Workflow and Maintenance Characteristics of Five Automated Laboratory Instruments for Molecular Assays That Detect Sexually Transmitted Infections

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Abstract

Background: Automated platforms are available for the detection of sexually transmitted infections using molecular assays. The choice of a suitable system for diagnostic laboratories depends on a number of factors. Comparative workflow studies of automated instruments provide quantifiable and objective metrics for hands-on time during specimen handling and processing, reagent preparation, return visits, maintenance, allowing calculation of test turnaround time and throughput.
Methods: Using objective time study techniques, we measured workflow and maintenance characteristics of four automated batching instruments, TIGRIS (Hologic/Gen-Probe), m2000 RealTime (Abbott), cobas 4800 (Roche) and Viper XTR (Becton Dickinson), and the PANTHER instrument (Hologic/Gen-Probe), which is a continuous random access system. Comparisons were made for 96 and 192 tests using respective second generation *Chlamydia trachomatis* molecular assays on first catch urine and self-collected vaginal swabs.
Results: PANTHER showed the least overall hands-on time and Viper XTR the most for testing and maintenance. Both PANTHER and TIGRIS showed greater efficiency than the rest when processing 192 tests. Viper XTR and PANTHER had the shortest times to results and m2000 RealTime the longest. Cobas 4800 had the longest sample preparation and loading time. Mandatory return visits were required only for m2000 RealTime and cobas 4800 when processing 96 tests. All instruments required return visits when processing 192 tests, with both m2000 RealTime and cobas 4800 requiring more return visits and substantially more hands-on time than the rest.
Conclusions: There were substantial differences in the amount of labor required to operate and maintain automated diagnostic laboratory instruments which are influenced by batching versus continuous random accessing and the number of specimens that can be batched. In addition to assay performance and testing capacity, laboratories should also consider workflow and maintenance characteristics of automated systems.

Background

Multiple automated instruments are commercially available for specimen extraction, amplification and detection of infectious agents by molecular assays. They require little operator interaction, thus improving workflow and test throughput.[1] Automated molecular testing improves the efficiency of clinical laboratories by ensuring diagnostic accuracy and decreasing result turnaround time (TAT). Existing studies have assessed clinical performances of molecular assays and workflow and maintenance characteristics of automated instruments.[2-4] In choosing a system, laboratories should also consider hands-on time for maintenance and testing, in-process interaction, time results and test capacity. Workflow studies can provide quantifiable and objective data for this purpose.

Objectives

To determine the relative workflow and maintenance characteristics of four automated batching instruments and one continuous flow instrument commonly used for the diagnosis of *C. trachomatis* and *N. gonorrhoeae.*

Materials & Methods

- As the study was based on 96 or 192 tests, processing and operator engagement times were normalized for instruments that are designed to process a greater number of tests, e.g. pre-analytical waste management in Tigris took 7 min 12 sec; since this is performed for every 1000 tests, the normalized time for 96 tests was calculated to be 41.5 sec (7 min 12 sec / 1000 x 96).
- All study sites processed vaginal swabs and urine specimens for *C. trachomatis* and *N. gonorrhoeae* per each manufacturer's instructions. At each site, two investigators and a resident technologist conducted a study assessment based on 96 tests. A month later, the investigators returned to each site and performed another evaluation for 192 tests.
- Two batches of 96 tests were run consecutively in batch-based systems at maximum capacity of 96 tests (m2000, cobas 4800 and Viper XTR). For Tigris, a batch-based system with greater capacity, 178 specimens and two controls were loaded to full capacity, with remaining 10 specimens and two controls loaded subsequently. For Panther, a non-batch, continuous flow system, 118 specimens with two controls were loaded to full capacity and the remaining 72 specimens loaded subsequently.
- RealTi*m*e m2000® CT/NG was performed on m2000 RealTi*m*e instrument (Abbott Molecular, Des Plaines, IL) at Centre de santé et de services sociaux de Trois-Rivières, Trois-Rivières, Quebec.
- ProbeTec™ ET CT/GC Q^X assay was performed on Viper XTR instrument (Becton Dickinson, Franklin Lakes, NJ) at Queen Elizabeth II Health Sciences Centre, Dalhousie University, Halifax, Nova Scotia.
- cobas® CT/NG 4800 test was performed on cobas 4800 instrument (Roche Molecular Diagnostics, Pleasanton, CA) at Public Health Laboratory, St. John's, Newfoundland and Labrador.
- Aptima Combo 2® (AC2) was performed on Tigris and Panther instruments (Hologic Gen-Probe, San Diego, CA) at St. Joseph's Healthcare, McMaster University, Hamilton, Ontario.

