Diagnosing Group A Strep pharyngitis - Which Technique is Best for You?

Gregory J. Berry, Ph.D., D(ABMM)
Assistant Professor, Pathology and Laboratory Medicine
Zucker School of Medicine at Hofstra/Northwell
Director, Molecular Diagnostics/ Asst. Director, Infectious Disease Diagnostics
Northwell Health Laboratories

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Learning objectives

Review the clinical background of Group A Strep and its role as a pathogen in human health

Identify various ways in which Group A Strep pharyngitis can be accurately diagnosed

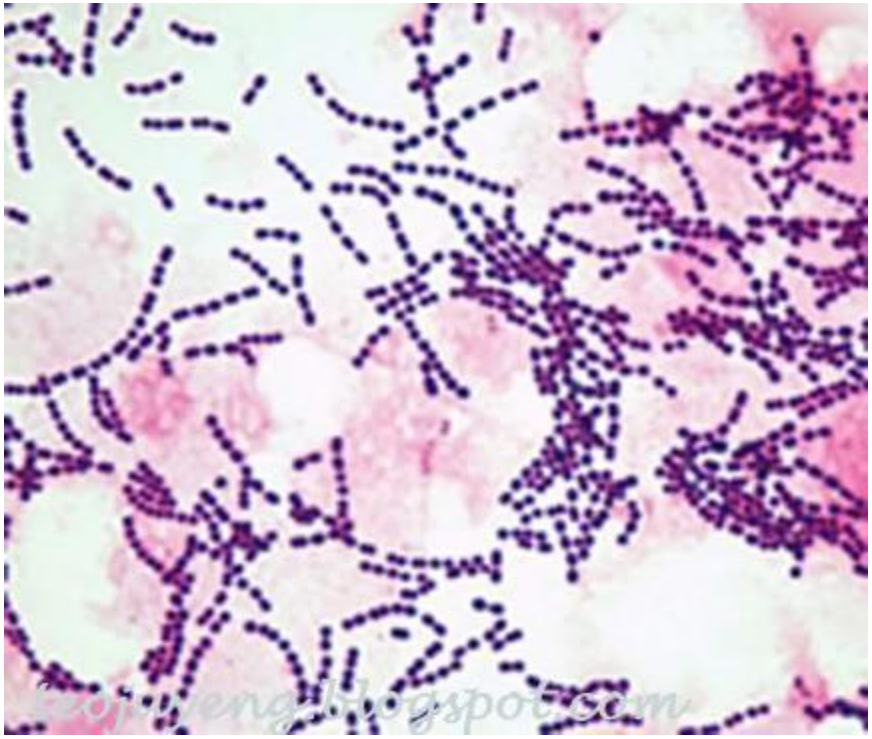
Discuss testing recommendations for Group A Strep pharyngitis

Explore aspects that influence which test(s) are the best fit for a clinic/health system

Streptococcus pyogenes (group A strep - GAS)

- Lancefield Group A serogrouping: “group A strep”
- Beta hemolytic (complete hemolysis) on blood agar plate: “β strep”
- Responsible for a wide range of human infections
  - Some individuals are carriers

Gram+ cocci, pairs and chains



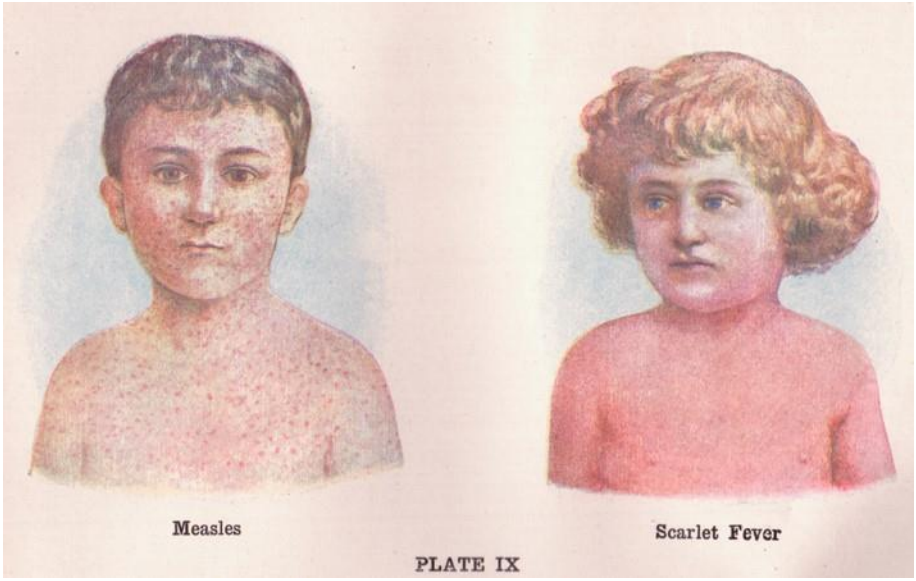
https://www.slideshare.net/AshleyHamilton11/clinical-microbiology-53574911

GAS as a human pathogen

- Responsible for many different infections
  - Range from minor illness to deadly infections
- Common cause of “strep throat” pharyngitis, impetigo, scarlet fever
  - Serious secondary complications include rheumatic fever, rheumatic heart disease, and glomerulonephritis
- Can also cause life-threatening invasive infections

GAS - Then and Now

- Illness was likely first described by Hippocrates in 400 BC
  - Erysipelas (red skin) and other symptoms[1]
- In the late 1880s and early 1900s scarlet fever was the leading cause of death in children[2]
- Incidence rapidly declined in the 20th century[2]
- Rapid resurgence in the UK- 2016 saw highest number of cases in almost 50 years[2]
  - Cases also increasing steadily in East Asia



The Practical Guide to Health by Frederick M. Rossiter, copyright 1908, Pacific Press Publishing Association, Mountain View, Cal., Between pages 258 and 259.

