# Pharmacist-driven Implementation of Fast Identification and Antimicrobial Susceptibility Testing Improves Outcomes for Patients with Gram-negative Bacteremia and Candidemia

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**Running Title:** Fast ID improves outcomes in gram negative bacteremia

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**Background**

Bloodstream infections (BSI) are associated with increased morbidity and mortality, especially when caused by gram-negative or fungal pathogens. The objective of this study was to assess the impact of fast ID/AST with the Accelerate Pheno™ system (AXDX) from May 2018 to December 2018 on antibiotic therapy and patient outcomes.

**Methods**

A pre-post quasi-experimental study of 200 patients (100 pre-AXDX implementation and 100 post-AXDX implementation) was conducted. The primary endpoints measured were time to first antibiotic intervention, time to most targeted antibiotic therapy, and 14-day hospital mortality. Secondary endpoints included hospital and intensive care unit (ICU) length of stay (LOS), antibiotic intensity score at 96 hours, and 30-day readmission rates.

**Results**

Of 100 patients with gram-negative bacteremia or candidemia in each cohort, 84 in the pre-implementation group and 89 in the AXDX group met all inclusion criteria. The AXDX group had a decreased time to first antibiotic intervention (26.3 vs 8.0 p=0.003), hours to most targeted therapy (14.4 vs 9, p=0.03), hospital LOS (6 vs 8, p=0.002), and average antibiotic intensity score at 96 hours (16 vs 12, p=0.002). Both groups had a comparable 14-day mortality (0% vs 3.6%, p = 0.11).

**Conclusion**

In this analysis of patients with gram-negative bacteremia or candidemia, fast ID/AST implementation was associated with decreased hospital LOS, decreased use of broad-spectrum antibiotics, shortened time to targeted therapy, and an improved utilization of antibiotics within the first 96 hours of therapy.

**Introduction**

Bloodstream infections (BSI) are associated with increased morbidity and mortality, especially when caused by gram-negative or fungal pathogens.[1] Pathogen identification (ID) and antimicrobial susceptibility testing (AST) are essential tools for appropriate treatment of BSI. Early and effective antimicrobial administration is essential to improve patient outcomes and overall survival.[2] Every hour of delay in initiating appropriate antimicrobial therapy in patients with sepsis has decreased survival by approximately 8%.[2-4] While multiple fast ID systems can identify pathogens within 2 hours, most require conventional culture methods for final AST. [5] This prevents clinicians from de-escalating therapy for gram-negative infections due to a variety of resistance mechanisms and a potential of intrinsic multi-drug resistance that is not captured by resistance gene testing. Two main technological advances enable early, pathogen-directed therapeutic interventions. These include implementation of molecular methods to identify bacteria and yeast present in positive blood cultures, along with select antibiotic resistance markers. The second is fast phenotypic susceptibility testing performed directly from the positive blood culture bottle, which provides MIC-level antimicrobial susceptibility data. In comparison to conventional culture methods, these technological advances can optimize microbiology workflows, decrease time to result, and offer clinicians the potential to improve time to antibiotic tailoring. [6] Studies of rapid PCR based organism identification and antimicrobial resistance markers have shown improved outcomes such as shortened time to targeted therapy, reduced time to antimicrobial de-escalation, decreased costs, and reduced patient hospital LOS. [7-12] However, these evaluations have been limited to mostly gram-positive (GP) BSI, and two rapid blood culture diagnostic methodologies have not been compared. Moreover, a comparison of patient outcomes between rapid molecular ID and fast ID and phenotypic AST has yet to be published.[7-9, 11]

The Accelerate Pheno™ system and the Accelerate PhenoTest™ BC kit (AXDX) is a novel, fully automated and FDA cleared solution using fluorescence in-situ hybridization based ID and phenotypic AST direct

from positive blood cultures. The system produces ID results in 2 hours and AST results in an additional 5 hours for a total turn-around time of 7 hours.[13] Gram-negative pathogens identified by AXDX are *Acinetobacter baumannii*, *Citrobacter* species, *Enterobacter* species, *Escherichia coli*, *Klebsiella* species, *Proteus* species, *Pseudomonas aeruginosa*, and *Serratia marcescens*. Fungal pathogens identified by AXDX are *Candida albicans* and *Candida glabrata*. The impact of this technology on antimicrobial stewardship and clinical outcomes for patients with gram-negative bacteremia as compared to rapid genotypic testing remains unclear. In this study, we investigated the clinical utility of fast ID and AST via AXDX on time to therapy interventions, antimicrobial utilization, and overall patient outcomes (mortality, length of stay, and readmission rates) when compared to VERIGENE® genotypic testing.

