOVERY OF “FALSE HIV ELITE CONTROLLERS” AMONG SOUTH AFRICAN BLOOD DONORS

ISBT TTID WP
17 June 2017

Marion Vermeulen, Karin van den Berg, Genevieve Jacobs, Brian Custer, Ronel Swanevelder, Ute Jentsch, Ravi Reddy, Lubbe Wiesner, Gary Maartens and Edward Murphy for the NHLBI Recipient Epidemiology and Donor Evaluation Study-III (REDS-III)
Background

- SANBS screens all donations for HIV, HBV & HCV using ID-NAT in parallel with serology testing

- Although variable, eclipse period from infection acquisition to disseminated viraemia is estimated ~10 days using ID-NAT\(^1\)

- Very early initiation of cART is likely to have a beneficial effect on the course of HIV disease and may facilitate HIV Cure Interventions\(^2\)

- Use of ID HIV antibody and RNA testing of blood donors and the high incidence of HIV infection in SA enables identification of:
  - Donors with very early (Fiebig stage I & II) incident infection (HIV RNA+, Antibody-)
  - Potential Elite Controllers (EC), a group who are able to control virus replications without treatment (HIV RNA-, Antibody+)
    - Confirmed using western blot
    - Definition of an EC is a viral load <50 copies/mL
  - Prevalent HIV infections (HIV RNA+, Antibody+)

\(^1\) Lee \textit{et al} \textit{Journal of theoretical Biology} 2009
\(^2\) Barouch & Deeks \textit{Science} 2014; Okulicz \textit{JAMA Intern Med} 2014
Monitoring and Acute treatment of HIV study (MATHS) Objectives:

1. Determine Fiebig stage at time of blood donation. For donors identified as being Fiebig stage I or II initiate cART, and ascertain Fiebig stage at the time of therapy initiation.

2. Establish the size of the peripheral blood viral reservoir at the initiation of cART and at defined time points post cART initiation for donors enrolled in the treatment study.

3. Conduct a “proof of concept study” to show how blood donors identified as having “hyper-acute” HIV infection by blood testing can be successfully linked to care with the initiation of early HIV treatment.
MATHS Study Design

• Enrolment commenced end-October 2015

• Acute (50 RNA+/Ab-) & Recent (25 RNA+/Ab+/Lag recent) HIV infections:
  • Open label, non-randomized treatment study
  • Rapid (<4 weeks post index donation) initiation of approved 3-drug antiretroviral therapy (cART)

• Elite Controllers (N=20)
  • Parallel prospective observational cohort of 20 elite controllers

• 2-year clinical and research follow-up

• Frequent research blood samples for HIV virology and immunology

• Less frequent, large volume leuka- and plasmapheresis for measurement of HIV reservoir
Background

- Loss of “Elite Control” by a MATHS participant
- Anecdotal evidence of Elite Controllers reporting ART and therefore “false EC” while recruiting and enrolling donors into the MATHS cohort study
- Apparent increase in EC over 1-2 years and during a winter incentive campaign

Antibody+, RNA- donations as a Proportion of all HIV positives

Loss of virologic control by an Elite controllers enrolled in MATHS*

Days Since Signing Consent

Viral Load

10

100

1000

10000

100000
Aim & Methods

Aim
• To understand the extent of the false EC phenomenon and generate hypothesis for its genesis and prevention

Methods
• 211 Potential EC tested for five ARV drugs using qualitative liquid chromatography tandem mass spectrometry (sensitivity 0.02µg/mL)
  • Nevirapine, Efavirenz, Darunavir, Atazanavir, Lopinavir
• Compare the frequency of false EC against blood drive characteristics, donor incentives and the temporal trend of ART rollout in South Africa using chi-square, Fisher exact and trend tests
ART Rollout

Of 211 Potential Elite Controllers tested, 129 (61%) had evidence of ART and were therefore “False Elite” Controllers.
“False” Elite controllers by donation site and incentives

<table>
<thead>
<tr>
<th></th>
<th>False Elites n=129 (%HIV+)</th>
<th>True Elites n=82 (%HIV+)</th>
<th>Total n=211 (%HIV+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Donation Site</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobile</td>
<td>116 (1.6)</td>
<td>68 (1.0)</td>
<td>184 (2.6)</td>
</tr>
<tr>
<td>Fixed</td>
<td>13 (0.75)</td>
<td>14 (0.81)</td>
<td>27 (1.6)</td>
</tr>
<tr>
<td>Donor Incentives</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incentive period</td>
<td>26 (2.1)</td>
<td>15 (1.2)</td>
<td>41 (3.3)</td>
</tr>
<tr>
<td>Non-incentive period</td>
<td>103 (0.96)</td>
<td>67 (0.62)</td>
<td>170 (1.6)</td>
</tr>
</tbody>
</table>
False Elite controllers by gender and age