1 Ferretti, Joseph; Kohler, Werner (February 2016). "History of Streptococcal Research". Streptococcus pyogenes : Basic Biology to Clinical Manifestations. PMID 26866232
2 BMJ 2016;352:i1658

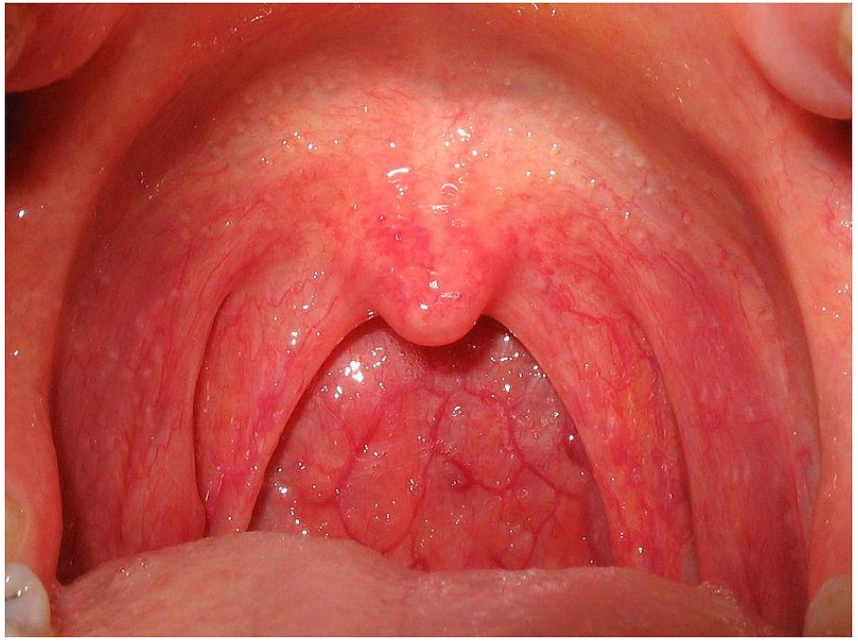
How do you get infected?

- GAS resides in the nose and throat of infected individuals
- Typically spread through person-to-person contact
  - Daycare centers, schools, military training facilities
- Bacteria can travel in respiratory droplets and nasal secretions that get expelled during coughing, sneezing, etc.

Good hygiene is the best way to prevent infection

Pharyngitis

- "Sore throat"
- Most common upper respiratory tract infection
- Inflammation of the back of the throat (pharynx)
  - Can also cause runny nose, cough, fever
- Typical duration: 3 - 5 days
- Majority of cases are viral, but can also be bacterial
  - Viral- typically self-limiting
  - Bacterial- treatment options available



https://upload.wikimedia.org/wikipedia/commons/b/b1/Pharyngitis.jpg

Table 3. Microbial Etiology of Acute Pharyngitis

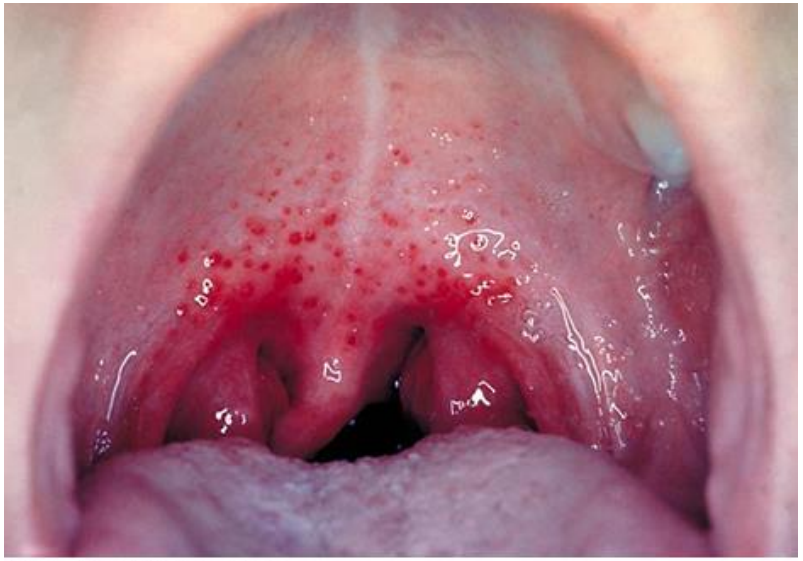
Organisms	Clinical Syndrome(s)
Bacterial	
Group A streptococcus	Pharyngotonsillitis, scarlet fever
Group C and group G streptococcus	Pharyngotonsillitis
Arcanobacterium haemolyticum	Scarlatiniform rash, pharyngitis
Neisseria gonorrhoeae	Tonsillopharyngitis
Corynebacterium diphtheriae	Diphtheria
Mixed anaerobes	Vincent's angina
Fusobacterium necrophorum	Lemierre's syndrome, peritonsillar abscess
Francisella tularensis	Tularemia (oropharyngeal)
Yersinia pestis	Plague
Yersinia enterocolitica	Enterocolitis, pharyngitis
Viral	
Adenovirus	Pharyngoconjunctival fever
Herpes simplex virus 1 and 2	Gingivostomatitis
Coxsackievirus	Herpangina
Rhinovirus	Common cold
Coronavirus	Common cold
Influenza A and B	Influenza
Parainfluenza	Cold, croup
EBV	Infectious mononucleosis
Cytomegalovirus	CMV mononucleosis
HIV	Primary acute HIV Infection
Mycoplasma	
Mycoplasma pneumoniae	Pneumonitis, bronchitis
Chlamydia	
Chlamydophila pneumoniae	Bronchitis, pneumonia
Chlamydophila psittaci	Psittacosis