## Methods

### *Study Design and Antimicrobial Stewardship Protocol*

A pre-post quasi-experimental study of 200 patients (100 pre-AXDX implementation and 100 post-AXDX implementation) was conducted at Peninsula Regional Medical Center (PRMC), a 288-bed community hospital in Salisbury, Maryland. PRMC has 24 ICU Beds, utilizes the EPIC electronic medical record system and is a level III trauma center. We chose 100 patients for each group after reviewing GNR and fungal bacteremia occurrence rates at our institution. Due to lower anticipated numbers in comparison to other tertiary centers, we determined that targeting 100 patients in each group was pragmatic and comparable to published literature on rapid testing.[7-12] All patients with positive blood cultures positive with gram-negative rods (GNRs) or yeast observed on Gram stain and hospital admission for > 24 hours were evaluated for inclusion. Patients with a prior positive blood culture(s) within the past 7 days or who were deceased, on comfort care or hospice status or designated for organ donation at time of positive blood culture were excluded from the study. Data collected included patient age, sex, level of immunosuppression, diagnosis of septic shock, Charlson comorbidity score, prior hospitalization within

90 days of blood culture draw, hospital length of stay (LOS), intensive care unit (ICU) days, 30-day readmission from blood culture draw, antibiotic therapy administered, infection source, and other clinical variables.[14] The Peninsula Regional Medical Center Institutional Review Board approved this study protocol.

*Standard of care microbiology workflow prior to implementation of AXDX*

VERIGENE® system testing for GNR ID followed by MicroScan WalkAway system (Beckman Coulter, Inc., Brea, CA) for final AST was standard of care in the pre-AXDX implementation group. The pre-AXDX study period included 100 patients from January 2017 to August 2017. Off-panel pathogen IDs were performed on MicroScan.

*Microbiology workflow with implementation of AXDX*

Implementation of AXDX at PRMC occurred on 12/4/2017. The post-AXDX implementation group consisted of fast ID and AST with the Accelerate Pheno™ system and Accelerate PhenoTest™ BC kit (Accelerate Diagnostics, Inc., Tucson, AZ) for positive blood cultures with gram-negative rods or yeast observed on Gram stain. The post-AXDX study group included 100 patients from May 2018 to December 2018. Off-panel pathogen IDs were performed on MicroScan.

*Microbiology laboratory reporting and Antimicrobial Stewardship Interventions*

Microbiology laboratory protocol and antimicrobial stewardship interventions for pre-AXDX and post-AXDX implementation groups are summarized in Figure 1. All other aspects of pharmacy antimicrobial stewardship services remained unchanged.

*Measured Endpoints and Clinical Assessment*

The primary endpoints measured were time to first antibiotic intervention, time to most targeted antibiotic therapy, and 14-day in-hospital mortality. Secondary endpoints included hospital and

intensive care unit (ICU) length of stay (LOS), antibiotic intensity score at 96 hours, and 30-day readmission rates.

Time to first antibiotic intervention was defined as the time from initial antibiotic(s) order to initiation, escalation, de-escalation or discontinuation of one or more antibiotics, or switch to an antibiotic regimen with a higher or lower antibiotic intensity score (Table 1). Most targeted antibiotic therapy was defined as narrowest antibiotic regimen acceptable for the source of infection in addition to isolated organism's susceptibilities. Antibiotic intensity score, developed internally, was calculated as the total score of all antibiotics administered at 96 hours, and used as a scoring system to measure antimicrobial de-escalation as described in literature.[15-16]

*Statistical Analysis*

For comparison of the categorical variables between the two groups, Fisher exact test or chi-squared were used as appropriate. 14-day mortality was compared using Fisher's test. Wilcoxon rank sum test was used for comparison of continuous variables such as average antibiotic intensity score, antibiotic days of broad-spectrum therapy (defined as initial empiric antimicrobial therapy), hospital LOS, ICU LOS, time to first antibiotic intervention, and time to most targeted antibiotics. JMP 13.0.0 software (SAS Institute Inc., Cary, NC) was used to perform statistical analysis. All tests were two-tailed, and a p value <0.05 was deemed statistically significant.