<table>
<thead>
<tr>
<th>Gender (p=0.35)</th>
<th>False EC (%HIV+)</th>
<th>N=129</th>
<th>True EC (%HIV+)</th>
<th>N=82</th>
<th>Total (%HIV+)</th>
<th>N=211</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>95 (1.10)</td>
<td></td>
<td>65 (0.75)</td>
<td></td>
<td>160 (1.85)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>34 (0.73)</td>
<td></td>
<td>17 (0.37)</td>
<td></td>
<td>51 (1.10)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age (p=0.03)*</th>
<th>False EC (%HIV+)</th>
<th>True EC (%HIV+)</th>
<th>Total (%HIV+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-19</td>
<td>10 (0.37)</td>
<td>13 (0.48)</td>
<td>23 (0.84)</td>
</tr>
<tr>
<td>20-25</td>
<td>12 (0.35)</td>
<td>16 (0.47)</td>
<td>28 (0.82)</td>
</tr>
<tr>
<td>26-30</td>
<td>23 (0.91)</td>
<td>12 (0.47)</td>
<td>35 (1.38)</td>
</tr>
<tr>
<td>31-40</td>
<td>58 (2.06)</td>
<td>23 (0.82)</td>
<td>81 (2.87)</td>
</tr>
<tr>
<td>41-50</td>
<td>23 (1.79)</td>
<td>10 (0.78)</td>
<td>33 (2.57)</td>
</tr>
<tr>
<td>&gt;50</td>
<td>3 (0.67)</td>
<td>8 (1.78)</td>
<td>11 (2.44)</td>
</tr>
</tbody>
</table>

* For age >30 versus <=30
## False Elite controllers by race

<table>
<thead>
<tr>
<th>Race</th>
<th>False EC (%HIV+)</th>
<th>True EC (%HIV+)</th>
<th>Total (%HIV+)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N=129</td>
<td>N=82</td>
<td>N=211</td>
</tr>
<tr>
<td>Asian</td>
<td></td>
<td>1 (0.72)</td>
<td>1 (0.72)</td>
</tr>
<tr>
<td>Black</td>
<td>120 (1.00)</td>
<td>70 (0.59)</td>
<td>190 (1.59)</td>
</tr>
<tr>
<td>Coloured</td>
<td>1 (0.23)</td>
<td>1 (0.23)</td>
<td>2 (0.45)</td>
</tr>
<tr>
<td>Unallocated</td>
<td>5 (2.45)</td>
<td>3 (1.47)</td>
<td>8 (3.92)</td>
</tr>
<tr>
<td>White</td>
<td>3 (0.56)</td>
<td>7 (1.31)</td>
<td>10 (1.88)</td>
</tr>
</tbody>
</table>

Due to the small number of Potential ECs in non black race group we did not analyse for significance

## Drugs detected

<table>
<thead>
<tr>
<th>Drugs</th>
<th>Atazanavir</th>
<th>Darunavir</th>
<th>Efavirenz</th>
<th>Lopinavir</th>
<th>Nevirapine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number (%)</td>
<td>0</td>
<td>0</td>
<td>111 (86)</td>
<td>7 (5.4)</td>
<td>11 (8.5)</td>
</tr>
</tbody>
</table>
## Viraemia in EC’s

<table>
<thead>
<tr>
<th>Treated &quot;Elite Controller&quot;</th>
<th>Elite Controller</th>
<th>Negative Donor</th>
</tr>
</thead>
<tbody>
<tr>
<td>27 cp/mL</td>
<td>9 cp/mL</td>
<td>0.3 cp/mL</td>
</tr>
<tr>
<td>3 cp/mL</td>
<td>1 cp/mL</td>
<td>1 cp/mL</td>
</tr>
<tr>
<td>0.3 cp/mL</td>
<td>0.3 cp/mL</td>
<td>0.3 cp/mL</td>
</tr>
<tr>
<td>TND= 0/18 reps; &lt;0.12 set at 0.1</td>
<td>(1/18 reps – poisson derived value 0.12)</td>
<td></td>
</tr>
</tbody>
</table>
In 7/28 (25%) no HIV-RNA detectable in 10-33 replicate dHIV assays.

Determined by probit analysis from proportion of positive samples on 30 replicate Ultrio assays against DDL HIV subtype B standard dilutions.
Modeling the proportion of RBC and FFP transfusions from elite controllers being infectious

Percent infectious

- RBC
- FFP (20 ml) (200 ml)

Modeled on 28 elite controllers whose viral loads were determined by probit analysis against DDL HIV subtype B standard.

