# CLINICAL UTILITY OF SYNDROMIC PANEL-BASED TESTING

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**ASCLS NORTH DAKOTA SPRING SYMPOSIUM**

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SANFORD HEALTH

# DISCLOSURE

- The presenter of this activity has no conflict of interest and nothing to disclose.

# OBJECTIVES

- Discuss the advantages of commercially available Multiplex assays in diagnosing various infectious diseases
- Learn about real life challenges in interpretation of these tests
- Understand how the results of these tests impact our quality metrics and resource utilization

# MULTIPLEX ASSAYS

- Commercial molecular assays that simultaneously detect and identify multiple pathogens associated with clinical syndromes.
- Syndrome based testing of Bloodstream, respiratory, gastrointestinal and central nervous system (CNS) infections

# BLOOD STREAM INFECTIONS

- Sepsis is a common and potentially fatal illness
- Rapid institution of appropriate antimicrobial therapy is the cornerstone of treatment
- Increasing drug resistance
- Empirical broad spectrum antimicrobial use
  - Direct end organ toxicity
  - Costs
  - Resistance
  - C diff

**TABLE 1** FDA-approved/cleared panel-based molecular assays for detection of select microorganisms and select resistance genes in positive blood culture bottles

| Parameter | FilmArray BCID | Verigene | |
|---|---|---|---|
| | | Gram-positive blood culture | Gram-negative blood culture |
| Total no. of targets | 27 | 15 | 14 |
| Ability to detect pathogen | | | |
| Gram-positive bacteria | | | |
| *Staphylococcus* species | ✓ | ✓ | |
| *Staphylococcus aureus* | ✓ | ✓ | |
| *Staphylococcus epidermidis* | | ✓ | |
| *Staphylococcus lugdunensis* | | ✓ | |
| *Streptococcus* species | ✓ | ✓ | |
| *Streptococcus agalactiae* | ✓ | ✓ | |
| *Streptococcus pyogenes* | ✓ | ✓ | |
| *Streptococcus pneumoniae* | ✓ | ✓ | |
| *Streptococcus anginosus* group | | ✓ | |
| *Enterococcus* species | ✓ | | |
| *Enterococcus faecalis* | | ✓ | |
| *Enterococcus faecium* | | ✓ | |
| *Listeria* species | | ✓ | |
| *Listeria monocytogenes* | ✓ | | |
| Gram-negative bacteria | | | |
| *Klebsiella oxytoca* | ✓ | | ✓ |
| *Klebsiella pneumoniae* | ✓ | | ✓ |
| *Serratia marcescens* | ✓ | | |
| *Proteus* species | ✓ | | ✓ |
| *Acinetobacter* species | | | ✓ |
| *Acinetobacter baumannii* | ✓ | | |
| *Haemophilus influenzae* | ✓ | | |
| *Neisseria meningitis* | ✓ | | |
| *Pseudomonas aeruginosa* | ✓ | | ✓ |
| *Enterobacteriaceae* | ✓ | | |
| *Escherichia coli* | ✓ | | ✓ |
| *Enterobacter* species | | | ✓ |
| *Enterobacter cloacae* complex | ✓ | | |
| *Citrobacter* species | | | ✓ |
| Yeasts | | | |
| *Candida albicans* | ✓ | | |
| *Candida glabrata* | ✓ | | |
| *Candida krusei* | ✓ | | |
| *Candida parapsilosis* | ✓ | | |
| *Candida tropicalis* | ✓ | | |
| Ability to detect presence of resistance gene | | | |
| *mecA* | ✓ | ✓ | |
| *vanA* | ✓ | ✓ | |
| *vanB* | ✓ | ✓ | |
| $bla_{KPC}$ | ✓ | | ✓ |
| $bla_{NDM}$ | | | ✓ |
| $bla_{OXA}$ | | | ✓ |
| $bla_{VIM}$ | | | ✓ |
| $bla_{IMP}$ | | | ✓ |
| $bla_{CTX-M}$ | | | ✓ |
| Time to result (h) | ~1 | ~2.5 | ~2 |

# ADVANTAGES

- Very quick
- Highly sensitive and specific
- Detect common resistance genes
- Specific antibiotic therapy
- ? Decreased phone calls
- Minimal hands-on time
- ? Detection of targets despite prior antibiotics

# LIMITATIONS

- $$$ - These are add-on tests
- Optimal antibiotic therapy is a team effort
- Only certain resistance markers detected
- False positives
  - *Pseudomonas*, *Candida parapsilosis*, *Proteus* sp.
- Species level misidentification
  - *S. mitis* vs *S. Pneumoniae*
- Gene presence vs Gene expression
- Effect on mortality
- Effect on hospital length of stay
- Rapid clearance of blood stream

# VERIGENE GP-BC CONCORDANCE

| Organisms | No. of isolates | | | | Concordance (%) |
|---|---|---|---|---|---|
| | Positive on culture | Correctly identified | Incorrectly identified | Targeted but not detected | |
| *Staphylococcus* | | | | | 92.9 |
| *S. aureus* | 22 | 22 | – | – | 100 |
| *S. epidermidis* | 25 | 21 | 1 | 3 | 84.0 |
| *S. lugdunensis* | 2 | 2 | – | – | 100 |
| Other CoNS | 7 | 7 | – | – | 100 |
| *Enterococcus* | | | | | 84.6 |
| *E. faecalis* | 14 | 11 | – | 3 | 78.6 |
| *E. faecium* | 12 | 11 | – | 1 | 91.7 |
| *Streptococcus* | | | | | 82.2 |
| *S. pneumoniae* | 10 | 9 | 1 | – | 90.0 |
| *S. pyogenes* | 2 | – | – | 2 | na |
| *S. agalactiae* | 2 | 2 | – | – | 100 |
| *S. anginosus* group | 7 | 5 | 2 | – | 71.4 |
| Other streptococci | 24 | 21 | 3 | – | 87.5 |
| *Listeria* spp. | 1 | 1 | – | – | 100 |
| *Micrococcus* spp. | 1 | 1 | – | – | 100 |
| Total isolates | 129 | 113 | 7 | 9 | 87.6 |

Dodémont, M et al. *European journal of clinical microbiology & infectious diseases.* 34.3 (2015): 473–477.