**Results**

*Patients*

A total of 200 patients with positive blood cultures with GNRs or *Candida* species and hospital admission for greater than 24 hours were identified during both study periods. A total of 84 in the pre-AXDX implementation group and 89 in the post-AXDX implementation group were included in final analysis

(Figure 2). There were no statistical differences between patient age, sex, level of immunosuppression, diagnosis of septic shock, or Charlson comorbidity score between the groups. A higher percentage of patients in the pre-AXDX group were admitted to the ICU during hospitalization than in the post-AXDX group (p=.04) There were no statistical differences between other clinical and demographic characteristics except ICU admission, which was higher in the pre-AXDX implementation group (Table 2).

*Microbiology*

In the pre-AXDX implementation group, positive blood culture identifications consisted of 62% *E. coli*, 17% *K. pneumoniae*, 7% *P. mirabilis*, 5% *P. aeruginosa*, and 9% other GNRs (see supporting material). In the post-AXDX implementation group, identifications consisted of 46% *E. coli*, 19% *Klebsiella* species, 7% *Proteus* species, 6% *Enterobacter* species, 4% *P. aeruginosa* and 18% other GNRs (see supporting material). *E. coli* was the only pathogen statistically significant between the two study groups (p= 0.037). One candida species was isolated in each group. The sensitivity and specificity for AXDX for organism ID was 100% when verified by conventional microbiology methodology.

The most common source of bacteremia was urinary followed by intra-abdominal/biliary in both pre-AXDX and post-AXDX implementation group (Table 2). A urinary source of bacteremia was more common in the pre-AXDX implementation group (66.7% vs 49.4%, *P*=.02).

*Antimicrobial Use and Stewardship Outcomes*

Primary, secondary, and other pre-defined endpoints of the study are summarized in Table 3. Time to first antibiotic intervention was significantly shorter in post-AXDX group compared to pre-AXDX implementation group (8 vs 26.3 hours, p=.003). Median time to targeted therapy was also significantly shorter in post-AXDX group (9 vs 14.4 hours, p=.03). Median days of broad-spectrum antibiotics (1 vs. 3 days, p<.0001), and antibiotic intensity score (12 vs. 16, p=0.0002) were reduced in the post-AXDX group. All of these endpoints remained statistically significant when restricting the analysis to non-ICU

patients, with the exception of time to targeted therapy which was comparable between groups (median: pre-AXDX 8 hours vs post AXDX 10 hours, p=.17). Targeted antibiotic regimen most commonly used in patients in pre-AXDX and post-AXDX implementation group was ceftriaxone monotherapy, approximately 55% in each group (see supporting material).

A higher percentage of antimicrobial stewardship interventions were made (40.4% vs 19.0%, p=.002) in the post-AXDX group than in the pre-AXDX group. Recommendations were most commonly de-escalation (11.9% vs 33.7%), escalation/initiation (4.8% vs. 4.5%), and change/modification (2.4% vs 2.2%) in both study periods.

*Clinical Outcomes*

There were no statistically significant differences in 14-day mortality in post-AXDX group (0% vs. 3.6%, p=.11). There was a statistically significant difference between pre-AXDX and post-AXDX implementation group in hospital LOS (8 vs. 6 days, p=.002), and it remained significantly shorter in the post-AXDX (median: 5 days, p=0.02) than in the pre-AXDX group (median: 7 days) when restricting the analysis to only non-ICU patients only. There were no significant differences in ICU LOS or 30-day readmission between the two groups (Table 3).

**Discussion**

In a community hospital where infectious diseases specialty services are not available 24 hours, 7 days a week, we sought to integrate fast diagnostics in combination with pharmacy-driven antimicrobial stewardship to improve patient outcomes. Our results demonstrate that in a resource-limited community hospital setting, fast ID and AST via AXDX can be used in conjunction with clinical pharmacy services to positively impact patient care. Additionally, due to an observed average hospital LOS reduction of 2 days, potential cost savings can be realized. Cost-effective initiatives are essential for community hospitals, especially in suburban settings, where financial viability is key.

