Published on *IVD Technology* (http://www.ivdtechnology.com)

Workflow analysis and performance evaluation of an automated blood testing system

Gilles Delage, Louis Thibault, and Frank Strobl
Created *2011-06-15 15:04*

[1]

Published: June 15, 2011
Find more content on: Feature Articles [2] Laboratory Automation [3]
Find Qualified IVD Industry Suppliers at Qmed:
IVD [4]

Workflow analysis and performance evaluation of an automated blood testing system

A study evaluated the workflow efficiency of a laboratory automation system, suggesting that fully automated and integrated nucleic acid testing systems can help to enhance blood testing laboratory logistics, human resource utilization, and screening turnaround times.

By: Gilles Delage, Louis Thibault, and Frank Strobl

Workflow, processing time, and staffing needs have emerged as key issues in the efficient testing and processing of donated blood. In addition to other testing technologies for infectious diseases, blood centers typically use nucleic acid amplification technology (NAT) to screen blood donations for human immunodeficiency virus-1 (HIV-1), hepatitis B virus (HBV), and hepatitis C virus (HCV). In some parts of the world, West Nile virus (WNV) has also become a significant public health concern in recent years. The single-stranded enveloped RNA virus is transmitted to birds, horses, humans, and other species by mosquito bites. Transmissions of WNV by blood components emerged in the United States in 2002, and public health authorities across North America began to require blood donation screening using NAT in 2003.[1,2]

Blood centers in North America use commercially available systems and assays such as either the cobas S 201 system by Roche Diagnostics or the Procleix Tigris system by Novartis Diagnostics to screen donations for HIV-1, HBV, HCV, and WNV. The Héma-Québec blood center (Montreal) has collected about 275,000 blood donations yearly and screens donations using the Roche system. In 2009,

Figure 1. The Procleix Tigris system is the only fully automated, integrated NAT testing platform for blood screening, enabling laboratories to attain optimal productivity.

Héma-Québec conducted an operational trial using the Procleix Tigris system. The Procleix Tigris system is a NAT screening platform to detect the presence of HIV-1, HBV, HCV, and WNV in human plasma samples (see Figure 1). Using the Procleix blood screening products, researchers from Héma-Québec applied three different testing and pooling scenarios based on seasonal WNV testing needs in Québec. The trial was designed to examine the suitability of the Procleix Tigris system within Héma-Québec's existing framework of human blood donations, blood testing laboratory logistics, human resource utilization, and screening turnaround time. The trial was not designed for any direct or indirect comparisons between the Roche and Novartis devices.

This simulated workflow trial was conducted in a research facility physically separated from the Héma-Québec blood testing laboratory used to screen human blood donations that will be released into the blood products supply chain for human use. The study was presented as a poster, "Workflow Analysis of the Procleix Tigris System for HIV-1, HCV, HBV, and WNV Molecular Testing Following Three Seasonal Scenarios," at the AABB Annual Meeting in October 2010.

Methods and Materials

The Procleix Tigris system is the only fully integrated and automated NAT blood testing system to be introduced into the North American market. Once a run has been initiated and multi-tube units (MTUs) are loaded 50 minutes later, the operator can walk away from the system and perform other tasks as needed while testing is completed. The system includes one analyzer and one user interface, although many users add a Tecan Genesis robotic sample processor to reduce the time and labor that are needed to prepare samples. The analyzer allows for testing of individual samples and pooled samples. A single tube containing a pooled or an individual donation sample can be used for both the Procleix Ultrio Assay (triplex HIV-1, HCV, and HBV) and the Procleix WNV Assay.

The entire testing process is automated and traceable by way of barcode identification of sample tubes and reagent bottles. Sample addition verification is controlled by the instrument, not by the operator. Through the user interface, the operator creates a work list, loads reagents and samples, manages fluid inventory, performs daily maintenance, and generates the final results. If a donor sample is reactive with the Procleix Ultrio Assay, discriminatory probe assays can identify which virus is infecting the blood.

