Intelligent Automation -the First US Use of the APAS Independence Delivering Artificial Intelligence for Clinical Microbiology Automation

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Abstract (revisited)

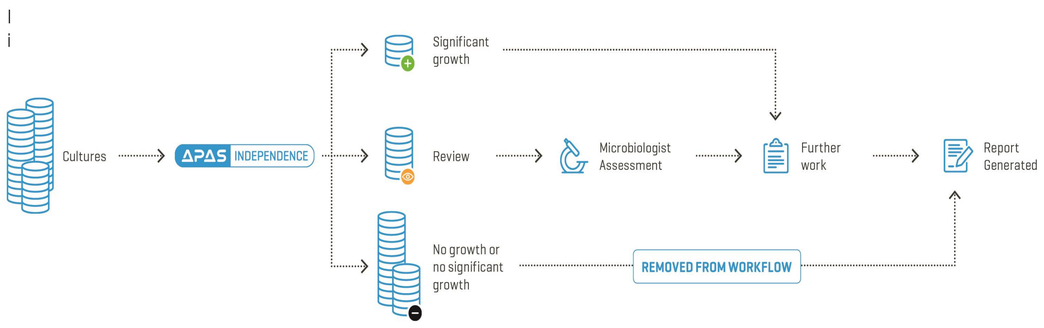
Background: Clinical Microbiology relies on technically skilled laboratorians to process, and interpret cultures from clinical specimens. Laboratory automation provides improved accuracy, decreased turn-around times, improves efficiency and reduces reliance on maintaining, acquiring and training qualified workforce. However, the impact of automation remains unfulfilled, in part, because robotics fails to incorporate interpretive processes needed to fully prioritize microbiology work needed to maximize efficiencies and impact reporting. The APAS independence (APAS) is an in-vitro diagnostic device incorporating machine learning algorithms with digital image capture. We report the first US experience of the APAS using urine cultures plated to sheep blood agar (SBA). **Methods:** Total of 369 urine cultures, (REMEL automated-SBA), were incubated at 35ºC CO_2 for 18-24hrs and placed in the APAS for review and reporting allocation. Reports were recorded based on the ability of the APAS to correctly identify bacterial growth and clear negative cultures from the workflow. Reporting was organized over 4 respective workflows: i) growth detected, ii) no growth, iii) additional microbiological review required, and iv) errors. Errors included category error (i-ii) /or system error code. **Results:** Percent-postive agreement between growth detected by the APAS system and manual culture review was 100% (153/153). No growth identified 56.7%(88/166) of true negative (no growth) cases and 67/166 negative cases were triaged for microbiological review. Combining negative reporting with negative cases requiring review, correctly captured 100% (155/155) of negative growth. An additional 17/369 cases selected for review, identified pinpoint/hazy growth patterns, and in all cases, prior to routine bench-based culture workup. Errors occurred in 9%(33/369) of cases. Error codes produced by the APAS occurred in 9%(33/369) of cases, which were primarily attributable to defects in SBA media such as gouges. Bacterial species and colony count did not affect APAS reporting. **Conclusions:** The APAS was able to report and finalize negative SBA urine cultures in 13 seconds. The system correctly identified growth form SBA in 100% of the cases and correctly screened negative cases, including those requiring review with 100% NPV. The APAS incorporates machine learning/artificial intelligence into routine microbiology workflow, applying decision making processes capable of prioritizing postive cases, screening negative growth, and reducing time-to-report.

Introduction

Automation within the field of clinical microbiology has historically lagged behind other areas of the laboratory, in part, because interpretive and workflow relative to microbiology laboratories remains highly manual. Given the impact that microbiology laboratory services have on treatment of infectious disease, control of hosptial infections, and impact on antimicrobial stewardship it's not surprising that microbiology services it's not surprising the microbiology workloads continue to increase. Increasing workload as a result of health system growth, ever-increasing screening protocols targeted multi-drug resistant organisms and diagnosis aimed at reducing hosptial-acquired infections and safely facilitate quicker discharge of hospitalized patietns are now contemporary laboratory metrics (1). Patient outcomes are now measured by hours to appropriate response (2) pacing increased emphasis on "on-demand" microbiology testing which is quickly outracing the pace with which microbiology staffing levels can accommodate. Current microbiology workforce is predicted to decline by 20% over the next 5 years (3), and as reimbursement rates for microbiology testing steadily decline, consolidation of laboratory testing requires automation in order to keep pace.