To our knowledge, this is the one of only a few studies to evaluate a fast diagnostic test on antimicrobial stewardship and clinical patient outcomes in GNR and *Candida* BSI at a community hospital. Lockwood et al. demonstrated a significant reduction in time to therapy adjustment and hospital costs using matrix-assisted laser desorption/ionization time-of-flight (MALDI-TOF) mass spectrometry and near real-time pharmacist notification in comparison to conventional ID and AST for gram-negative bacteremia.[7] However, no difference in hospital LOS was observed in their study.[7] Our study results are also consistent with others in literature that have demonstrated benefit of fast diagnostics in reducing time to first antibiotic intervention, time to targeted therapy, hospital LOS, and other clinical outcomes in primarily GP BSI.[4-6, 8-9] Nevertheless, this study contributes new information on the impact of fast diagnostic tests compared to others previously published literature. First, it adds the perspective of utilizing fast ID and AST in GNR or *Candida* BSI as popularity of using such diagnostic methodologies increase. Additionally, this is the first study to compare fast ID and AST (AXDX) to a standard of care with established fast ID and resistance gene testing (VERIGENE® system) followed by conventional AST.

Our findings highlight collaboration and workflow optimization between pharmacists, providers, and microbiology laboratory personnel. Such meaningful reductions in time to first antibiotic intervention and time to targeted therapy results would not have been possible without the technology as well as the commitment of these stakeholders in the hospital. We observed that providers were more willing to de-escalate empiric antimicrobial therapy after final AST (provided by AXDX) as opposed to ID and resistance gene results alone, primarily due to the possibility of undetected resistance with genotypic testing. This is similar to other institutions that have shown time from gram stain to ID and AST, time to optimal therapy, time to step-down antimicrobial therapy, and length of stay outcomes through AXDX utilization.[17-18] This earlier de-escalation of antimicrobial therapy in *Enterobacteriaceae* bloodstream infections can significantly help decrease *Clostridioides difficile* infection rates as recently reported in literature.[19]

This study is not without limitations, which include a single-center design, making it less generalizable to hospitals with dissimilar patient populations. Second, differences in antimicrobial stewardship program involvement need to be addressed when determining the generalizability of these data to other centers. Third, microbiology laboratory staffing during post-AXDX period to run AXDX on the evening shift was greater than what was available during the pre-AXDX period. This could have resulted in delays for final ID and AST in the pre-AXDX implementation group. In addition, during the post-AXDX period, the on-call infectious diseases/critical care pharmacist was paged if *Pseudomonas*, *Acinetobacter*, or *Candida* species were isolated with subsequent adjustment of therapy through provider paging. This service was not available during the pre-AXDX period which could have resulted in variability of antibiotic modifications and patient outcomes. However, all other pharmacy stewardship services remained unchanged between the study periods. It is important to note different seasonal timeframes of both groups, which could account for higher variability of GNRs observed in the post-AXDX group, particularly *vibrio* and *salmonella* species. There were minimal *Candida* species isolated in each group, which decreases the applicability of the study findings in those pathogens. There were more patients admitted to the ICU in the pre-AXDX implementation group, which could impact many of the endpoints evaluated in the study. However, when removing ICU patients from the analysis, the majority of association observed in the study remained statistically significant. Lastly, the study sample size was not powered to detect a difference in 14-day mortality. Despite these limitations, this is the first trial that investigated the clinical utility of fast ID and AST for GNR and *Candida* BSI in a community hospital with existing rapid testing methodology as a conventional comparator and observed impact on antimicrobial stewardship and patient outcomes.

In conclusion, fast ID and AST implementation via AXDX system was associated with decreased time to first antibiotic intervention, time to most targeted antibiotics, and antibiotic intensity score at 96 hours after positive blood culture. This is essential in improving antimicrobial stewardship programs and

minimizing unintended consequences of antibiotic use across hospital systems. Pharmacists can play a crucial role in interpreting AST results, identifying ineffective therapy, and contacting attending providers to suggest escalation, de-escalation, or other modifications to therapeutic regimens. In addition, hospital LOS for patients in the post-AXDX implementation group was significantly shorter which can have a substantial impact on decreasing hospital costs. Multi-center prospective studies are required to evaluate the impact of fast ID and AST implementation via AXDX and its effects on clinical outcomes and antimicrobial stewardship programs, but the value of its use in this study is undeniable.