Abbreviations: CMV, cytomegalovirus; EBV, Epstein-Barr virus; HIV, human immunodeficiency virus.

Shulman et al., Clinical Practice Guideline for the Diagnosis and Management of Group A Streptococcal Pharyngitis: 2012 Update by the Infectious Diseases Society of America. Clinical Infectious Diseases 2012;55(10):e86-102

GAS pharyngitis

- Most common bacterial cause of pharyngitis
- Seasonality: winter and early spring
- Clinical manifestation
  - Rapid onset sore throat
  - Painful swallowing
  - Red, swollen tonsils
  - White patches/streaks of pus
  - Petechiae on roof of mouth
  - Swollen lymph nodes
  - Fever
  - Headache, abdominal pain, nausea, vomiting



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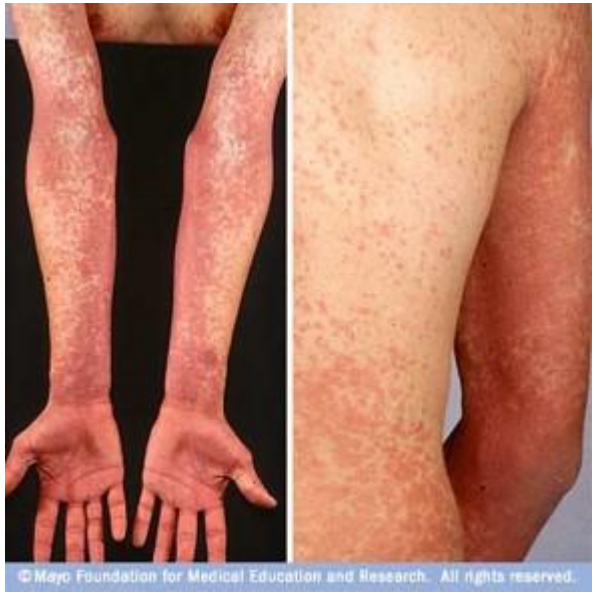
20 - 30% of all sore throat cases in children
5 - 15% of all sore throat cases in adults

https://www.cdc.gov/groupastrep/diseases-public/strep-throat.html

GAS pharyngitis

- Can be accompanied by scarlatiniform rash- scarlet fever or scarlatina.
  - "Strawberry tongue"
- Incubation period: 2-5 days
- Most common in children 5-15 years of age, uncommon under age 3
- Costs to US economy- $224-$539 million/yr[1]



https://www.mayoclinic.org/diseases-conditions/scarlet-fever/symptoms-causes/syc-20377406

https://upload.wikimedia.org/wikipedia/commons/4/4a/Skarlatina.jpg

1) Pfoh E, Wessels MR, Goldmann D, Lee GM. Burden and economic cost of group A streptococcal pharyngitis. Pediatrics 2008; 121:229–34.

Table 4. Epidemiologic and Clinical Features Suggestive of Group A Streptococcal and Viral Pharyngitis

Feature, by Suspected Etiologic Agent
GROUP A STREPTOCOCCAL
• Sudden onset of sore throat • Age 5–15 years • Fever • Headache • Nausea, vomiting, abdominal pain • Tonsillopharyngeal inflammation • Patchy tonsillopharyngeal exudates • Palatal petechiae • Anterior cervical adenitis (tender nodes) • Winter and early spring presentation • History of exposure to strep pharyngitis • Scarlatiniform rash
VIRAL
• Conjunctivitis • Coryza • Cough • Diarrhea • Hoarseness • Discrete ulcerative stomatitis • Viral exanthema

Shulman et al., Clinical Practice Guideline for the Diagnosis and Management of Group A Streptococcal Pharyngitis: 2012 Update by the Infectious Diseases Society of America. Clinical Infectious Diseases 2012;55(10):e86-102