The system offers the ability to use control brackets within a run, thus enabling the automated release of results on 50 or more samples without waiting for the completion of the entire run. Tigris software allows the operator to program controls at any interval in the run, and once the first bracket of controls is processed, the tube results obtained within this bracket can be uploaded and released even as the system is still processing other samples within the same run. A workstation is set up next to the Procleix Tigris system that includes a rolling stand with a CPU, monitor, printer, and uninterruptible power supply. The compact footprint minimizes operator movement and improves efficiency of use.

In the United States, the Procleix Tigris system has been approved by FDA for use with the Procleix Ultrio Assay, which tests for HIV-1, HBV, and HCV, and with the Procleix WNV Assay, which tests for WNV. The system has also received CE Mark certification and has been licensed by Health Canada for use in screening human blood donations since 2006.

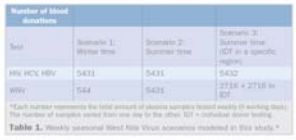
While the incidence of HIV-1, HBV, and HCV in donated blood is largely independent of seasonal variation, the incidence of WNV varies dramatically in climates with significant seasonal change. WNV is primarily an avian virus that is transmitted through mosquito vectors. Humans, horses,

and other warm-blooded species can become infected if they are bitten by an infected mosquito, but they are largely incidental hosts.

Because WNV transmission requires the presence of infected birds and mosquitoes actively feeding on both avian and human blood, transmission almost never occurs during winter when temperatures are too low to support vectors and most birds have migrated to warmer areas. WNV transmission spikes in summer months, typically May through October, when both avian and mosquito activity are at seasonal peaks. This seasonal variation in transmission translates into significantly increased testing loads at blood banks during the warmer months of the year when the risk of WNV transmission is elevated.

The present study protocol included three testing scenarios to mimic the seasonal variation in WNV that is commonly seen in Québec. Scenario 1 represents a week of winter donations and testing when WNV transmission risk is low in Canada so WNV screening is performed only on donors who have travelled outside Canada in the past 56 days. Scenario 2 represents a week of pooled donation testing (in which blood from multiple donors is pooled before testing) during summer when WNV testing becomes imperative and overall screening demand is higher than in winter.

Scenario 3 represents summertime testing under WNV trigger conditions in a specific region using the Procleix Ultrio Assay in a pooled testing format for all of the samples and the Procleix WNV Assay both in an individual donation testing (IDT) format (in which each donor's blood is tested individually) for some of the samples and a pooled format for the rest of the samples. Triggering occurs when certain epidemiological conditions indicate an enhanced risk of WNV infection in humans (see Table I).

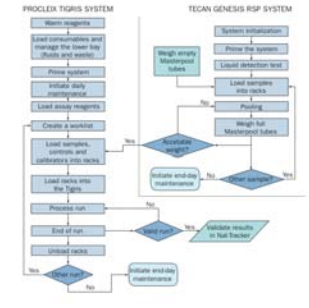


[6]

Table I. Weekly seasonal West Nile Virus scenarios modeled in this study.

One Procleix Tigris system and one pooling Genesis RSP system by Tecan Group Ltd. were installed, operated, and validated at the Héma-Québec blood center research and development facility in Québec City as recommended by the respective manufacturers. Four technicians were trained to operate the instruments before the study was initiated.

Testing was conducted using simulated pools of 16 plasma samples using the Procleix Ultrio Assay and the Procleix WNV Assay, except for Scenario 3 in which only the Ultrio assay was run mainly in pools and the WNV assay was run in IDT or in pools. In all of the scenarios, if the daily sample volume that was intended for the pooled testing format did not divide evenly into 16, the remaining samples were run in IDT. Therefore, the total number of samples tested in pools was lower than the total number of samples tested in each of the three scenarios.



[7]

Figure 2. Operational workflow of the Procleix

Test tubes were filled with commercial plasma from SeraCare Life Sciences and kept frozen at -20º C until testing. After thawing, the plasma tubes were labeled and collected for either pooling or individual testing. Random tubes were spiked with a Procleix positive calibrator or a WNV training panel from Acrometrix for HIV-1, HCV, HBC, or WNV. About 0.08% of the samples were spiked with commercially available calibrators or panel members in order to reproduce the typical positive sample rate at Héma-Québec. The sample spiking and sample testing were conducted blindly by different individuals. A comparison of the operational workflows of the Procleix Tigris system and the Tecan Genesis RSP system can be seen in Figure 2.