Antimicrobial Agents and Chemotherapy

233 **References**


234 1. Suárez CJ, Lolans K, Villegas MV, Quinn JP. Mechanisms of resistance to beta-lactams in some
235 common Gram-negative bacteria causing nosocomial infections. Expert Rev Anti Infect Ther.
236 2005;3(6):915-22.
237 2. Ibrahim EH, Sherman G, Ward S, Fraser VJ, Kollef MH. The influence of inadequate antimicrobial
238 treatment of bloodstream infections on patient outcomes in the ICU setting. Chest.
239 2000;118(1):146-55.
240 3. Kang CI, Kim SH, Park WB, Lee KD, Kim HB, Kim EC, Oh MD, Choe KW. Bloodstream infections
241 caused by antibiotic-resistant gram-negative bacilli: risk factors for mortality and impact of
242 inappropriate initial antimicrobial therapy on outcome. Antimicrob Agents Chemother.
243 2005;49(2):760-6.
244 4. Singer M, Deutschman CS, Seymour CW, Shankar-Hari M, Annane D, Bauer M, Bellomo R,
245 Bernard GR, Chiche JD, Coopersmith CM, Hotchkiss RS, Levy MM, Marshall JC, Martin GS, Opal
246 SM, Rubenfeld RS, Poll TV, Vincent JL, Angus DC. The third international consensus definitions
247 for sepsis and septic shock (Sepsis-3). JAMA. 2016;315(8):801-10.
248 5. Peker N, Couto N, Sinha B, Rossen JW. Diagnosis of bloodstream infections from positive blood
249 cultures and directly from blood samples: recent developments in molecular approaches. Clin
250 Microbiol Infect. 2018;24(9):944-955.
251 6. Maurer FP, Christner M, Hentschke M, Rohde H. Advances in rapid identification and
252 susceptibility testing of bacteria in the clinical microbiology laboratory: Implications for Patient
253 Care and Antimicrobial Stewardship Programs. Infect Dis Rep. 2017;9(1):6839.
254 7. Avdic E, Wang R, Li DX, Tamma PD, Shulder SE, Caroll KC, Cosgrove SE. Sustained impact of a
255 rapid microarray-based assay with antimicrobial stewardship interventions on optimizing

therapy in patients with gram-positive bacteraemia. J Antimicrob Chemother. 2017;72(11):3191-3198.

8. Heyerly A, Jones R, Bokhart G, Shoaff M, Fisher D. Implementation of a pharmacist-directed antimicrobial stewardship protocol utilizing rapid diagnostic testing. Hosp Pharm. 2016;51(10):815-822.
9. Banerjee R, Teng CB, Cunningham SA, Ihde SM, Steckelberg JM, Moriarty JP, Shah ND, Mandrekar JN, Patel R. Randomized trial of rapid multiplex polymerase chain reaction-based blood culture identification and susceptibility testing. Clin Infect Dis. 2015;61(7):1071-80.
10. Lockwood AM, Perez KK, Musick WL, Ikwuagwu JO, Attia E, Fasoranti OO, Cernoch PL, Olsen RJ, Musser JM . Integrating rapid diagnostics and antimicrobial stewardship in two community hospitals improved process measures and antibiotic adjustment time. Infect Control Hosp Epidemiol. 2016;37(4):425-32.
11. Box MJ, Sullivan EL, Ortwine KN, Parmenter MA, Quigley MM, Aguilar-Higgins LM, MacIntosh CL, Goerke KF, Lim RA. Outcomes of rapid identification for gram-positive bacteremia in combination with antibiotic stewardship at a community-based hospital system. Pharmacotherapy. 2015;35(3):269-76.
12. Huang AM, Newton D, Kunapuli A, Gandhi TN, Washer LL, Isip J, Collins CD, Nagel JL. Impact of rapid organism identification via matrix-assisted laser desorption/ionization time-of-flight combined with antimicrobial stewardship team intervention in adult patients with bacteremia and candidemia. Clin Infect Dis. 2013;57(9):1237-45.
13. Marschal M, Bachmaier J, Autenrieth I, Oberhettinger P, Willmann M, Peter S. Evaluation of the Accelerate Pheno System for fast identification and antimicrobial susceptibility testing from positive blood vultures in bloodstream infections caused by gram-negative pathogens. J Clin Microbiol. 2017;55(7):2116-2126.