Treatment for GAS pharyngitis

Table 2. Antibiotic Regimens Recommended for Group A Streptococcal Pharyngitis

Drug, Route	Dose or Dosage	Duration or Quantity	Recommendation Strength, Quality[a]	Reference(s)
For individuals without penicillin allergy				
Penicillin V, oral	Children: 250 mg twice daily or 3 times daily; adolescents and adults: 250 mg 4 times daily or 500 mg twice daily	10 d	Strong, high	[125, 126]
Amoxicillin, oral	50 mg/kg once daily (max = 1000 mg); alternate: 25 mg/kg (max = 500 mg) twice daily	10 d	Strong, high	[88–92]
Benzathine penicillin G, intramuscular	<27 kg: 600 000 U; ≥27 kg: 1 200 000 U	1 dose	Strong, high	[53, 125, 127]
For individuals with penicillin allergy				
Cephalexin,[b] oral	20 mg/kg/dose twice daily (max = 500 mg/dose)	10 d	Strong, high	[128–131]
Cefadroxil,[b] oral	30 mg/kg once daily (max = 1 g)	10 d	Strong, high	[132]
Clindamycin, oral	7 mg/kg/dose 3 times daily (max = 300 mg/dose)	10 d	Strong, moderate	[133]
Azithromycin,[c] oral	12 mg/kg once daily (max = 500 mg)	5 d	Strong, moderate	[97]
Clarithromycin,[c] oral	7.5 mg/kg/dose twice daily (max = 250 mg/dose)	10 d	Strong, moderate	[134]

Abbreviation: Max, maximum.

[a] See Table 1 for a description.

[b] Avoid in individuals with immediate type hypersensitivity to penicillin.

[c] Resistance of GAS to these agents is well-known and varies geographically and temporally.

Shulman et al., Clinical Practice Guideline for the Diagnosis and Management of Group A Streptococcal Pharyngitis: 2012 Update by the Infectious Diseases Society of America. Clinical Infectious Diseases 2012;55(10):e86-102

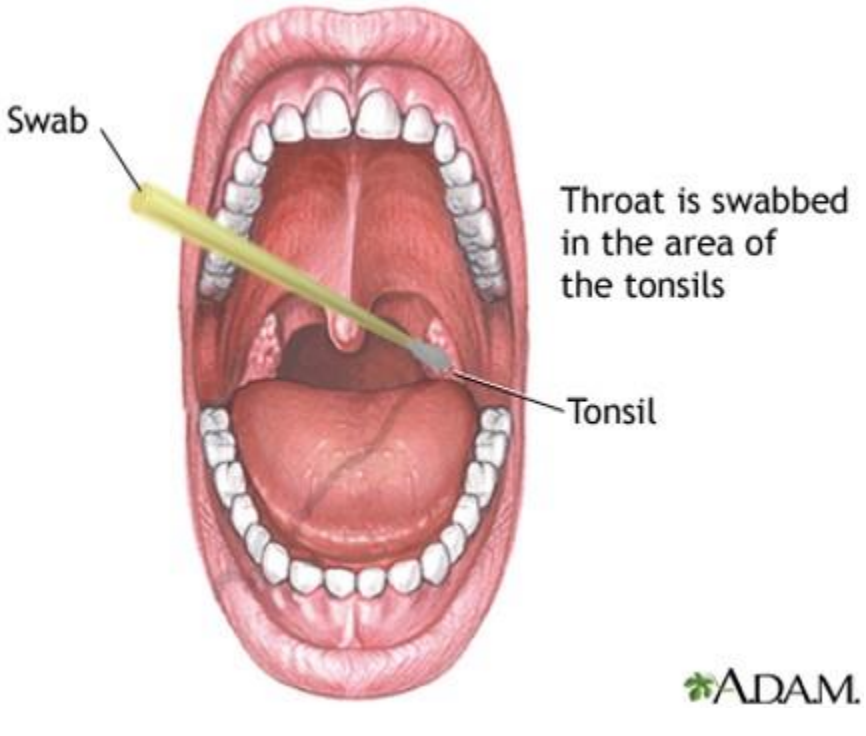
Clinical Laboratory Standards Institute (CLSI) guidelines M100 28th edition:

- ***Streptococcus* spp. footnote n:** "Penicillin and ampicillin are the drugs of choice for treating β-hemolytic streptococcal infections. Susceptibility testing of penicillins and other β-lactams approved by the US Food and Drug Administration for treating β-hemolytic streptococcal infections does not need to performed routinely, because nonsusceptible isolates…are extremely rare in any β-hemolytic streptococci and have not been reported for *Streptococcus pyogenes*."

Testing Methodologies for GAS Detection

No matter the test, proper specimen collection is critical

1. Have the patient tilt their head backwards, open mouth, and stick out tongue.
2. Use tongue depressor to hold the tongue in place.
3. Without touching the sides of the mouth, swab the posterior nasopharynx and the tonsillar arches.
4. Insert swab into sterile transport system.
5. Deliver samples to laboratory for testing.



Testing for GAS pharyngitis

Testing in clinic
(Point of Care)

- Rapid antigen tests
- Molecular nucleic acid amplification testing (POCT)

Laboratory Testing

- Throat culture
- Molecular nucleic acid amplification

What determines where the test can be performed?