J Infect Chemother (2007) 13:79–86
DOI 10.1007/s10156-006-0502-7


ORIGINAL ARTICLE

Yasuko Hososaka · Hideaki Hanaki · Harumi Endo
Yumiko Suzuki · Zenzo Nagasawa · Yoshihito Otsuka
Taiji Nakae · Keisuke Sunakawa

# Characterization of oxacillin-susceptible *mecA*-positive *Staphylococcus aureus*: a new type of MRSA

PLOS ONE

OPEN ACCESS PEER-REVIEWED

RESEARCH ARTICLE

# Prevalence of vancomycin-variable *Enterococcus faecium* (VVE) among *vanA*-positive sterile site isolates and patient factors associated with VVE bacteremia

Philipp Kohler, Alireza Eshaghi, Hyunjin C. Kim, Agron Plevneshi, Karen Green, Barbara M. Willey, Allison McGeer, Samir N. Patel, for the Toronto Invasive Bacterial Diseases Network (TIBDN)

Published: March 22, 2018 • https://doi.org/10.1371/journal.pone.0193926

# CHALLENGES AND OPPORTUNITIES

- Polymicrobial bacteremias
- Fastidious organisms
  - *Coxiella*, *Rickettsia*, *Tropheryma*
- Direct MALDI-TOF from positive blood cultures
- Multiplex assay on partially incubated bottles
- Direct identification from blood samples

# CNS INFECTIONS

- Meningitis / Encephalitis
- Very High Morbidity / Mortality
- Rapid and Specific Treatment Essential

| CSF Parameter | Normal | Viral Infection | Bacterial Infection | Fungal / TB Infection |
|---|---|---|---|---|
| Opening Pressure ($mmH_2O$) | 100 - 180 | Normal - Elevated | 200 - 500 | 150 - 340 |
| WBC (cells/µL) | 0-5 | 5 – 1000 | 100 – 1000 | 5 – 1000 |
| Protein (mg/dL) | < 30 | 30 - 300 | 60 - 500 | > 60 |
| Glucose (%Blood glucose) | > 60 | > 60 | <45 | <45 |

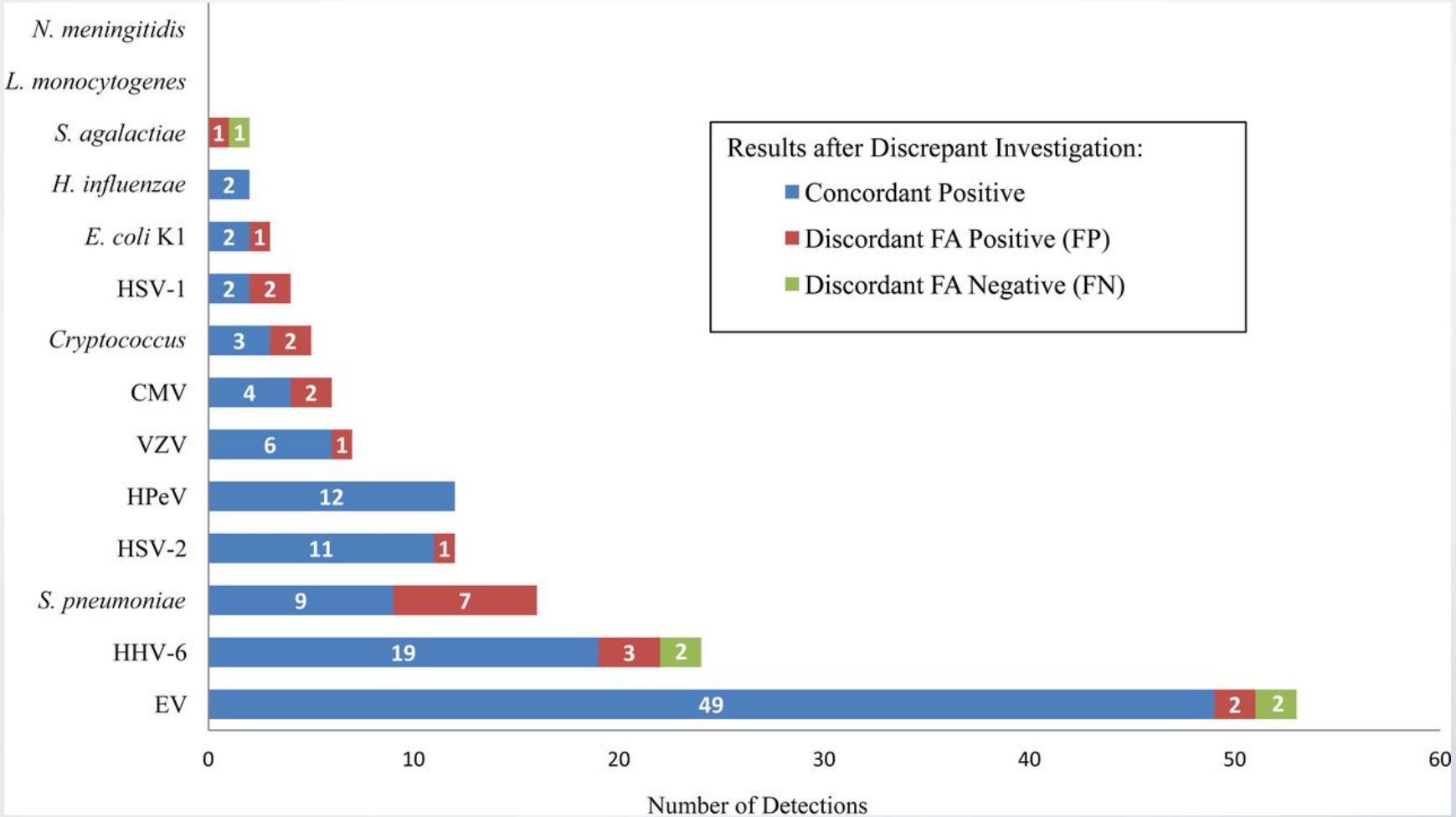
| Parameter | FilmArray Meningitis/Encephalitis panel |
|---|---|
| Pathogen detected | |
| Viruses | Cytomegalovirus, enterovirus, herpes simplex virus 1, herpes simplex virus 2, human herpesvirus 6, human parechovirus, varicella-zoster virus |
| Bacteria | *Escherichia coli* K1, *Haemophilus influenzae*, *Listeria monocytogenes*, *Neisseria meningitidis*, *Streptococcus agalactiae*, *Streptococcus pneumoniae* |
| Fungi | *Cryptococcus neoformans-C. gattii* |
| Analysis platform | FilmArray system or FilmArray Torch |
| Acceptable specimen type | CSF |
| Time to results (h) | ~1 |