14. Charlson ME, Pompei P, Ales KL, Mackenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis. 1987;40(5):373-83.
15. Madaras-kelly K, Jones M, Remington R, Caplinger C, Huttner B, Samore M. Description and validation of a spectrum score method to measure antimicrobial de-escalation in healthcare associated pneumonia from electronic medical records data. BMC Infect Dis. 2015;15:197.
16. Madaras-kelly K, Jones M, Remington R, Hill N, Huttner B, Samore M. Development of an antibiotic spectrum score based on veterans affairs culture and susceptibility data for the purpose of measuring antibiotic de-escalation: a modified Delphi approach. Infect Control Hosp Epidemiol. 2014;35(9):1103-13.
17. Dare MK, McCain K, Lusardi K, Daniels K, Painter J, Lakkad M, Emery N, Rosenbaum E, Bariola JR. Impact of Accelerate Pheno™ system rapid blood culture detection system on laboratory and clinical outcomes in bacteremic patients. Paper presented at: IDWEEK2018. https://idsa.confex.com/idsa/2018/webprogram/Paper70067.html
18. Ehren K, Meißner A, Jazmati N, Wille J, Jung N, VehreschildJJ, Hellmich M, Seifret H. Clinical impact of rapid species identification from positive blood cultures with same-day phenotypic antimicrobial susceptibility testing on the management and outcome of bloodstream infections. Clin Infect Dis. 2019;
19. Seddon MM, Bookstaver PB, Justo JA, Kohn J, Rac H, Haggard E, Mediwala, KN, Dash S, Al-Hasan MN. Role of early de-escalation of antimicrobial therapy on risk of Clostridioides difficile infection following enterobacteriaceae bloodstream infections. Clin Infect Dis. 2018;
20. Timbrook TT, Morton JB, Mcconeghy KW, Caffrey AR, Mylonakis E, Laplante KL. The effect of molecular rapid diagnostic testing on clinical outcomes in bloodstream infections: a systematic review and meta-analysis. Clin Infect Dis. 2017;64(1):15-23.

304 21. Sakarikou C, Altieri A, Bossa MC, Minelli S, Dolfa C, Piperno M, Favalli C. Rapid and cost-effective
305 identification and antimicrobial susceptibility testing in patients with Gram-negative bacteremia
306 directly from blood-culture fluid. J Microbiol Methods. 2018;146:7-12.

**Table 1.** Antimicrobial rank system used for Antibiotic Intensity scoring (at 96 hours of therapy)

| Antimicrobial | Rank (score) | Antifungal | Rank (score) |
|---|---|---|---|
| Anti-Pseudomonal carbapenems | 5 | Amphotericin B | 3 |
| Anti-Pseudomonal penicillin/penicillinase combinations, aztreonam, ceftazidime, ertapenem | 4 | Micafungin | 2 |
| Aminoglycosides, IV fluoroquinolones | 3 | Fluconazole | 1 |
| Amoxicillin/clavulanic acid, ampicillin/sulbactam, 2nd-generation cephalosporins, 3rd generation cephalosporins (except ceftazidime), PO fluoroquinolones, tetracyclines, trimethoprim-sulfamethoxazole, daptomycin, linezolid, vancomycin | 2 | None | 0 |
| Amoxicillin, ampicillin, first-generation cephalosporins, clindamycin, macrolides, metronidazole, nafcillin, penicillin, rifampin | 1 | | |
| None | 0 | | |

**Table 2**. Baseline patient demographics and clinical conditions

| Characteristic[a] | Pre-AXDX Group (n= 84) | Post-AXDX Group (n = 89) | P-value |
|---|---|---|---|
| Age, y, median (IQR) | 71 (60-79) | 70 (60-79) | .88 |
| Female | 42 (50) | 48 (53.9) | .60 |
| Immunosuppression | 13 (15.5) | 19 (21.4) | .32 |
| Charlson Comorbidity Score, median (IQR) | 5 (3.0-7.0) | 5 (3.5-8.0) | .29 |
| Septic Shock Diagnosis | 13 (15.5) | 7 (7.9) | .12 |
| ICU admission | 24 (28.6) | 13 (14.6) | .04 |
| Source of infection | | | .27 |
| Urine | 56 (66.7) | 44 (49.4) | |
| Intra-abdominal/Biliary | 12 (14.3) | 20 (22.5) | |
| Line-related | 7 (7.9) | 6 (6.7) | |
| Other/Unknown | 2 (2.2) | 11 (12.4) | |
| ID consulted | 24 (28.6) | 33 (37.1) | .23 |
| Prior hospitalization within 90 days | 22 (26.2) | 28 (31.5) | .23 |

[a] Data are presented as number (percent) of patients, unless specified otherwise.