CLIA regulations for testing

- All laboratory testing in the U.S. falls under the jurisdiction of Clinical Laboratory Improvement Amendments of 1988 (CLIA)
- Administered by CMS and is implemented through three federal agencies—CDC, CMS, and the Food and Drug Administration (FDA)
- The three categories of testing for CLIA purposes are **waived, moderate complexity** (including the provider-performed microscopy procedures [PPMP] subcategory), and **high complexity**

CLIA regulations for testing

- Waived, moderate complexity, and high complexity designation based on ease of use
- CLIA requires that waived tests must be simple and have a low risk for erroneous results
- Tests classified as moderately complex must be performed in a clinical laboratory

Only CLIA-waived tests can be performed at point-of-care

Point-of-care testing (POCT)

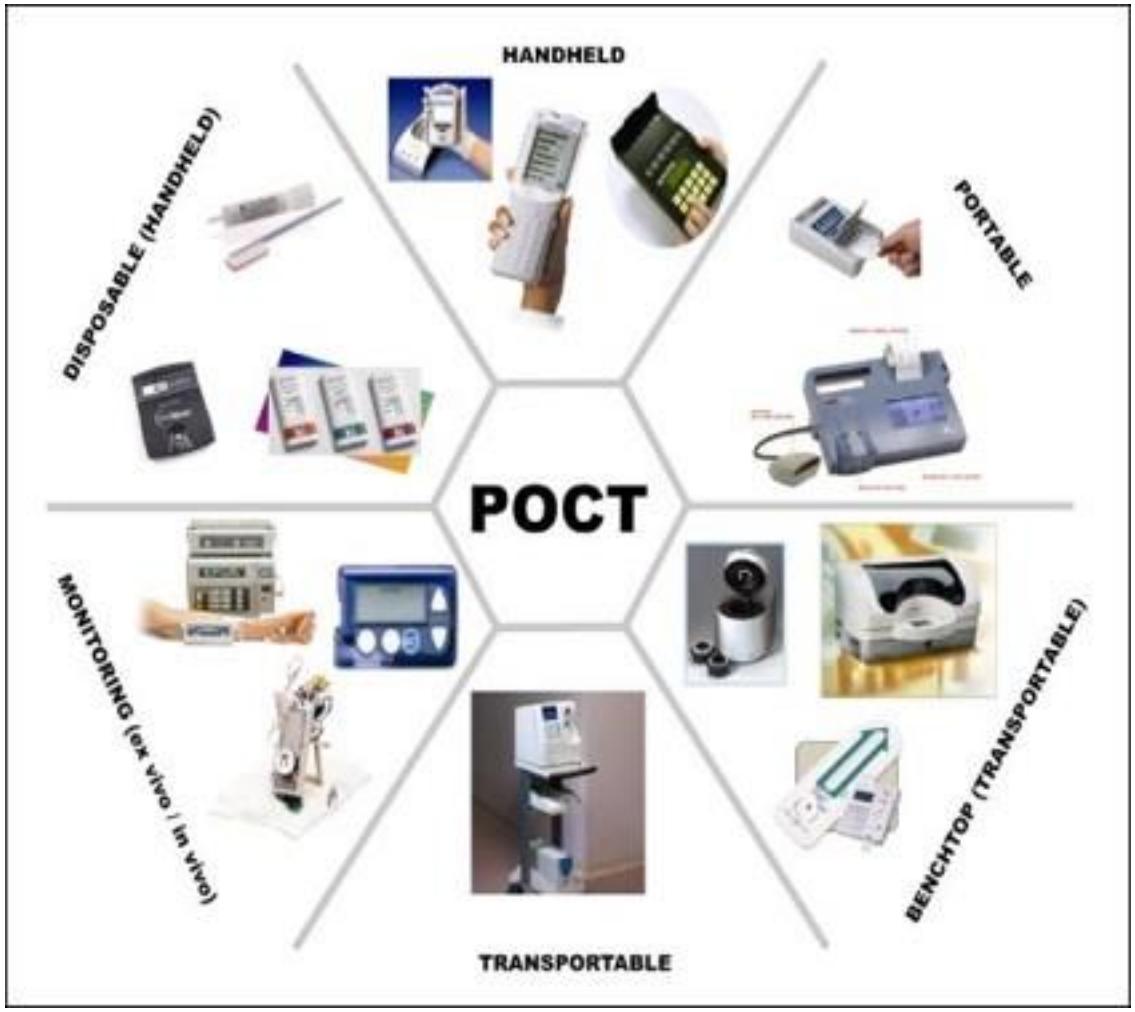
Testing performed <u>while</u> patient care is occurring

Main advantage is time gained

Therapeutic choices in real time

- Identify treatment to administer
- Avoid unnecessary drugs/treatments

Requires simple platforms with accurate results



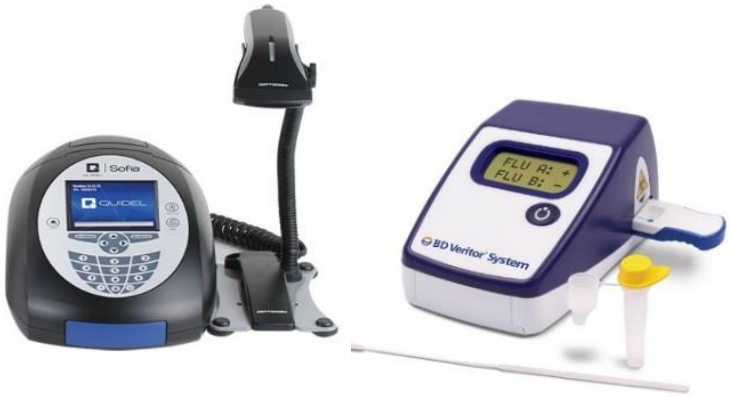
https://i.pinimg.com/736x/0c/26/a9/0c26a969cd5be705139c9a71f39e3665--point-of-care-testing-lab-tech.jpg