Scenario 1 included 5,431 Procleix Ultrio Assay plasma samples, 544 Procleix WNV Assay plasma samples, 337 Ultrio assay pools, and 32

Tigris NAT technology.

WNV assay pools. There were 25 Tecan pooling runs and 18 Tigris testing runs. A total of four positive samples had been spiked in the scenario sample collection, and all four were identified: one HIV-1, two HCV, and one HBV. There were no invalid runs and six invalid samples.

Scenario 2 included 5,431 Procleix Ultrio Assay samples, 5,431 Procleix WNV Assay samples, 337 Ultrio assay pools, and 337 WNV assay pools. There were 26 Tecan pooling runs and 20 Tigris testing runs. A total of five positive samples had been spiked in the scenario sample collection, and all five were identified: one HIV, one HCV, two HBV, and one WNV. There was one invalid run and 39 invalid samples.

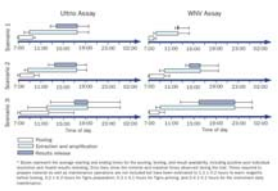
Scenario 3 included 5,432 Procleix Ultrio Assay samples, 2,716 Procleix WNV Assay non-trigger samples, 2,716 WNV assay IDT trigger samples, 337 Ultrio assay pools, 2,716 WNV assay IDT samples, and 167 WNV assay pools. There were 36 Tecan pooling runs and 23 Tigris testing runs. A total of four positive samples had been spiked in the scenario sample collection, and all four were identified: one HIV, one HCV, one HBV, and one WNV. There were no invalid runs and 41 invalid samples (see Table II).

[8]

Table II. Overview of the three WNV seasonal scenarios.

If any pool was found to be reactive with the Procleix Ultrio Assay or the Procleix WNV Assay, the pool was de-convoluted, and its individual constituents were tested with the appropriate screening assay to find the reactive sample within the pool. The Procleix Tigris system was used with two assays: the Ultrio assay for the detection of HIV-1, HCV, and HBC, and the WNV assay for the detection of WNV. All of the individual samples found to be positive using the Ultrio assay were tested with discriminatory assays at the end of the study. The WNV assay detects a single virus so no discriminatory assay was needed.

Results



[9]

Figure 3. Comparison of the pooling, testing, and result issuing timelines obtained with the Ultrio and WNV assays following three seasonal WNV scenarios.

In this simulation of Héma-Québec's standard blood bank screening procedures, the Procleix Tigris system produced turnaround times that are comparable to the current NAT blood screening procedures. On average, the total sample pooling times for the system were 3 hours ± 0.5 for scenario 1 (winter), 3 hours ± 0.6 for scenario 2 (summer, pooled testing only), and 3.7 hours ±1.2 for scenario 3 (summer, pooled and individual testing). The total run times for the system were 11.2 hours ± 2, 11.8 hours ± 0.7, and 14.4 hours ± 1.6, respectively, for the three scenarios, including time for the resolution of individual samples as indicated and retesting of invalid results (see Figure 3). The total operator hands-on time was 3 hours ± 0.8, 4.1 hours ± 0.6, and 5.1 hours ± 1.1, respectively, for the three scenarios. Reagent preparation adds 1.1 hours ± 0.2 to the total operator hands-on time in each scenario (see Table III).

With testing starting at 7 a.m., the first results were released at 1:58 p.m. ± 45 min., 2:31 p.m. ± 38 min., and 7:41 pm ± 183 min., respectively (see Figure 3). In this standard workflow simulation, the staffing needs for all three scenarios were two technicians for the day shift and one technician for the night shift. No false positive results were found. Only one run out of 148 runs total (0.7%) was invalid and required retesting. The one invalid run was produced by the Procleix Tigris system, which was used for a total of 61 runs, producing an invalid run rate of 1.6% for the instrument (see Table II).

Discussion

[10]

Table III. Operator hands-on times for each scenario. Mean ± SD of six testing days per scenario (range).