**Table 3**. Primary, secondary, and other pre-defined endpoints

| Endpoint[a] | Pre-AXDX Group (n= 84) | Post-AXDX Group (n= 89) | P-value |
|---|---|---|---|
| Time to first antibiotic intervention, hours | 26.3 (4.5-43.6) | 8 (6.5-11.3) | .003 |
| Time to most targeted therapy[b], hours | 14.4 (0-49.6) | 9.0 (0-18.5) | .03 |
| 14-day mortality, n (%) | 3 (3.6) | 0 | .11 |
| Hospital LOS, days | 8 (6-10.75) | 6 (4.5-8.5) | .002 |
| Hospital LOS post positive BC, days | 6 (4-9) | 5 (3-7) | .01 |
| ICU LOS post positive BC, days | 3 (2-6.25) | 2 (2-2.5) | .25 |
| Antibiotic Intensity Score[c] | 16 (10.5-20) | 12 (9-15.5) | .0002 |
| 30-day readmission, n (%) | 7 (8.6) | 5 (5.6) | .44 |
| Broad-spectrum antibiotics, days | 3 (2-3) | 1 (0.5-2) | <.0001 |

Abbreviation: BC, blood cultures

[a] Data are presented as median (IQR), unless specified otherwise.

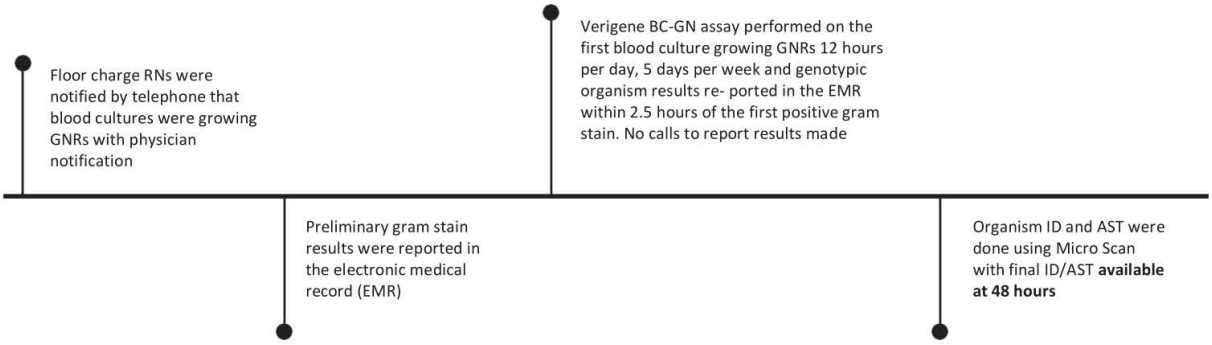
[b] After positive blood cultures

[c] Calculated at 96 hours of antibiotic therapy

**Figure 1.** Comparison of laboratory protocol and antimicrobial stewardship activities

**Pre-AXDX Group (VERIGENE® ID and conventional AST)**

Microbiology Laboratory Protocol

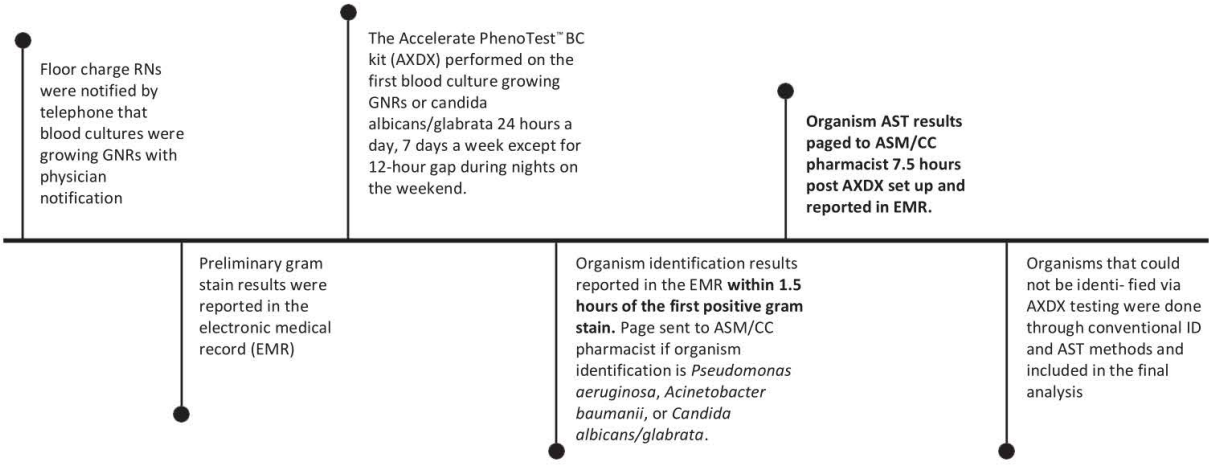



**Antimicrobial Stewardship Activities**

- Retrospective review by Antimicrobial Stewardship (ASM) pharmacist performed on all locations and services Monday – Friday from 0700 – 1600