POCT in infectious disease diagnostics

- These are CLIA waived tests that can be performed by facilities with a Certificate of Waiver
- Increasingly larger portion of infectious disease testing
- Huge advantage of rapid answer for treatment decisions
- Quality is key- results must approach the same sensitivity and specificity of laboratory tests

Rapid antigen tests for GAS

- Available since the 1980s
- Most common first line of testing at clinic
- Immunoassays: detect GAS-specific antigens
- Qualitative resulting
- Vary greatly in their sensitivity
  - **Negative GAS results need culture confirmation**



[Diagnostic Test Accuracy Review]

Rapid antigen detection test for group A streptococcus in children with pharyngitis

Jérémie F Cohen[1,2], Nathalie Bertille[1], Robert Cohen[3,4], Martin Chalumeau[1,2]

[1]Obstetrical, Perinatal and Pediatric Epidemiology Research Team (EPOPé), Centre de Recherche Épidémiologie et Statistique Sorbonne Paris Cité (CRESS), Inserm UMR1153, Paris Descartes University, Paris, France. [2]Department of Pediatrics, Necker Hospital, AP-HP and Paris Descartes University, Paris, France. [3]Association Clinique et Thérapeutique Infantile du Val-de-Marne (ACTIV), Saint-Maur-des-Fossés, France. [4]Department of Microbiology, Centre Hospitalier Intercommunal de Créteil (CHIC), Créteil, France

Contact address: Martin Chalumeau, Obstetrical, Perinatal and Pediatric Epidemiology Research Team (EPOPé), Centre de Recherche Épidémiologie et Statistique Sorbonne Paris Cité (CRESS), Inserm UMR1153, Paris Descartes University, Paris, France. martin.chalumeau@gmail.com, martin.chalumeau@nck.aphp.fr.

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ABSTRACT

Background

Group A streptococcus (GAS) accounts for 20% to 40% of cases of pharyngitis in children; the remaining cases are caused by viruses. Compared with throat culture, rapid antigen detection tests (RADTs) offer diagnosis at the point of care (within five to 10 minutes).

Objectives

To determine the diagnostic accuracy of RADTs for diagnosing GAS in children with pharyngitis. To assess the relative diagnostic accuracy of the two major types of RADTs (enzyme immunoassays (EIA) and optical immunoassays (OIA)) by indirect and direct comparison.

Search methods

We searched CENTRAL, MEDLINE, EMBASE, Web of Science, CDSR, DARE, MEDION and TRIP (January 1980 to July 2015). We also conducted related citations tracking via PubMed, handsearched reference lists of included studies and relevant review articles, and screened all articles citing included studies via Google Scholar.

Selection criteria

We included studies that compared RADT for GAS pharyngitis with throat culture on a blood agar plate in a microbiology laboratory in children seen in ambulatory care.

Data collection and analysis

Two review authors independently screened titles and abstracts for relevance, assessed full texts for inclusion, and carried out data extraction and quality assessment using the QUADAS-2 tool. We used bivariate meta-analysis to estimate summary sensitivity and specificity, and to investigate heterogeneity across studies. We compared the accuracy of EIA and OIA tests using indirect and direct evidence.

Study characteristics

We searched for studies published in any language from January 1980 to July 2015. We found 98 unique studies, for a total of 116 test evaluations, involving 101,121 children. The number of participants ranged from 42 to 11,644 across test evaluations. The proportion of children with strep throat ranged from 9.5% to 66.6% across test evaluations.

Quality of the evidence

Important study design features were frequently not reported. The overall methodological quality of included studies was poor. For most studies, we had concerns about the ways in which participants were selected.

Key results

On average, rapid tests for strep throat had a sensitivity (ability to correctly detect people with the disease) of 86% and a specificity (ability to correctly identify people who do not have the disease) of 95%. There was substantial variability in rapid test performance across studies, which was not explained by study characteristics, including methodological quality. The two types of rapid tests under evaluation seemed to have comparable sensitivity (85.4% versus 86.2% for enzyme immunoassays and optical immunoassays, respectively). Based on these results, we would expect that amongst 100 children with strep throat, 86 would be correctly detected with the rapid test while 14 would be missed and not receive antibiotic treatment. Of 100 children with non-streptococcal sore throat, 95 would be correctly classified as such with the rapid test while 5 would be misdiagnosed as having strep throat and receive unnecessary antibiotics.