Likely scenario:
- ID_{50} 316 virions: 15.5%
- ID_{50} 3160 virions: 2.2%
Conclusions

• False EC due to undisclosed ART use, represent a large and growing proportion of potential EC in SA blood donors
• False EC status may be associated with older age but not with sex or race
• False EC status is not associated with small incentives or fixed versus mobile collection site
• False EC may seem to be increasing as ART coverage increases in South Africa
• True EC and False EC do still have viremia and therefore pose a risk to blood safety
Way forward

• Enrol False Elite controllers into a qualitative research study to determine
  • Whether donors feel peer pressure at Mobile clinics
  • Whether donors believe they are cured
  • If more education is required at the treatment clinics
  • If donors are test seeking for confirmatory purposes
  • Whether donors donate for incentives/ small gifts

• Test concordant HIV NAT+/antibody+ donors – especially those with low viral load - for ART to measure the extent of undisclosed ART usage in that group.
## Acknowledgements

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karin van den Berg</td>
<td>South African National Blood Service</td>
</tr>
<tr>
<td>Genevieve Jacobs</td>
<td>Clinical HIV Research Unit (WITS)</td>
</tr>
<tr>
<td>Ronel Swanevelder</td>
<td>Right to Care</td>
</tr>
<tr>
<td>Coreen Barker</td>
<td>RTI</td>
</tr>
<tr>
<td>Amisha Rama</td>
<td>Blood Systems Research Institute</td>
</tr>
<tr>
<td>Rachel Lockyear</td>
<td>University of California San Francisco</td>
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<tr>
<td>Chris McClure</td>
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<td>Nathan Sikes</td>
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<td>Brian Custer</td>
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<tr>
<td>Edward Murphy</td>
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<tr>
<td>Jennifer Norman</td>
<td>University of Cape Town</td>
</tr>
</tbody>
</table>

**REDS-III MATHS is a NHLBI funded project**

HHSN268201100009I
Impact of early ART treatment and pre-exposure prophylaxis on performance of assays for HIV diagnosis and donor screening

Michael P. Busch, MD, PhD
Blood Systems Research Institute
University of California San Francisco
HIV Viremia during early infection

Ramp-up viremia

DT = 21.5 hrs

p24 Ag EIA -

HIV MP-NAT -

HIV ID-NAT -

Peak viremia: $10^6$-$10^8$ gEq/mL

Viral set-point: $10^2$ - $10^5$ gEq/mL
Fiebig Stages of Acute HIV Infection

- **Eclipse Phase**
  - V: 10 days
  - Fiebig I: 17 days
  - Fiebig II: 22 days
  - Fiebig III: 25 days
  - Fiebig IV: 31 days
  - Fiebig V: 101 days

- **Plasma virus RNA (copies/ml)**
  - Viral RNA cutoff: 50 copies/ml

- **Days following HIV-1 transmission**
  - 0 to 150 days

References:
- Fiebig/Busch et al., AIDS 2003
- Cohen/Hecht et al. JID 2010
Data from 17 plasma donors that progressed from NAT positive to WB positive used to construct a relative sequence of reactivity timeline.
Time Until Emergence of HIV Test Reactivity Following Infection With HIV-1: Implications for Interpreting Test Results and Retesting After Exposure

Kevin P. Delaney,¹ Debra L. Hanson,¹ Silvina Masciotra,¹ Steven F. Ethridge,¹ Laura Wesolowski,¹ and Sherry Michele Oven²

¹Division of HIV/AIDS Prevention, and ²Office of the Director, National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention, Centers for Disease Control and Prevention, Atlanta, Georgia