# ADVANTAGES

- Really Really Rapid TAT
- Only 200 µL of CSF
- Multiple common targets

# LIMITATIONS

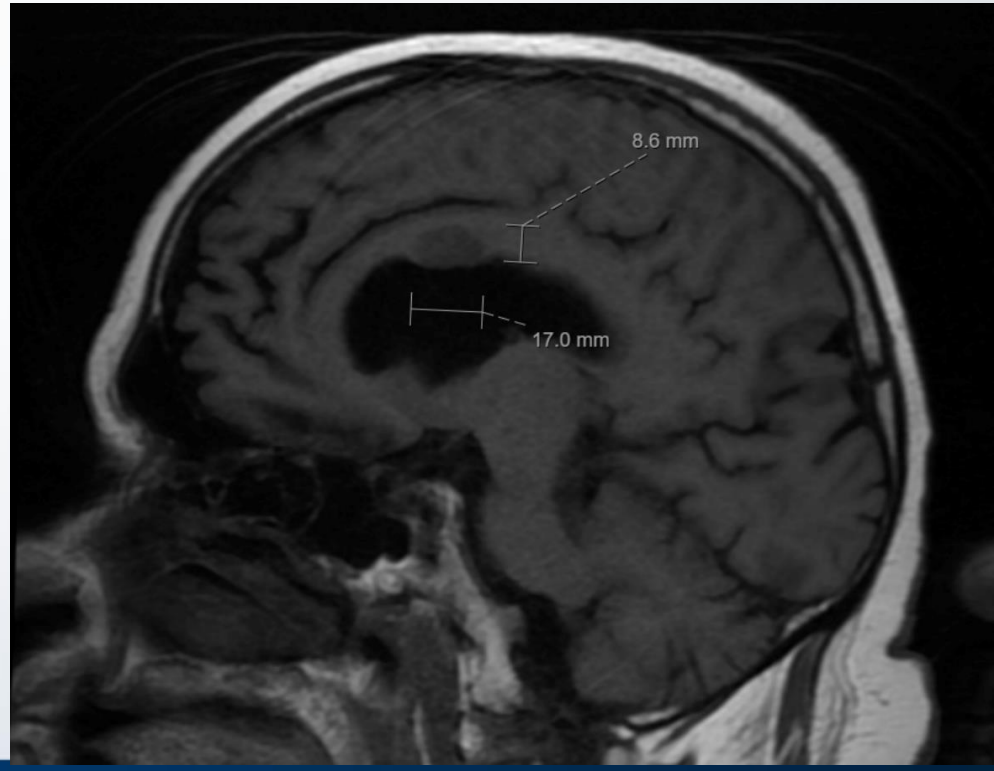
- Bacterial meningitis is relatively rare in US
  - *S. pneumoniae, H. influenzae, N. meningitidis*
  - Dependent on immunization rates
- Post-surgical infections
  - *S aureus, Candida* sp, *Cutibacterium* sp, Gram negatives
- False positive results for *S. pneumoniae*
- $$$ cf. CrAg
- False negative with *Cryptococcus* sp.
- Detection of multiple pathogens