Recent advances in microbiology automation have facilitated liquid handling and automated platers (4) as well as digital image capture (5). However, current technologies fall short of providing us with decision-making tools capable of active decision making processes in the lab further defining the differences between robotics versus active artificial intelligence systems. The Automated Plating Assessment System (APAS) Independence (Clever Culture Systems) represents an automated plate reading system capable of screening urine cultures for significant growth directing targeted laboratory work-up and screening negative urine cultures within 16 seconds, actively removing them from laboratory workflow (5). However clinical validation of the system is lacking. The present study represents some of the first US-laboratory testing of the APAS independence in routine clinical practice.

Figure 1. Incorporating the APAS Independence into Routine Laboratory Workflow



Methods

Total of 720 urine cultures, (REMEL automated-SBA), were incubated at 35oC CO2 for 18-24hrs and placed in the APAS for review and reporting allocation.

Reports were recorded based on the ability of the APAS to correctly identify bacterial growth and clear negative cultures from the workflow. Reporting was organized over 4 respective workflows:
i) growth detected,
ii) no growth,
iii) additional microbiological review required, and
iv) errors

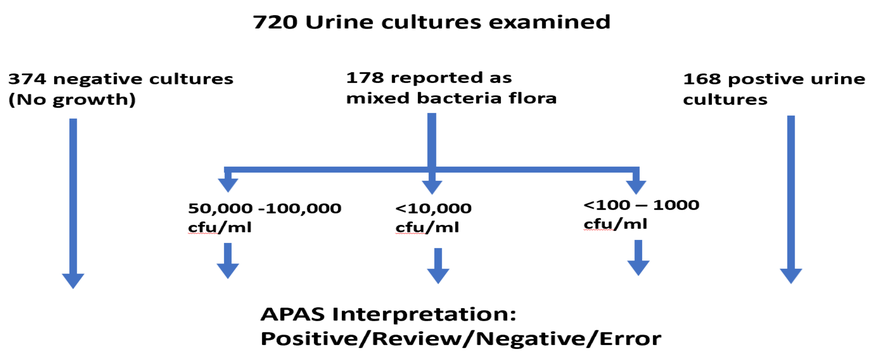


Figure 2. Automated Plate Assessment System (APAS)

Results

Table 1. Incorporating the APAS Independence into Routine Laboratory

			APAS Independence Reporting			
				Significant growth detected	Review	No Growth	Error
							42
Lab Interpretation Reporting	Significant growth reported (n=168)		168	92			
	Mixed bacterial Flora (n=178)	<100 – 1000 cfu	56		216		
		< 10,000 cfu	96				
		50,000 – 100,000 cfu	26				
	No Growth Reported (n=374)		374			370	

- **A total of 720 urine cultures submitted to the clinical were evaluated by the APAS.**
- **The APAS categorized cases based on one of four reporting categories (Significant growth/cases marked for review/No growth/Errors). The APAS successfully identified all 374 cases reported as "no growth" by the clinical laboratory. Of the 720 cases analyzed, 216/720 (30%) cases were marked for review by the laboratory.**
- **Combining cases where significant growth patterns were detected with cases marked for review, successfully identified all significant cases reported by the laboratory. However, 30 cases marked for review by the APAS, identified pinpoint/hazy growth patterns that were identified prior to routine bench-based culture workup.**
- **A total of 4 cases, reported by the clinical laboratory as "no growth" were not identified by the APAS but instead reported as "error". Error reports were overwhelming caused by defects in the media such as obvious gouges or scrapes.**

Table 2. Sensitivity of The APAS in Screening Positive Urine Cultures (significant growth) by UTI Pathogen

Organism	Sensitivity	Number of cases
Total n= 166	100	
Escherichia coli	100	51
Klebsiella pneumoniae	100	17
Enterococcus faecalis	100	9
Pseudomonas aeruginosa (	100	8
Proteus mirabilis	100	9
Coag. Neg Staphylococcus	100	13
Staphylococcus aureus	100	19
Enterobacter cloacae complex	100	7
Citrobacter freundii	100	6
Staphylococcus saprophyticus	100	6
Aerococcus spp.	100	3
Enterobacter aerogenes	100	5
Citrobacter koseri	100	4
Morganella morganii	100	1
Streptococcus (GBS, S. anginousus)	100	3
Candida albicans	100	7

Conclusions

1. **The APAS correctly detected 98% (370/374) of all negative urine cultures tested**
2. **Negative urine cultures could be actively reviewed and removed from the conventional microbiology at 16 seconds/case. Removing negative and non-significant urine cultures from the workflow reduces laboratory hands-on time**
3. **The combination of significant growth plus cases markeed for review by the APAS correctly identified 100% of all postive urine cultures.**
4. **Errors signals reported on the APAS were attributed to defects in the plated media**
5. **Further time studies are needed to further assess the impact of additional plated media and time studies to assess the potential impact of the APAS on routine laboratory workflow**

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