This study was a simulation of Héma-Québec's routine blood bank operations in winter, when the need for WNV testing is low, and in summer, when WNV testing is mandatory for all blood donations. This seasonal increase in blood donor testing volume can increase operational stress and staffing needs for many blood screening instruments. The study results show that throughput for the Procleix Tigris system is well suited to adapt to these seasonal variations. The system can produce testing result quality and turnaround times that are comparable to the current NAT testing technology. The instrument meets all of the requirements for blood donor screening quality, volume, turnaround time, technician training, operating time, physical space, compliance with cGMP, and interface with the existing information technology network.

This study confirms that the Procleix Tigris system is a fully automated and integrated walk away system with stable operator requirements regardless of seasonal demand. Once samples and reagents have been loaded, the system performs all of the steps needed for testing in a fully automated mode that requires no technician input or attention until the run has been completed. During the most time- and labor-intensive of the three scenarios, the total technician hands-on time with the instrument was 5.1 hours of the 14.4 hour total run time, a combination of batch testing and IDT of positive pools to identify the positive donors in the batch. Full automation gives blood bank operators nearly 10 hours of technician time each day that can be devoted to other tasks. The less intensive winter scenario required only 3 hours of technician time out of a total of 11.2 hours of runtime, a time savings of approximately 8 hours per day. This is a major benefit which potentially affects the technician's workload and staffing requirements within blood centers.

While the Procleix Tigris system that is designed for use in the United States and Canada uses English as the only language choice for its software user interface, Héma-Québec found that the system has been well designed for ease of use and requires only minimal knowledge of English terminology. Héma-Québec technicians confirmed that the user interface, alerts, and instructions are clear, easy to understand, and simple to follow correctly. Héma-Québec's French speaking technicians who were trained on the system by French-speaking instructors found the instrument as easy to use as English-speaking technicians who were trained by English-speaking instructors.

In addition, the barcode system enables the Procleix Tigris system to provide a clear trail of electronic documentation for all elements in a test run, including reagents, samples, test procedures, alarms, errors, and results. The document trail can be printed as needed, but the electronic default format is directly compatible with the existing information technology (IT) architecture. Fully automated and integrated NAT testing systems, like the Procleix Tigris system, represent the future of automated blood donation screening.

References

1. L. Pealer, et al., "Transmission of West Nile Virus Through Blood Transfusion in the United States in 2002," *New England Journal of Medicine* 13 (2003): 1236-1245.

2. Centers for Disease Control and Prevention Update, "West Nile Virus Screening of Blood Donations and Transfusion-Associated Transmission—United States, 2003," *Morbidity and Mortality Weekly Report* 53 (2004): 281-284.

Gilles Delage, MD, is Vice-President of Medical Affairs–Microbiology at Héma-Québec (Québec City, QC, Canada). He can be reached at gilles.delage@hema-quebec.qc.ca [11].

Louis Thibault, PhD, is Director of the Operational Research Group at Héma-Québec (Québec city, QC, Canada). He can be reached at louis.thibault@hema-quebec.qc.ca [12].

Frank Strobl, MD, PhD, is global head of Scientific Affairs at Novartis Diagnostics. He can be reached at frank.strobl@novartis.com [13].

Feature Articles Laboratory Automation

Links:
[1] http://www.ivdtechnology.com/
[2] http://www.ivdtechnology.com/department/feature-articles
[3] http://www.ivdtechnology.com/categories/laboratory-automation
[4] http://www.qmed.com/suppliers/4/2774
[5] http://www.facebook.com/sharer.php
[6] http://www.ivdtechnology.com/sites/www.ivdtechnology.com/files/image/1107/Delage%20Tab%201.jpg
[7] http://www.ivdtechnology.com/sites/www.ivdtechnology.com/files/image/1107/Delage%20Fig%202.jpg
[8] http://www.ivdtechnology.com/sites/www.ivdtechnology.com/files/image/1107/Delage%20Tab%202.jpg
[9] http://www.ivdtechnology.com/sites/www.ivdtechnology.com/files/image/1107/Delage%20Fig%203.jpg
[10] http://www.ivdtechnology.com/sites/www.ivdtechnology.com/files/image/1107/Delage%20Tab%203.jpg
[11] mailto:gilles.delage@hema-quebec.qc.ca
[12] mailto:louis.thibault@hema-quebec.qc.ca
[13] mailto:frank.strobl@novartis.com