Table 2. Inter-Test Reactivity Intervals of Plasma Specimens

<table>
<thead>
<tr>
<th>HIV Test</th>
<th>Median (Standard Deviation)</th>
<th>95% Confidence Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ag/Ab combo laboratory test</td>
<td>6.0 (1.1)</td>
<td>3.8, 8.2</td>
</tr>
<tr>
<td>AROKITEC HIV Ag/Ab Combo</td>
<td>5.3 (1.51)</td>
<td>1.7, 8.1</td>
</tr>
<tr>
<td>BioPlex 2200 HIV Ag/Ab</td>
<td>5.3 (2.49)</td>
<td>3.6, 10.0</td>
</tr>
<tr>
<td>GS Combo Ag/Ab EIA</td>
<td>6.9 (1.11)</td>
<td>4.7, 9.1</td>
</tr>
<tr>
<td>Siemens Combo HIV Ag/Ab</td>
<td>7.4 (1.35)</td>
<td>4.8, 10.1</td>
</tr>
<tr>
<td>Ag/Ab combo rapid test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Determine HIV-1/2 Ag/Ab Combo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conjugated synthetic peptide laboratory test (kG4KgM-sensitive)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADVA HIV 1/2 Enhanced</td>
<td>10.4 (2.67)</td>
<td>5.1, 15.6</td>
</tr>
<tr>
<td>GS HIV-1/2 PLUS O EIA</td>
<td>13.3 (1.58)</td>
<td>10.2, 16.4</td>
</tr>
<tr>
<td>VITROS Anti-HIV1 + 2 Assay</td>
<td>12.0 (0.94)</td>
<td>10.1, 13.9</td>
</tr>
<tr>
<td>kG4KgM-sensitive rapid test&quot;</td>
<td>14.9 (1.69)</td>
<td>11.7, 18.2</td>
</tr>
<tr>
<td>INSTI HIV-1/2 Antibody Test</td>
<td>20.3 (3.63)</td>
<td>13.4, 27.3</td>
</tr>
<tr>
<td>Uni-Gold Recombigon HIV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synthetic or recombinant peptide rapid screening test (kG4KgM-sensitive)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleanview COMPLETE HIV-1/2</td>
<td>20.2 (2.79)</td>
<td>14.6, 25.8</td>
</tr>
<tr>
<td>Cleanview HIV 1/2 STAT-PAX</td>
<td>18.9 (1.69)</td>
<td>15.2, 22.9</td>
</tr>
<tr>
<td>OraQuick ADVANCE Rapid HIV-1/2</td>
<td>16.6 (1.53)</td>
<td>13.2, 19.9</td>
</tr>
<tr>
<td>OraQuick ADVANCE Rapid HIV-1/2 Antibody Assay</td>
<td>22.9 (4.22)</td>
<td>14.6, 31.2</td>
</tr>
<tr>
<td>OraQuick ADVANCE Rapid HIV-1 Antibody Test</td>
<td>18.0 (1.31)</td>
<td>16.0, 21.2</td>
</tr>
<tr>
<td>Synthetic or recombinant peptide laboratory test (kG4KgM-sensitive)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avioq HIV-1/2 Microplex System²</td>
<td>17.9 (1.26)</td>
<td>14.6, 23.2</td>
</tr>
<tr>
<td>Synthetic or recombinant peptide supplemental HIV-2/HIV-2 differentiation test (kG4KgM-sensitive)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genius HIV-2/1 Ab Supplemental Assay</td>
<td>21.3 (2.68)</td>
<td>16.0, 26.5</td>
</tr>
<tr>
<td>Multistep HIV-1/2 Rapid Test&quot;</td>
<td>22.2 (2.67)</td>
<td>17.0, 27.4</td>
</tr>
</tbody>
</table>

Estimated median, interquartile range, that is, the 25th and 75th percentiles, and 99th percentiles of the Window period distribution, the duration of time between human immunodeficiency virus exposure and immunosassay reactivity. Percentiles are means of respective percentiles from 4 computational methods and from all tests of a category of tests. Window period estimates were from 10,000 simulated days into patient activation, using parameters from the observed data (testing of plasma specimens), and 10,000 simulated window day as per Figure 1.

Abbreviation: Ig, immunoglobulin.

Table 3. Window Periods

<table>
<thead>
<tr>
<th>Category (No. of Inclusive Tests)</th>
<th>Median (Interquartile Range; Days)</th>
<th>99th Percentile (Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antibody/antigen laboratory (4)</td>
<td>17.8 (13.0, 23.6)</td>
<td>44.3</td>
</tr>
<tr>
<td>IgG/gM-sensitive laboratory (3)</td>
<td>23.1 (18.4, 28.8)</td>
<td>49.5</td>
</tr>
<tr>
<td>IgG-sensitive rapid screening (6)</td>
<td>31.1 (26.2, 37.0)</td>
<td>56.7</td>
</tr>
<tr>
<td>IgG-sensitive supplemental (2)</td>
<td>33.4 (28.5, 39.2)</td>
<td>58.2</td>
</tr>
<tr>
<td>Western blot (viral lysate) (1)</td>
<td>36.5 (31.0, 43.2)</td>
<td>64.8</td>
</tr>
</tbody>
</table>

Estimated median, interquartile range, that is, the 25th and 75th percentiles, and 99th percentiles of the window period distribution, the duration of time between human immunodeficiency virus exposure and immunosassay reactivity. Tests are alphabetically ordered within each test category.