Notes from the Field

Group A Streptococcal Pharyngitis Misdiagnoses at a Rural Urgent-Care Clinic — Wyoming, March 2015

Alexia Harrist, MD, PhD[1,2]; Clayton Van Houten, MS[2]; Stanford T. Shulman, MD[3]; Chris Van Beneden, MD[4]; Tracy Murphy, MD[2]

Group A *Streptococcus* (GAS) is the most common bacterial cause of pharyngitis, implicated in 20%–30% of pediatric and 5%–15% of adult health care visits for sore throat (*1*). Along with the sudden onset of throat pain, GAS pharyngitis symptoms include fever, headache, and bilateral tender cervical lymphadenopathy (*1*,*2*). Accurate diagnosis and management of GAS pharyngitis is critical for limiting antibiotic overuse and preventing rheumatic fever (*2*), but distinguishing between GAS and viral pharyngitis clinically is challenging (*1*). Guidelines for diagnosis and management of GAS pharyngitis have been published by the Infectious Diseases Society of America (IDSA)* (*1*). IDSA recommends that patients with sore throat be tested for GAS to distinguish between GAS and viral pharyngitis; however, IDSA emphasizes the use of selective testing based on clinical symptoms and signs to avoid identifying GAS carriers rather than acute GAS infections (*1*). Therefore, testing for GAS usually is not recommended for the following: patients with sore throat and accompanying

The line list revealed nonadherence to IDSA guidelines in testing and treatment procedures. Ten of 34 (29%) patients aged ≥3 years who were tested for GAS reported no sore throat, the symptom that should prompt evaluation for GAS pharyngitis in patients aged ≥3 years (*1*). Two of these 10 were asymptomatic adult contacts of patients with diagnosed GAS pharyngitis; both asymptomatic contacts had positive RADT results and were prescribed an antibiotic. Of the 24 tested patients aged ≥3 years with sore throat, 19 (79%) reported cough or rhinorrhea, symptoms that suggest a viral rather than bacterial etiology (*1*). Although diagnostic testing of patients aged <3 years is not routinely recommended, testing of symptomatic children who are household contacts of persons with laboratory-confirmed GAS pharyngitis can be considered (*1*). Among the seven patients aged <3 years who were tested for GAS pharyngitis, five (71%) had GAS-positive family members indicated by shared surname included in the line list; however, all seven (100%) had cough, and five (71%) had rhinorrhea.

Four of six patients with negative RADT results received an antibiotic. The clinic practice was to send throat swabs from patients with negative RADTs to a commercial laboratory for back-up culture, but it is unknown whether the clinic obtained any GAS-positive throat cultures from RADT-negative patients

Investigation

- In March 2015, a rural urgent-care clinic serving a population of 5,000–7,000 reported a substantial increase in GAS pharyngitis infections since November 2014, with some infections nonresponsive to penicillin and amoxicillin to the Wyoming Department of Health (WDH).

- Findings
  - Testing asymptomatic patients (no sore throat)
  - Testing of patients with viral illness symptoms
  - 86% positivity rate on rapid antigen tests performed
  - Clinic staff were reading tests at longer intervals than manufacturer's instructions- can lead to false positives

- Intervention
  - Cases declined, no resistance was found- likely viral illnesses misdiagnosed as GAS

Follow the FDA approved package insert

Molecular POCT

Historical impediments to POCT

- Not accurate enough for definitive diagnosis
  - E.g. rapid strep and flu tests
- Too difficult to perform at point-of-care
  - E.g. molecular testing
- Too Expensive

How does Molecular POCT address these issues?

Problems

- Not accurate enough for definitive diagnosis
  - E.g. rapid strep and flu tests
- Too difficult to perform at point-of-care
  - E.g. molecular testing
- Too Expensive

Solutions

- Increasing sensitivity and specificity
  - Molecular testing
- Assays designed to be user-friendly and more error-proof
- Costs decreasing over time and reimbursement that matches test costs

Molecular POCT tests for infectious diseases

- Traditionally designated by CLIA as moderate/high complexity
  - performed in the clinical laboratories
- Only rapid antigen testing was available as CLIA waived
- CLIA waived tests have recently become available

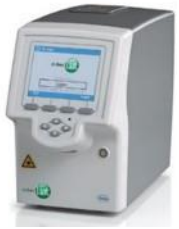
CLIA waived molecular tests for infectious diseases

- **January 8th, 2015:** First CLIA waived test for influenza A and B (Alere i Influenza A&B)
- Followed by the Roche cobas Influenza A/B
- **GAS** and RSV are also now available on both platforms

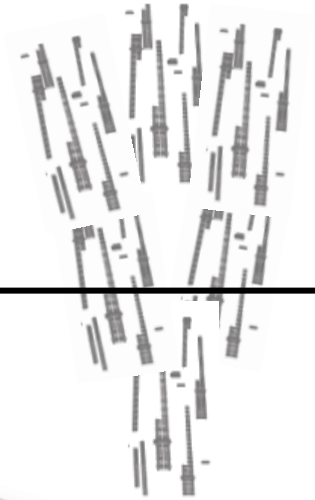
Molecular testing pros and cons

Pros	Cons
• Can amplify genome • Highly sensitive and specific	• Typically costs more • Takes longer