Leber, A.L. et al. *Journal of Clinical Microbiology. 2016;54(9):2251-2261*

# CASE SCENARIO

- A 79-year-old male presets to the hospital with worsening confusion for 2 months. He has a history recent chemotherapy for breast cancer and is also on Prednisone for myasthenia gravis.
- MRI image is shown
- Possible mets vs other etiology
- CSF analysis is performed



| CSF Parameter | Result |
| --- | --- |
| Opening Pressure | Not measured |
| WBC | 34 cells/µL; 47% N, 35% L, 18% M |
| Protein | 49.2 |
| Glucose | 55 |
| Gram stain | Yeast |

| | Ref Range & Units | |
|---|---|---|
| **Escherichia coli K1** | Not Detected | Not Detected |
| **Haemophilus influenzae** | Not Detected | Not Detected |
| **Listeria monocytogenes** | Not Detected | Not Detected |
| **Neisseria meningitidis** | Not Detected | Not Detected |
| **Streptococcus agalactiae (Group B)** | Not Detected | Not Detected |
| **Streptococcus pneumoniae** | Not Detected | Not Detected |
| **Cytomegalovirus** | Not Detected | Not Detected |
| **Enterovirus** | Not Detected | Not Detected |
| **Herpes Simplex Type 1** | Not Detected | Not Detected |
| **Herpes Simplex Type 2** | Not Detected | Not Detected |
| **Human Herpesvirus 6** | Not Detected | **Detected!!** |
| Comment: Detection of HHV-6 may indicate primary, secondary reactivation, or the presence of latent virus. | | |
| **Human Parechovirus** | Not Detected | Not Detected |
| **Varicella Zoster Virus** | Not Detected | Not Detected |
| **Cryptococcus neoformans/gattii** | Not Detected | **Detected!!** |
| Comment: Specimen submitted for Cyptococcal Antigen Titer testing. Additional report to follow. | | |

EDITOR'S CHOICE

# Delayed Diagnosis of Tuberculous Meningitis Misdiagnosed as Herpes Simplex Virus-1 Encephalitis With the FilmArray Syndromic Polymerase Chain Reaction Panel

Carlos A. Gomez, Benjamin A. Pinsky, Anne Liu, Niaz Banaei Author Notes

*Open Forum Infectious Diseases*, Volume 4, Issue 1, Winter 2017, ofw245,
https://doi.org/10.1093/ofid/ofw245

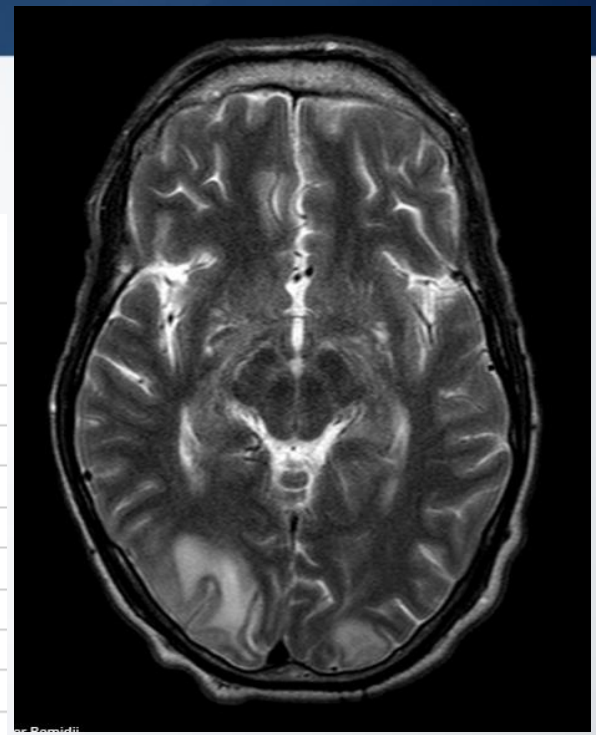
# CASE SCENARIO

- A 39-year-old male with history of IVDU, HIV and syphilis presented to the hospital with 2 weeks of fever and confusion. This prompted MRI of the brain. The findings are shown on the next slide. He has no history of immunosuppression.

| CSF | | |
|---|---|---|
| Volume 1 CSF | | 5.5 |
| Clarity, CSF | | |
| Turbidity 1 CSF | | Clear |
| Color 1 CSF | | Colorless |
| Supernate 1 CSF | | Colorless |
| Tube Number CSF | | Tube 3 |
| CSF RBC | | 4 ▲ |
| WBC CSF Cell Count | | 190 ▲ |
| % Neutrophils CSF | | 15 ▲ |
| % Lymphocytes CSF | | 58 |
| % Macro/Monos CSF | | 17 |
| % Eosinophils CSF | | 10 ▲ |
| Tube Number CSF Gl... | | One |
| Glucose CSF | | 34 ▼ |
| Tube Number CSF Pr... | | One |
| Protein CSF | | 249.7 ▲ |

| | Ref Range & Units | |
|---|---|---|
| Escherichia coli K1 | Not Detected | Not Detected |
| Haemophilus influenzae | Not Detected | Not Detected |
| Listeria monocytogenes | Not Detected | Not Detected |
| Neisseria meningitidis | Not Detected | Not Detected |
| Streptococcus agalactiae (Group B) | Not Detected | Not Detected |
| Streptococcus pneumoniae | Not Detected | Not Detected |
| Cytomegalovirus | Not Detected | Not Detected |
| Enterovirus | Not Detected | Not Detected |
| Herpes Simplex Type 1 | Not Detected | Not Detected |
| Herpes Simplex Type 2 | Not Detected | Not Detected |
| Human Herpesvirus 6 | Not Detected | Not Detected |
| Human Parechovirus | Not Detected | Not Detected |
| Varicella Zoster Virus | Not Detected | Not Detected |
| Cryptococcus neoformans/gattii | Not Detected | Not Detected |

| CRYPTOCOCCAL | | | | | | |
|---|---|---|---|---|---|---|
| Cryptococcal Ag | Positive ! | | | | | |
| Cryptococcal Ag CSF | | Positive ! | | | Positive ! | Positive ! |
| Cryptococcal Ag Titer | 1:1024 ▲ | | | | 1:256 ▲ | |