Figure 1. Simulated eclipse period probability density function (PDF) translated from 3-parameter Weibull prior distribution. Parameters for location, shape, and scale: Day 0.001, 8.6, and 20.4, respectively.
New Testing Strategy to Detect Early HIV-1 Infection for Use in Incidence Estimates and for Clinical and Prevention Purposes

Robert S. Janssen, MD; Glen A. Satten, PhD; Susan L. Stramer, PhD; Bhupat D. Rawal, PhD; Thomas R. O'Brien, MD, MPH; Barbara J. Weiblen, MS; Frederick M. Hecht, MD; Noreen Jack, MBBS, MPH; Farley R. Cieghorn, MD, MPH; James O. Kahn, MD; Margaret A. Chesney, PhD; Michael P. Busch, MD, PhD
Beyond detuning: 10 years of progress and new challenges in the development and application of assays for HIV incidence estimation

Michael P. Busch\textsuperscript{a, b}, Christopher D. Pilcher\textsuperscript{c}, Timothy D. Mastro\textsuperscript{d}, John Kaldor\textsuperscript{e}, Gaby Vercauteren\textsuperscript{f}, William Rodriguez\textsuperscript{g}, Christine Rousseau\textsuperscript{g}, Thomas M. Rehle\textsuperscript{h}, Alex Welte\textsuperscript{i}, Megan D. Averill\textsuperscript{d}, Jesus M. Garcia Calleja\textsuperscript{f}, for the WHO Working Group on HIV Incidence Assays

*From AIDS 2010, 24:2763–2771*

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**Fig. 1.** Principle of assays that discriminate recent from long-standing HIV infections, based on maturation of HIV-specific antibody responses, for use in cross-sectional incidence estimation. LS-EIA, less-sensitive-enzyme immunoassay.

**Fig. 2.** Representative testing algorithm incorporating two incidence assays and available clinical data (CD4 count and antiretroviral treatment history) for determination of recent HIV infection status of specimens evaluated for HIV incidence estimation. Assay 1 and assay 2 represent two assays...
REVIEW ARTICLE
Moving towards a reliable HIV incidence test – current status, resources available, future directions and challenges ahead

Fig. 2. CEPHIA incidence assay critical path.

<table>
<thead>
<tr>
<th>STAGES</th>
<th>CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomarker discovery</td>
<td></td>
</tr>
<tr>
<td>Biomarker proof of concept</td>
<td></td>
</tr>
<tr>
<td>Assay development</td>
<td></td>
</tr>
<tr>
<td>Qualification</td>
<td></td>
</tr>
<tr>
<td>Independent evaluation</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Potential uses for HIV incidence assays

<table>
<thead>
<tr>
<th>Use</th>
<th>Description of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Incidence estimate for national surveillance</td>
<td>To provide national estimate of incidence; may be part of a broader demographic study</td>
</tr>
<tr>
<td>2. Incidence estimation for programme, prevention or trial planning</td>
<td>To provide incidence estimate in sub-populations for planning, prioritizing, or other instances when an estimate of incidence is required. May often be for only a city or region (e.g. prioritize programmes or investments, or identify sites for intervention trials)</td>
</tr>
<tr>
<td>3. Incidence estimate in key or sentinel populations</td>
<td>To provide incidence estimates in special sub-population using targeted sampling methods</td>
</tr>
<tr>
<td>4. Incidence estimation to assess the impact of population-level interventions</td>
<td>To assess the impact of a population-level intervention (e.g. community-level intervention) by comparing incidence before and after the intervention</td>
</tr>
<tr>
<td>5. Incidence estimate from case-based surveillance</td>
<td>To provide national or regional incidence estimates via case-based reporting of newly identified HIV+ individuals</td>
</tr>
<tr>
<td>6. Identification of individuals with ‘recent’ infections for research purposes</td>
<td>Identification of individuals with ‘recent’ infections for multiple potential applications (e.g. recruitment of recently infected individuals into longitudinal cohort studies)</td>
</tr>
<tr>
<td>7. Identification of patients with ‘recent’ infections for individual patient management</td>
<td>Identification of patients with ‘recent’ infections for to guide clinical management and/or public health programmes (e.g. selecting therapy, and/or prioritizing contact tracing)</td>
</tr>
<tr>
<td>8. Targeted prevention planning</td>
<td>To provide population-level data on recent infections to enable risk factors analysis or identify hotspots to inform targeted prevention planning (no incidence estimate is obtained)</td>
</tr>
</tbody>
</table>
Reduction in HIV Ab reactivity in EC and Following ART in CEPHIA

Keating et al. JID, in press
HIV Abs in Early/Late Treatment Cohort

Keating et al, JID, in press
HIV Antibody Levels and Avidity Slowly but Steadily Decrease during ART in A5321 Cohort

Sheila et al, in preparation
HIV latency is established in acute HIV infection
Latency persists despite early and long-term ART
Pool of latently infected cells is stable with little to no decay in the presence of long-term ART
HIV DNA Set Point is Rapidly Established in Acute HIV Infection and Dramatically Reduced by Early ART☆☆☆