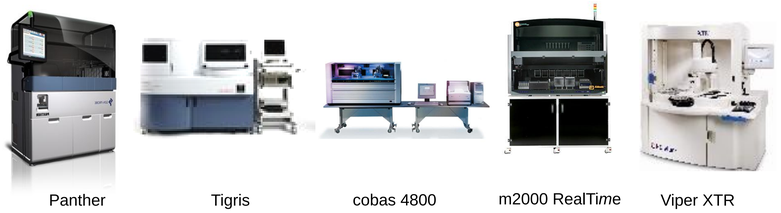

Figure 1: Five automated platforms capable of specimen extraction, amplification and detection of infectious agents by molecular assays.

Results

Table 1: Description of the five automated platforms.

Instrument	Manufacturer	Configuration	Specimen capacity	Number of controls per run
m2000 RealT*im*e	Abbott Molecular	Batch system. Separate units for specimen extraction (m2000sp) and detection (m2000rt)	93[1]	3
Viper XTR[2]	BD Diagnostic System	Batch system. Single unit for specimen extraction and detection	92[3]	4
cobas 4800	Roche Molecular Diagnostics	Batch system. Separate units for specimen extraction (x480) and detection (z480)	94[1]	2
Tigris	Hologic Gen-Probe	Batch system. Single unit for specimen extraction and detection	178[3]	4
Panther	Hologic Gen-Probe	Non-batch random access system. Single unit for specimen extraction and detection	118	2

[1]Maximum number of specimens processed per run with return visits
[2]Two modes of operation, walk-away and throughput
[3]Maximum number of specimens processed per batch without a return visit

Table 2: Hand-on and automation times for processing 96 tests with second generation assays[1] on five automated instruments.

Stage of assay processing	Instrument				
	m2000 RealTi*m*e	Viper XTR[2]	cobas 4800	Tigris	Panther
1. Pre-analytical interaction	0:02:35[3]	0:04:43	0:02:46	0:03:34	0:02:05
2. Reagent preparation and loading	0:08:51	0:12:07	0:05:10	0:04:45	0:04:49
3. Sample preparation and loading	0:09:36	0:08:08	0:15:58	0:08:51	0:06:56
4. In-process interaction	2 visits 0:02:00	None	1 visit 0:02:25	None	None
5. Post-analytical interaction	0:09:30	0:10:06	0:08:00	0:03:03	0:03:46
6. Daily maintenance	0:25:05	1:05:48	0:06:00	0:08:17	0:03:26
Total hands-on time	0:57:57	1:40:52	0:40:19	0:28:30	0:21:02
7. Automation	5:15:48	3:06:27	3:23:00	4:27:00	5:06:00

[1]Second generation assays for *C. trachomatis* and *N. gonorrhoeae* on vaginal swabs and urine.
[2]Viper XTR was used in walk-away mode
[3]Time shown in hr:min:sec