# Failure of multiplex meningitis/encephalitis (ME) NAT during cryptococcal meningitis in solid organ recipients

Benoit Pilmis[1,2,3] | Marie-Elizabeth Bougnoux[4] | Romain Guery[1] | Yaye Senghor[5] | Alban Le Monnier[5] | Fanny Lanternier[1,6] | Stephane Bretagne[6,7,8] | Alexandre Alanio[6,7] | Olivier Lortholary[1,6]

**TABLE 1** Summary of the clinical/ features of four episodes of *Cryptococcus neoformans* meningitis

| Patient<br>Lead symptoms | No 1<br>Meningeal symptoms, fever | No 2<br>Meningeal symptoms, fever | No 3<br>Confusion | No 4<br>confusion, fever |
|---|---|---|---|---|
| Sex—Age | Male-53 | Male-58 | Male-62 | Male-60 |
| Medical history | KT | KT (PCLKD) | KT (diabetic nephropathy) | KT (diabetic nephropathy) |
| Duration of symptoms before diagnosis (days) | 5 | 6 | 15 | 13 |
| Immunosuppressive regimen | Corticosteroïds<br>Tacrolimus<br>Mycophenolate mofetil | Corticosteroïds<br>Tacrolimus<br>Mycophenolate mofetil | Tacrolimus<br>Mycophenolate mofetil | Corticosteroïds<br>Tacrolimus<br>Mycophenolate mofetil |
| CSF analysis | | | | |
| WBC (/mm$^3$), (% Lymphocytes) | 22 (91) | 48 (75) | 106 (90) | 115 (95) |
| Ratio (Glycorrachia/glycemia) | 0.51 | 0.33 | 0.3 | 0.34 |
| Protein (g/L) | 0.61 | 0.73 | 1.56 | 2.23 |
| India ink staining | (–) | (–) | (–) | (–) |
| Culture (delay for culture positivity) | (+*C neoformans*) (7) | (+*C neoformans*) (4) | (–) | (+*C neoformans*) (7) |
| CSF CrAg (titer) | (+) (1:160) | (+) | (+) 1:20 | (+) 1:256 |
| FilmArray ME panel | (–) | (–) | (–) | (–) |
| Specific in house *C neoformans* qPCR | (–) | (–) | (NA | NA |
| Serum CrAg (titer) | (–) | (+) | (+) 1:1280 | (+) 1:128 |
| Blood culture | (–) | (–) | (–) | (–) |
| Urinary culture | (–) | (–) | (–) | (–) |

Abbreviations: KT, kidney transplantation; NA, Not available; PCLKD, Polycystic Liver and Kidney Disease; WBC, White Blood Cells.

Pilmis B. et al. *Transplant Infectious Diseases. 2020;22(4):e13263*

# GASTROINTESTINAL INFECTIONS

- 2 billion cases / yr worldwide
- Major cause of mortality among children < 5
- Primarily in developing countries
- Primary mode of transmission: Contaminated food and water
- Large number of pathogens
- Travel, Migration, Food supply chains

# SYNDROMIC TESTING

- Targeted testing less feasible; costs can accumulate
- Traditionally, stool culture
- Replaced by multiplex
- Multiplex provides rapid TAT
- Minimal amount of stool
- Detection of outbreaks

**TABLE 4** FDA-approved/cleared multiplex gastrointestinal panels[a]

| Parameter | Verigene EP | Luminex GPP | BioFire GIP |
|---|---|---|---|
| Analysis platform | Verigene system | Magpix or Luminex 100/200 system | FilmArray system or FilmArray Torch |
| Acceptable specimen type | Stool in Cary-Blair medium | Fresh stool or stool in Cary-Blair medium | Stool in Cary-Blair medium |
| No. of targets | 9 | 14 | 22 |
| Ability to detect pathogen | | | |
| Bacteria | | | |
| *Campylobacter* species | ✓ | ✓ | ✓ |
| *Salmonella* species | ✓ | ✓ | ✓ |
| *Shigella* species/enteroinvasive *E. coli*[b] | ✓ | ✓ | ✓ |
| *Vibrio* species | ✓ | | ✓ |
| *Vibrio cholerae* | | ✓ | ✓ |
| *Yersinia enterocolitica* | ✓ | | ✓ |
| *Escherichia coli* O157 | | ✓ | ✓ |
| Enterotoxigenic *E. coli* | | ✓ | ✓ |
| Enteropathogenic *E. coli* | | | ✓ |
| Enteroaggregative *E. coli* | | | ✓ |
| *Plesiomonas shigelloides* | | | ✓ |
| Shiga toxin-producing *E. coli* ($stx_1$-$stx_2$) | ✓[c] | ✓ | ✓ |
| *Clostridium difficile* (toxin A/B) | | ✓ | ✓ |
| Viruses | | | |
| Norovirus GI/GII | ✓ | ✓ | ✓ |
| Rotavirus A | ✓ | ✓ | ✓ |
| Astrovirus | | | ✓ |
| Adenovirus 40/41 | | ✓ | ✓ |
| Sapovirus | | | ✓ |
| Parasites | | | |
| *Cryptosporidium* species | | ✓ | ✓ |
| *Entamoeba histolytica* | | ✓ | ✓ |
| *Giardia lamblia* | | ✓ | ✓ |
| *Cyclospora cayetanensis* | | | ✓ |
| No. of samples (throughput) | 1–32 (scalable) | 24 | 1–12 (scalable) |
| Time to result (h) | <2 | ~5 | ~1 |