Jintanat Anaworinich a,b,c, Nicolas Chomont d,e,1, Leigh Ann Eller a,b, Eugene Kroon c,f, Sodsai Tovanabutra a,b, Meera Bose a,b, Martin Nau a,b, James L.K. Fletcher c, Somporn Tipsuk c, Claire Vandergeeten e,1, Robert J. O’Connell d, Suteeraphorn Pinyakorn a,b, Nelson Michael a, Nittaya Phanuphak c, Merlin L. Robb a,b, on behalf of the, RV217 and RV254/SEARCH010 study groups:

Fig. 1. Plasma HIV RNA of RV217 untreated and RV254 treated acute HIV infection participants. Footnote: The detection limit of HIV RNA was either 1.7 or 1.3 log_{10} copies/ml.

Fig. 2. Total and integrated HIV DNA and 2-LTR circles in peripheral blood mononuclear cells of Fiebig I to IV RV217 untreated and RV254 treated acute HIV infection participants. Footnote: PRMCs: peripheral blood mononuclear cells.

Commentary

The Benefits of Early Antiretroviral Therapy for HIV Infection: How Early is Early Enough?

Sulgi A. Lee, Steven G. Deeks *

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The size of the expressed HIV reservoir predicts timing of viral rebound after treatment interruption

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\textsuperscript{a} Association of pre-ART levels of CA-RNA, CA-DNA, and residual viremia with timing of viral rebound. Levels of pre-ART

\textsuperscript{b} Threshold < 200 HIV RNA copies/ml
\textsuperscript{c} Threshold < 1000 HIV RNA copies/ml

\textsuperscript{d} \( P < 0.01 \)
\textsuperscript{e} \( P = 0.01 \)

\textsuperscript{f} \( P = 0.02 \)
\textsuperscript{g} \( P = 0.06 \)
Seroreversion in Subjects Receiving Antiretroviral Therapy during Acute/Early HIV Infection

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Steven S. Alexander,2 Christopher Bentzen,1 Clarissa A. Ramstead,1 Douglas F. Nixon,1 Jay A. Levy,1
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Timing is Everything – Shortcomings of Current HIV Diagnostics in the Early Treatment Era


Figure 1. After HIV infection, p24 antigen and IgM and IgG antibody seroconversion occur which are progressively detected by 4th, 3rd or 2nd generation assays over the weeks post-infection. Diverse antigen-specific responses can be differentially detected during this period by western blot (WB) and other confirmatory assays. Sustained antigenic stimulation is required for maturation and maintenance of these antibody responses. Early treatment with ART aborts the development of antibodies if treatment is initiated very early and subsequent seroreversion may occur if treatment is initiated shortly following seroconversion, making it difficult to detect or confirm HIV infection by standard diagnostic tests.
Initiation of Antiretroviral Therapy During Acute HIV-1 Infection Leads to a High Rate of Nonreactive HIV Serology

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**Results.** Participants (N = 234) initiating ART at a median of 19 days (range, 1–62 days) from HIV exposure demonstrated different frequencies of reactivity prior to and following 24 weeks of ART depending on the IA. Third-generation IA nonreactivity prior to ART was 48%, which decreased to 4% following ART (P < .001). Fourth-generation IA nonreactivity was 18% prior to ART and 17% following ART (P = .720). Negative WB results were observed in 89% and 12% of participants prior to and following 24 weeks of ART, respectively (P < .001). Seroreversion to nonreactivity during ART was observed in at least one of the tests in 20% of participants, with fourth-generation IA demonstrating the highest frequency (11%) of seroreversion.
Absence of Serological Response Following Early Treatment of Acute HIV Infection

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In press, Clinical Infectious Diseases
Background

Initiation of HAART at very early times in acute HIV infection (AHI) can reduce viral load to below detectable levels.

The reduction of plasma viremia may reduce HIV-1 immune response and emergence of HIV diagnostic markers in blood.

HIV infected infants who initiated treatment before 12 weeks of age frequently become HIV seronegative by 2 years of age, but have not cleared virus from latent reservoirs.

Examine evolution of HIV serological markers following early HAART Therapy
Study Populations and Assays

Evolution of HIV Markers in two Acute HIV Infection Cohorts
RV217 - Untreated population
RV254 – Initiated HAART Treatment during AHI
Viral markers were followed at various times post first infection

RNA Screen – Aptima (Hologic)
Viral Load – (Abbott m200)

p24 Ag Bio-Rad p24 Ag (RUO)
4th Gen EIA Bio-Rad Ab/Ag Combo
3rd Gen EIA Bio-Rad EIA 1/2/O
Supplementary Bio-Rad Western blot
Bio-Rad MultiSpot
Untreated Volunteers were Reactive by 3rd Gen EIA by 2 weeks with s/co >14.