**Post-AXDX Group (AXDX ID and AST)**

Microbiology Laboratory Protocol

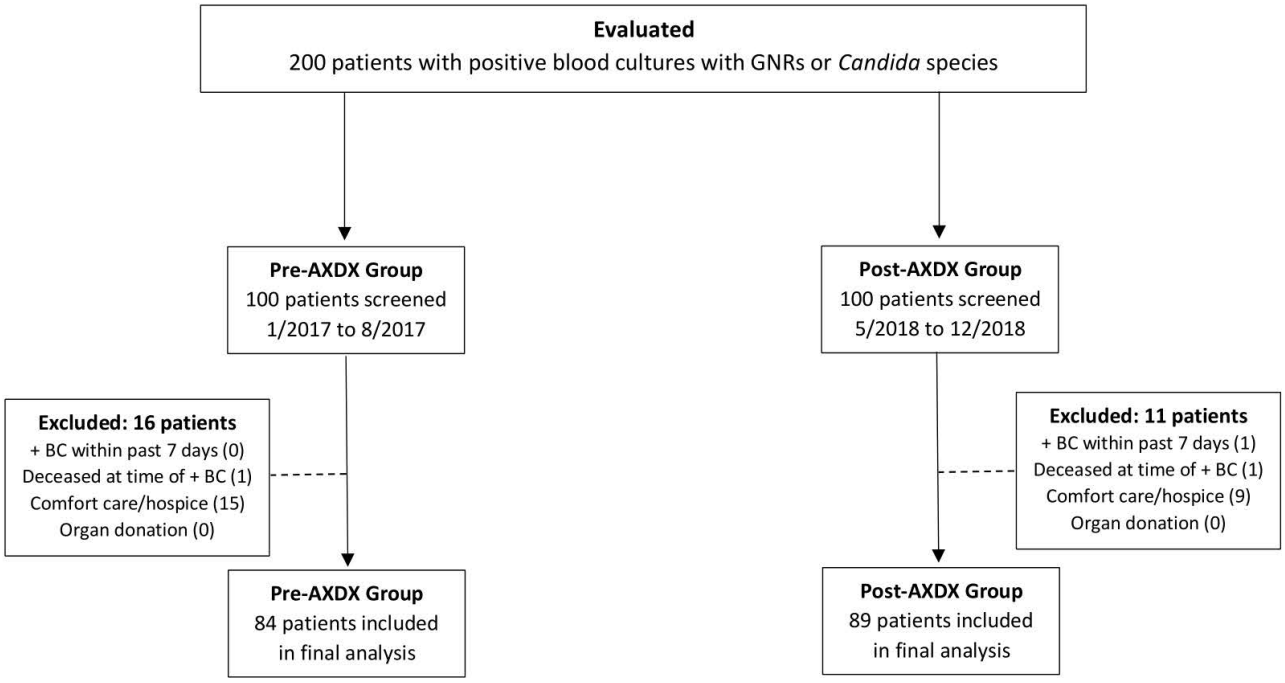



**Antimicrobial Stewardship Activities**

- Retrospective review by Antimicrobial Stewardship (ASM) pharmacist performed on all locations and services Monday – Friday from 0700 – 1600

- ASM/CC pharmacist to review patient profile if organism identification is *Pseudomonas aeruginosa*, *Acinetobacter baumanii*,
- or *Candida albicans/glabrata* and contact attending physician to escalate therapy if necessary (24 hours per day, 7 days a week)
- ASM/CC pharmacist to review patient profile after final AST reported in EMR and de-escalate/escalate therapy accordingly
- De-escalation not performed outside of 0700 to 1600 hours to limit physician paging burden

**Figure 2.** Flowchart of study patients.




Abbreviation: BC, blood cultures