[a]EP, enteric pathogens; GPP, gastrointestinal pathogen panel; GIP, gastrointestinal panel.
[b]The Verigene EP and Luminex GPP do not specifically target enteroinvasive *E. coli*.
[c]The Verigene EP has separate targets for $stx_1$ and $stx_2$.

Ramanan, P. et al. *Clinical Microbiology Reviews. 2018;31(1):e00024-17*

# LIMITATIONS

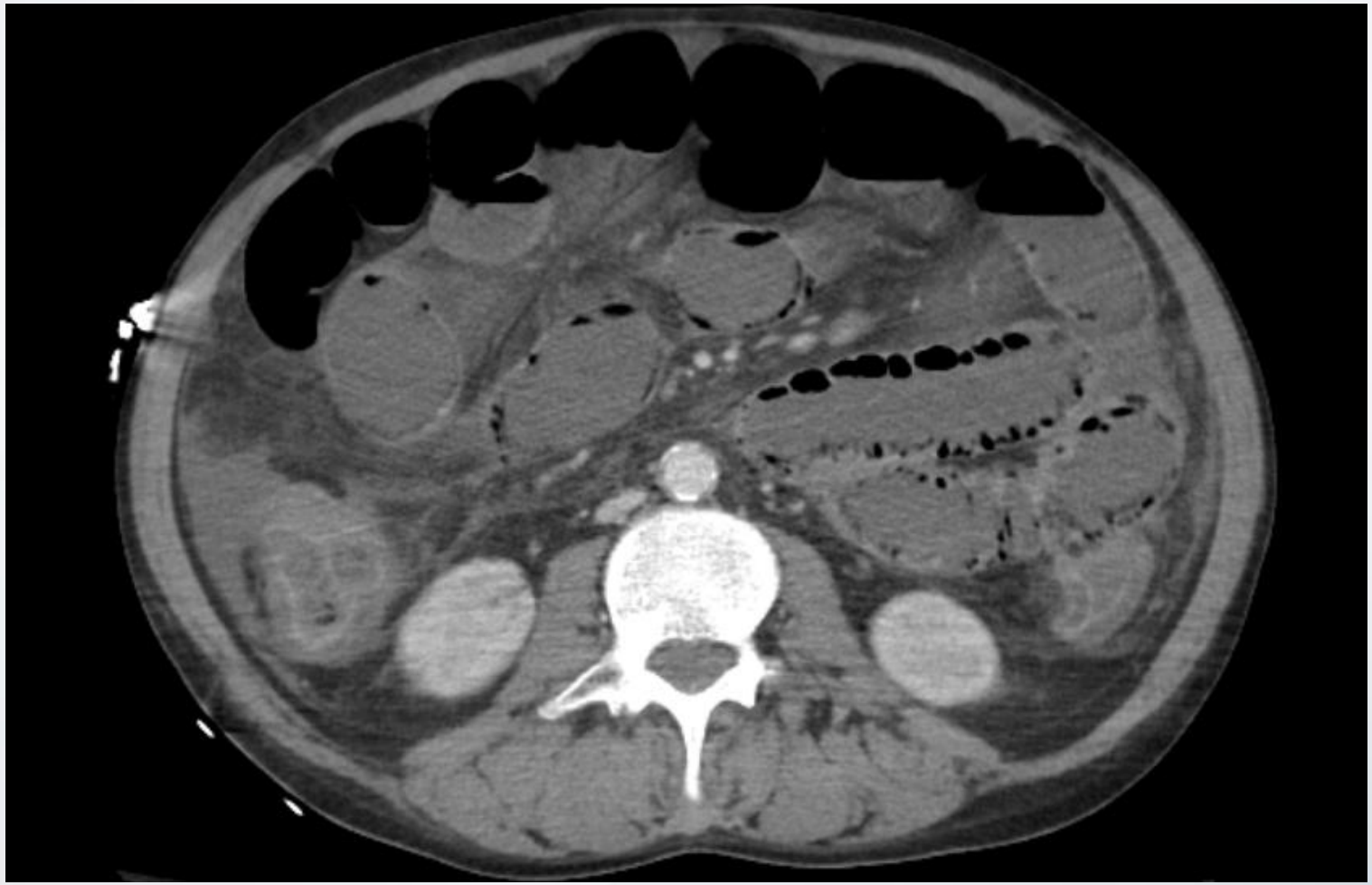
- $$$
- ≥ 2 pathogens in up to 16% samples
  - EPEC and EAEC most frequent "co-pathogens"
  - Clinical significance of EPEC and EAEC unclear
  - 20% of children colonized
- Colonization vs Infection
  - Free DNA/RNA vs infectious organism
  - ?Isolate and / or ?treat
- Lack of Susceptibility Testing