Once seroconversion took place, all samples remained EIA Reactive throughout subsequent testing periods.
3rd Gen EIA signal in Individuals Treated at Fiebig I

Treated at Fiebig I  \( N = 20 \)
11 (55%) Non Reactive (NR) [6 (30%) Transient]
3 (15%), Low
3 (15%) Medium
3 (15%) High.
3rd Gen EIA signal in Individuals Treated at Fiebig II

<table>
<thead>
<tr>
<th>Weeks on HAART</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td>s/co</td>
<td>16</td>
<td>14</td>
<td>12</td>
<td>10</td>
<td>8</td>
<td>6</td>
</tr>
</tbody>
</table>

Treated at Fiebig II  N = 30

- 2 (6.7%) NR
- 8 (26.7%) Low
- 14 (46.7%) Medium
- 6 (20%) High
3rd Gen EIA signal in Individuals Treated at Fiebig III/IV

Treated at Fiebig III/IV  \( N = 20 \)

1. (5.0%)  NR
5. (25.0%)  Low
6. (30.0%)  Medium
8. (40%)  High.
**Delay/Reversion of 3rd Gen EIA following early HAART**

HAART treatment at Fiebig I - IV results in decreased seroreactivity at later times.

<table>
<thead>
<tr>
<th></th>
<th>3rd Gen EIA Reactivity (s/co)</th>
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<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Untreated</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24</td>
</tr>
<tr>
<td>Treated</td>
<td></td>
</tr>
<tr>
<td>Fiebig I</td>
<td>20</td>
</tr>
<tr>
<td>Fiebig II</td>
<td>30</td>
</tr>
<tr>
<td>Fiebig III/IV</td>
<td>20</td>
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</tbody>
</table>

**EIA Reactivity by Wk 24**
Conclusions

In untreated individuals, serological markers evolve with time post infection:
- $4^{th}$ Gen EIA (Ag/Ab Combo) reactive within 7 days,
- $3^{rd}$ Gen (Ab) within 14 days, and
- WB Pos within 24 days post infection.

Treatment at Fiebig I blocks subsequent emergence of anti-HIV
- 72.7% of individuals remained serologically HIV negative by week 24

Treatment at Fiebig II caused delay or decrease of serological markers,
- 68.6% of individuals at Wk 12, and 70.7% by Wk 24.

Treatment at Fiebig III and IV results in delay/decrease in seroreactivity
- in 60% participants

Western Blot reactivity is significantly delayed/reduced
- 45% of individuals had IND or Neg WB even after Wk 12 and 24.

Caution is urged in interpretation of negative serological signal in
- individuals on early HAART as absence of infection.
HIV Seroincidence Panel Project (SIPP)

Timepoints of SIPP specimens with ARV treatment

Days from ART Initiation (Time 0)

Days from EDDI to ART initiation

SC013: 0.5
SC012: 20
ISCP109: 26
ISCP106: 29
ISCP108: 39
ISCP107: 41
ISCP104: 44
ISCP103: 45
ISCP102: 50
ISCP101: 54
ISCP100: 55
LSS102: 63
LSS101: 66
SC017: 83
SC018*: 93
SC016: 214
SC004: 411
ISCP105: 686

These specimens were all collected prior to ART initiation.

*Also includes one time point 1586 days after ART initiation.
The Effect of Oral Pre-Exposure Prophylaxis (PrEP) on the Progression of HIV-1 Seroconversion: The Known Unknowns

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Centers for Disease Control, Indiana University
University of Manitoba and University of Washington
Background

• Six randomized clinical trials of tenofovir disoproxil fumarate (TDF) alone or in combination with emtricitabine (TDF/FTC) [TRUVADA®] used as pre-exposure prophylaxis (PrEP) for HIV-1 infection have shown a reduced risk of HIV-1 acquisition between 44% and 87%
• Success of PrEP is associated with antiretroviral drug adherence
• Primate model suggests that PrEP reduces viral load associated with break-through of SHIV$_{SF162P3}$ infection but has little impact on the timing of seroconversion or neutralizing antibodies; however, maturation of antibody avidity is delayed (Curtis et al., J Acquir Immune Defic Syndrome 2011;57:355-362)
• It is biologically plausible that PrEP could affect the appearance and concentration of biomarkers of acute HIV-1 infection (AHI) – HIV-1 RNA, p24 antigen, HIV-1 antibodies – i.e., Fiebig Stage
• PrEP could result in the delay or attenuation or perhaps even skipping the detection of expected biomarkers of AHI
• These potential effects of PrEP would have implications for the routine laboratory diagnosis of acute/early HIV-1 infection
Partners PrEP study