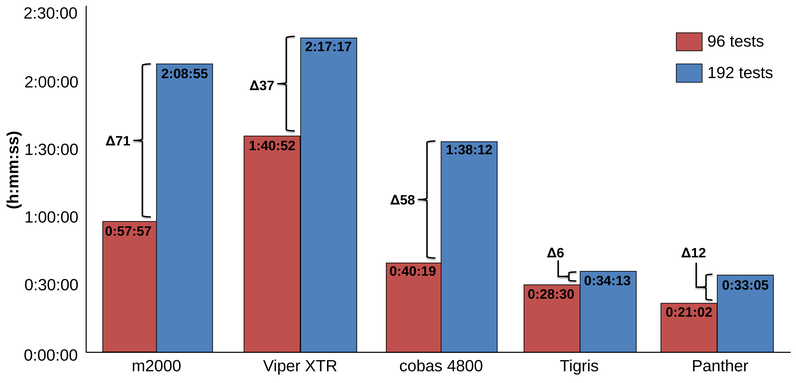

Figure 2: Total hands-on time for each instrument for 96 and 192 tests. (Viper XTR had the most hands-on time and Panther the least.)

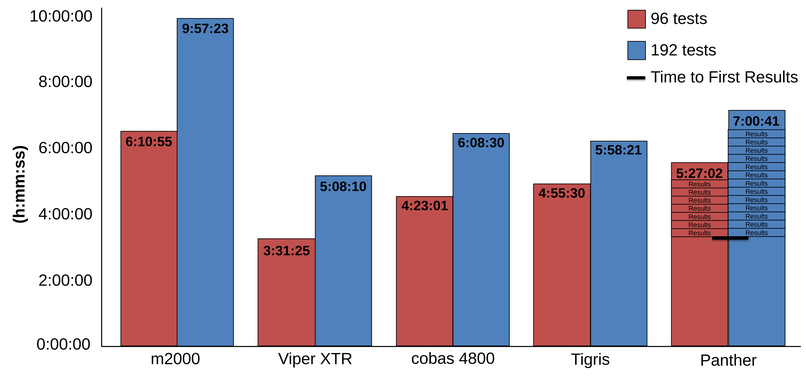

Figure 3: Time to result for 96 and 192 tests. (Viper had the shortest time to results, while m2000 had the longest time.)

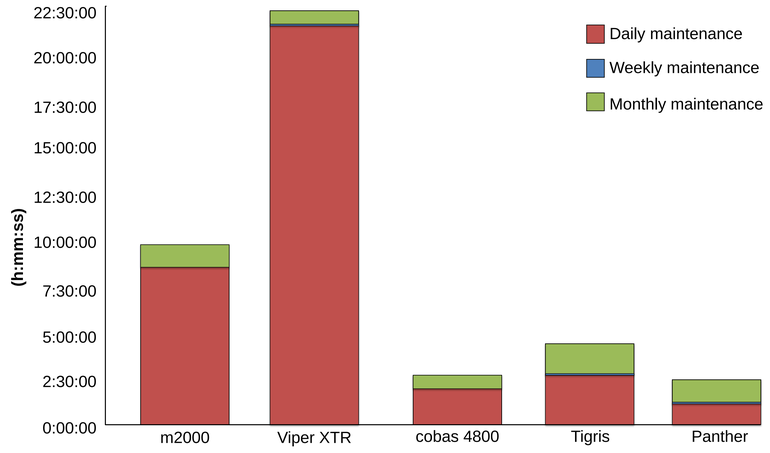

Figure 4: Cumulative hands-on time for maintenance based on 96 tests per day, 20 days per month. (Viper XTR required the most hands-on time for daily maintenance and Panther the least.)

Conclusion

- **Tigris and Panther had substantially less hands-on time for 96 tests than the other three platforms.**
- **For 192 tests, m2000, cobas 4800, and Viper XTR had larger increases in hands-on time compared to Tigris and Panther.**
- **For all platforms, the time to results were all within a normal workday when processing 96 tests. For 192 tests, the m2000 results were not available until the next workshift.**
- **Very little maintenance was needed for Tigris and Panther compared to the other platforms.**
- **Viper XTR had the shortest time to results for both 96 and 192 tests, but had the highest daily maintenance.**
- **Panther allowed continuous access to reagents and samples for loading and unloading while processing, with greater workflow efficiency than batched systems.**

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