# C DIFF

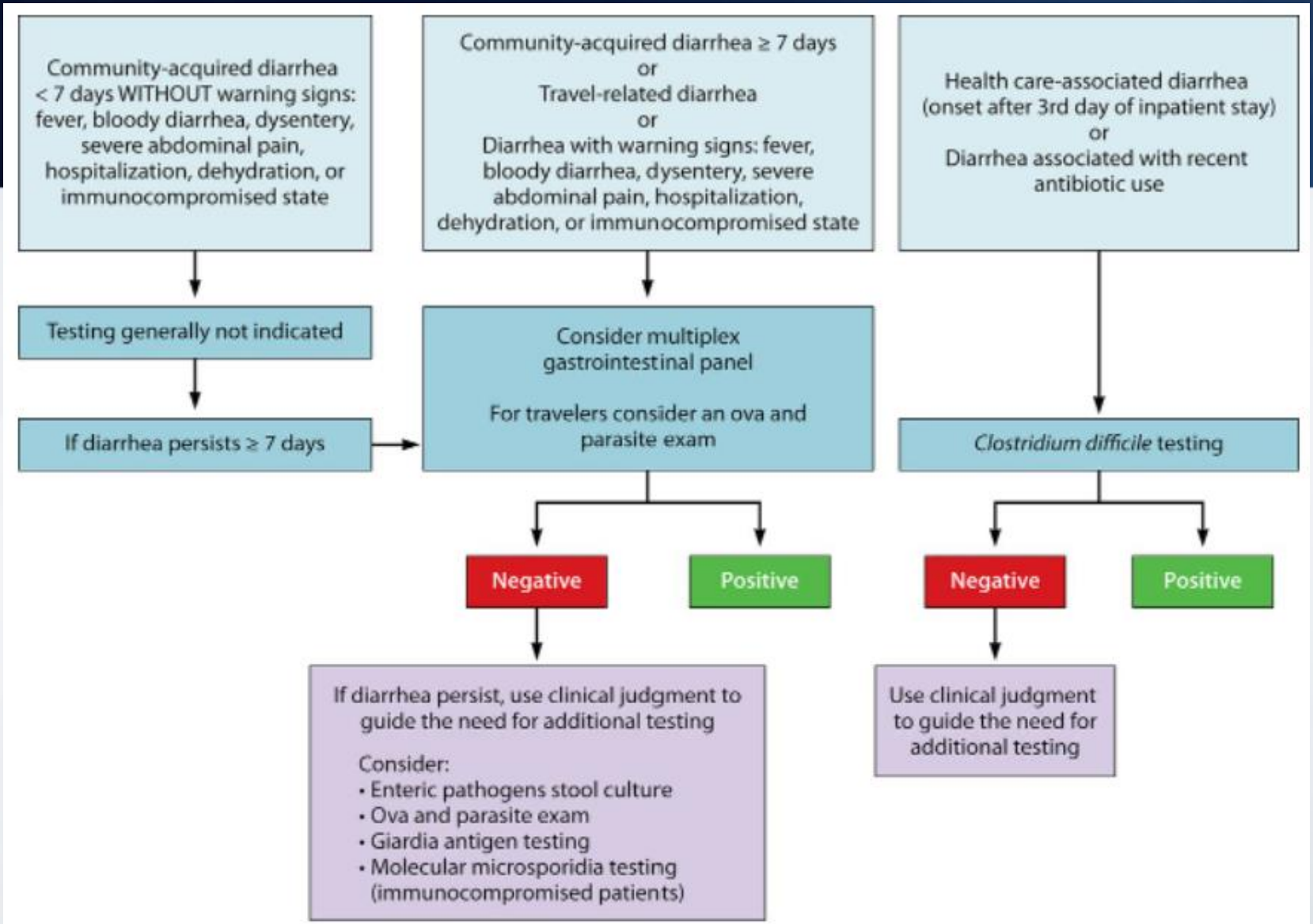
- Most common hospital acquired infection
- Associated with high rates of antibiotic utilization
- However, 20% patients colonized
- Simultaneous administration of:
  - Laxatives
  - Contrasts
  - Tubal Feeding
- Quality metrics – Are we measuring the right target?

# CASE SCENARIO

- A 51-year-old male with common variable immunodeficiency and history of multiple opportunistic infections presents with acute on chronic abdominal pain with blood in stools. He has had multiple prior admissions for the same problem. However, this time, he is in septic shock. A CT abdomen is performed, and findings are as follows:



| Component | Ref Range & Units | 2 yr ago (11/26/19) | 2 yr ago (5/31/19) | 3 yr ago (3/28/19) | 3 yr ago (3/9/19) | 3 yr ago (1/19/19) | 3 yr ago (1/9/19) | 4 yr ago (12/19/17) |
|---|---|---|---|---|---|---|---|---|
| Campylobacter | Not Detected | Not Detected | Not Detected | Not Detected | Not Detected | Not Detected | Not Detected | Not Detected |
| Salmonella | Not Detected | Not Detected | Not Detected | Not Detected | Not Detected | Not Detected | Detected ! | Not Detected |
| Shigella | Not Detected | Not Detected | | Not Detected | Not Detected | Not Detected | Not Detected | Not Detected |
| Vibrio | Not Detected | Not Detected | Not Detected | Not Detected | Not Detected | Not Detected | Not Detected | Not Detected |
| Yersinia enterocolitica | Not Detected | Not Detected | Not Detected | Not Detected | Not Detected | Not Detected | Not Detected | Not Detected |
| Shiga-Like Toxin 1 | Not Detected | Not Detected | | Not Detected | Not Detected | Not Detected | Not Detected | Not Detected |
| Shiga-Like Toxin 2 | Not Detected | Not Detected | | Not Detected | Not Detected | Not Detected | Not Detected | Not Detected |
| Norovirus | Not Detected | Detected ! | | Detected ! | Detected ! | Detected ! | Detected ! | Detected ! |
| Rotavirus | Not Detected | Not Detected | | Not Detected | Not Detected | Not Detected | Not Detected | Not Detected |




1. This algorithm should not be used for chronic diarrhea (duration >30 days).
2. For ova and parasite exams, submit 3 stool samples collected on separate days for maximum sensitivity.
3. During the summer, consider molecular detection of Shiga toxin in fecal samples for children with diarrhea even if they do not have bloody diarrhea, are not toxic-appearing, and diarrhea has been present <7 days.