- Enrolled 4,747 HIV serodiscordant couples in Kenya and Uganda between July 2008 and November 2010 (Baeten et al., Lancet Infect Dis 2014; 14:1055-64)
- Randomized 1:1:1 to FTC/TDF:TDF:Placebo
- Stopped early for efficacy
  - re-randomized Placebo 1:1 to FTC/TDF:TDF after DSMB meeting July 2013
- N = 138 seroconversions observed
Specific Aims

- **Hypothesis**: PrEP will delay the expected biomarker-defined Fiebig stages of acute/recent/early HIV-1 infection for human clinical trial subjects infected with non-clade B virus

  - Assess whether time to progress through Fiebig stages was affected by PrEP
  - Assess whether virologic or antibody response was affected by PrEP
  - Assess an association of PrEP with a delay in detection of seroconversion by the site versus the central laboratory
# Seroconverter characteristics (N=138)

<table>
<thead>
<tr>
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<th>PrEP</th>
<th>Placebo</th>
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<tbody>
<tr>
<td></td>
<td>(N = 67)</td>
<td>(N = 71)</td>
</tr>
<tr>
<td>Male</td>
<td>27 (40%)</td>
<td>37 (52%)</td>
</tr>
<tr>
<td>Viral load of partner (median RNA log10 copies/mL)</td>
<td>4.33</td>
<td>4.43</td>
</tr>
<tr>
<td>Age (median, IQR)</td>
<td>31</td>
<td>30</td>
</tr>
<tr>
<td>Infected at Randomization</td>
<td>9 (14%)</td>
<td>6 (8%)</td>
</tr>
<tr>
<td>No site HIV test for &gt;100 days prior to first HIV-infected visit</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Time to detect seroconversion at site*</td>
<td>N = 58</td>
<td>N = 71</td>
</tr>
<tr>
<td>0 days</td>
<td>21 (36%)</td>
<td>36 (51%)</td>
</tr>
<tr>
<td>Within 100 days</td>
<td>27 (47%)</td>
<td>31 (44%)</td>
</tr>
<tr>
<td>&gt;100 days</td>
<td>10 (17%)</td>
<td>4 (6%)</td>
</tr>
</tbody>
</table>

*Time from first HIV-infected sample to site detection of seroconversion
N=138 (113 included for analysis)

Exclusion of 25:
16 had no HIV-uninfected samples;
9 had >100 days with no site HIV test
HIV-1 RNA level for all samples during seroconversion

As treated: $\log_{10}$ VL change = -0.74, $p < 0.001$ (5.5-fold)

As randomized: $\log_{10}$ VL change = -0.64, $p < 0.001$ (4-fold)

N=134

N=121
HIV-1 antibody response was not affected by PrEP
Time between first HIV-infected sample tested positive by Central Laboratory and Site detection of seroconversion before and after 90 days (N=129)

Detection delayed by > 90 days (OR) P-value
As randomized  1.12 (0.95, 1.33)  0.17
As treated     1.28 (1.11,1.46)  <0.001
Summary

• PrEP during seroconversion
  – Slightly slower progression through Fiebig stages
  – Modest decrease in viral load
  – Some participants had delayed seroconversion
• Antibody response not changed by PrEP
• Regardless of PrEP, rapid tests were not highly sensitive for detection of acute/early infection
Antigen/Antibody HIV Screening Tests are Crucial for Pre-Exposure Prophylaxis Programs

Delaugerre et al. JID in press

• 488 high-risk MSM in IPERGAY Trial (949 pys)
• 31 diagnosed with HIV infection (Architect Ag/Ab Combo)
  – 13 infected at screening or at randomization visit
  – 19 acquired infection during PREP monitoring (q1 month)
    • 16 placebo; 2 TDC/FTC; one during open phase;
  – Prior samples tested for RNA and 2 positive
• Sensitivity of Ag/Ab combo assays:
  – EIA 4G Architect and BioPlex: 83% (95% CI: 76-99%)
  – VIKIA: 54% (34-72%)
  – AUTOTEST: 50% (31-69%)
  – ALERE: 78% (59-91%)
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BILL & MELINDA GATES foundation

CEPHIA

Blood Systems Research Institute
Public Health England
SACEMA
UCSF
San Francisco

Dare to find a cure
Fiebig Staging Laboratory Methods
(after Fiebig et al., *AIDS* 2003; 17:1871-79)

Period of full seroconversion ~ 3-4 months

**HIV-1 Assays**

**RNA:** Abbott m2000rt

**P24:** ARCHITECT or Bio-Rad HIV-1/2

**IgM/IG Ab:** Multispot HIV-1/2

**WB IND**

**WB -p31**

**WB +p31**

Genetic Systems