Ramanan, P. et al. *Clinical Microbiology Reviews. 2018;31(1):e00024-17*

# RESPIRATORY INFECTIONS

- Common cause of morbidity and mortality
- Wide array of pathogens
- Similar clinical syndrome
- Multiplex assays can identify many common pathogens
- Rapid TAT
- Almost POC testing
- Higher sensitivity compared to Ag or cultures
- Potential for cost savings
- Potential for decreased antimicrobial use

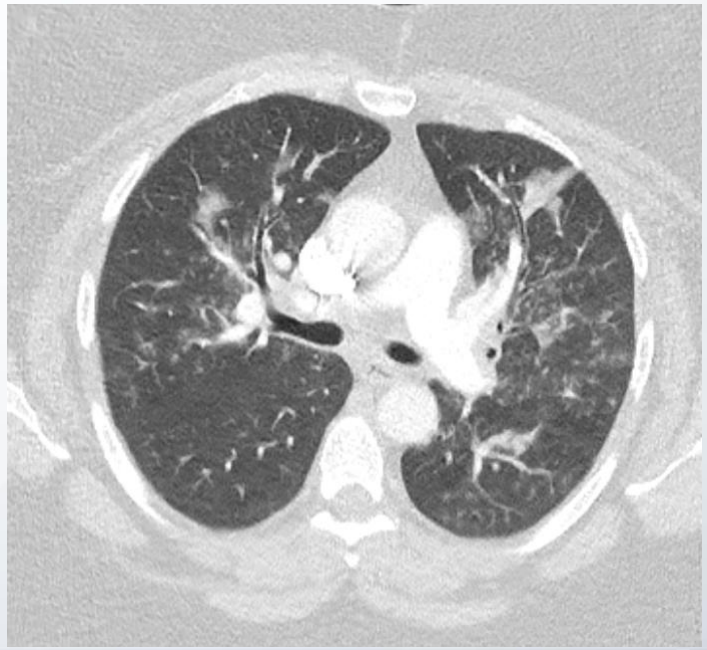
# LIMITATIONS

- Co-infections
- Colonization vs Infection
- Susceptibility testing
- $$$
  - Still less than shell vial culture or and  DFA staining
- No specific treatment for most viruses
  - Potential for decreased antibiotic prescriptions
  - Lower odds for admission
  - Lower odds for unnecessary imaging
  - Lower length of hospital stay
  - Increase in duration of isolation
  - Provides sense of closure

Subramony, A.  et al. *J Pediatr. 2016;173:196-201*

# CASE SCENARIO

- A 43-year-old lay with DM2 and Class III obesity presents with severe shortness of breath, fever and cough. She is found to be severely hypoxic and intubated in the ER. CXR & CT are performed.

# RESPIRATORY SPECIMEN TESTING

**Respiratory Viral Panel TEM-PCR** About this test

Performed at: Eurofins Viracor

Received: [redacted]
Final Approved: [redacted]

| Result (Unit) | Flag | Ref Range |
|---|---|---|
| **Adenovirus** | | |
| Not Detected | | Not Detected |
| *Detects Serotypes B and E. Detection of Serotype C may be limited. If Adenovirus infection is suspected and a Not Detected result is returned the sample should be re-tested for adenovirus using an independent method (e.g. Eurofins Viracor Adenovirus Quantitative Real-time PCR test).* | | |
| **Enterovirus/Rhinovirus** | | |
| Not Detected | | Not Detected |
| **Human bocavirus** | | |
| Not Detected | | Not Detected |
| **Human coronavirus** | | |
| Not Detected | | Not Detected |
| *This test does NOT assay for the novel 2019 Coronavirus out of China. This test detects the respiratory Coronaviruses: types 229E, OC43, NL63, and HKU1.* | | |
| **Human metapneumovirus** | | |
| POSITIVE | A | Not Detected |
| **Influenza A - Human** | | |
| Not Detected | | Not Detected |
| **Influenza A - H1N1-09** | | |
| Not Detected | | Not Detected |
| **Influenza B** | | |
| Not Detected | | Not Detected |
| **Parainfluenza** | | |
| Not Detected | | Not Detected |
| **Respiratory Syncytial** | | |
| Not Detected | | Not Detected |

## Sputum Culture

Methicillin Susceptible
*Staphylococcus aureus*

# FUTURE OPPORTUNITIES AND CHALLENGES

- Multiplex assays for Sterile body fluids
  - Pleural fluid
  - Peritoneal fluid
  - Synovial fluid
- Colonization vs Infection
- Effect of prior antimicrobial therapy
- Cost
- Multiplex assay after inoculation in blood culture bottles
- Polymicrobial infections

# THANK YOU!

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