Advantage of sample amplification



Detection threshold



Nurse A

Nurse B

Amplified
GAS+ Sample

Not Amplified
GAS+ Sample

Alere™ i

4 - 8 minutes to result for GAS

8-13 minutes to result for Flu/RSV

Small footprint (8.15” W x 5.71” H x 7.64” D)

Weight= 1.4 lbs / 3 kg

LIAT - Lab In a Tube

- 15 minutes to results GAS
- 20 minutes to results Flu/ RSV
- Footprint 4.5 x 9.5 x 7.5
- Weight 8.3 lbs

Laboratory testing

- Testing performed in centralized location
- Lab is licensed and accredited to perform patient testing
- Licensed laboratory personnel perform testing

Laboratory Workup for GAS

Identification of GAS by culture

- Throat swab is collected and inoculated onto plates
  - Most laboratories are routinely identifying only GAS
    - Agar selective for strep, or BAP can be used with a bacitracin (A) disk
      - GAS is susceptible to bacitracin
      - Catalase (-); PYR(+); MALDI-TOF can also be used for identification
    - Additional workup can be done if other pathogens suspected
      - e.g. blood agar for other streptococci (B, C, F, G) and *A. haemolyticum*, or modified Thayer-Martin for *N. gonorrhoeae* isolation
- Incubate in aerobic incubator with 5% CO_2
- Result: 24-48 hours

Beta hemolysis

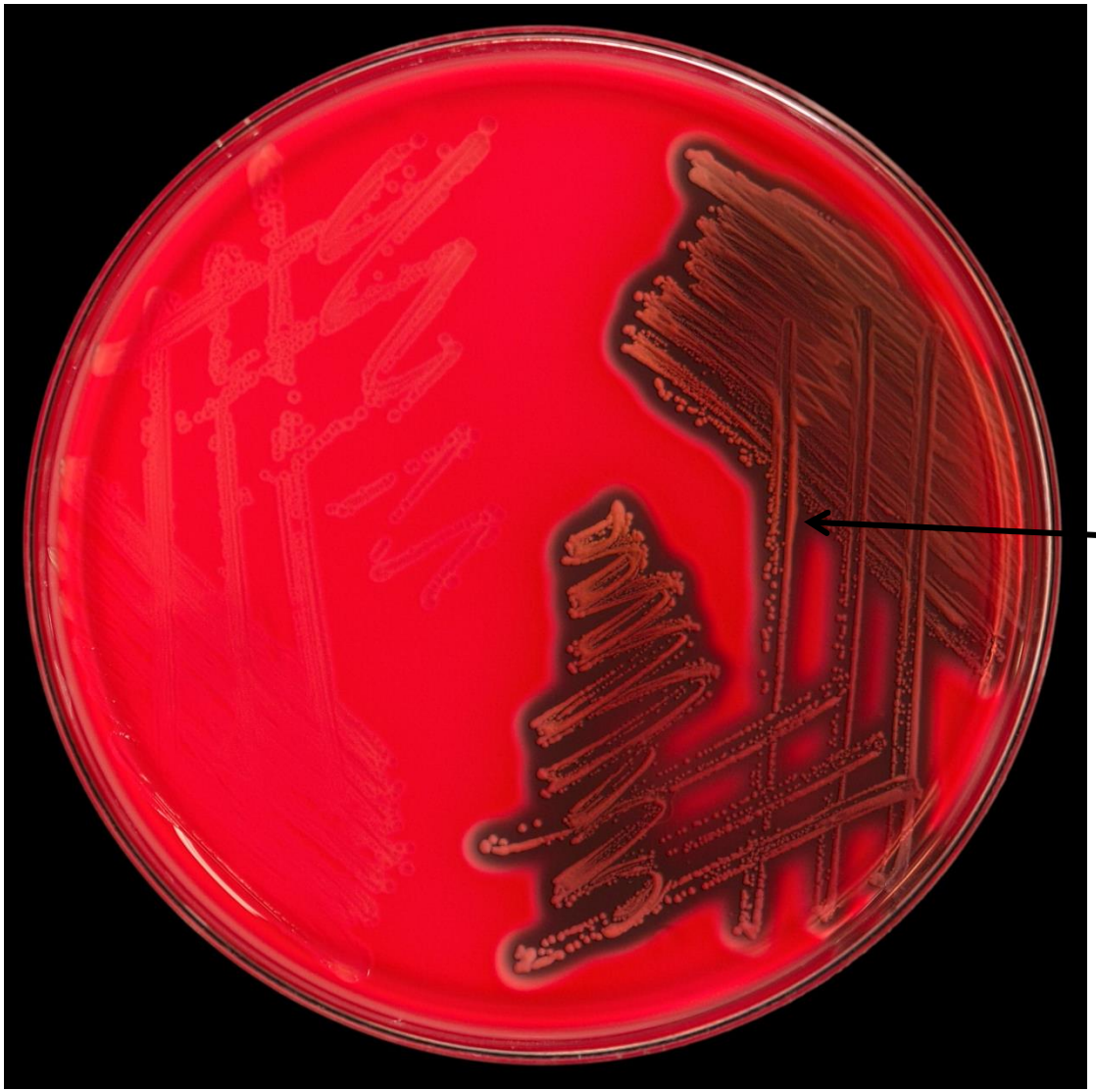
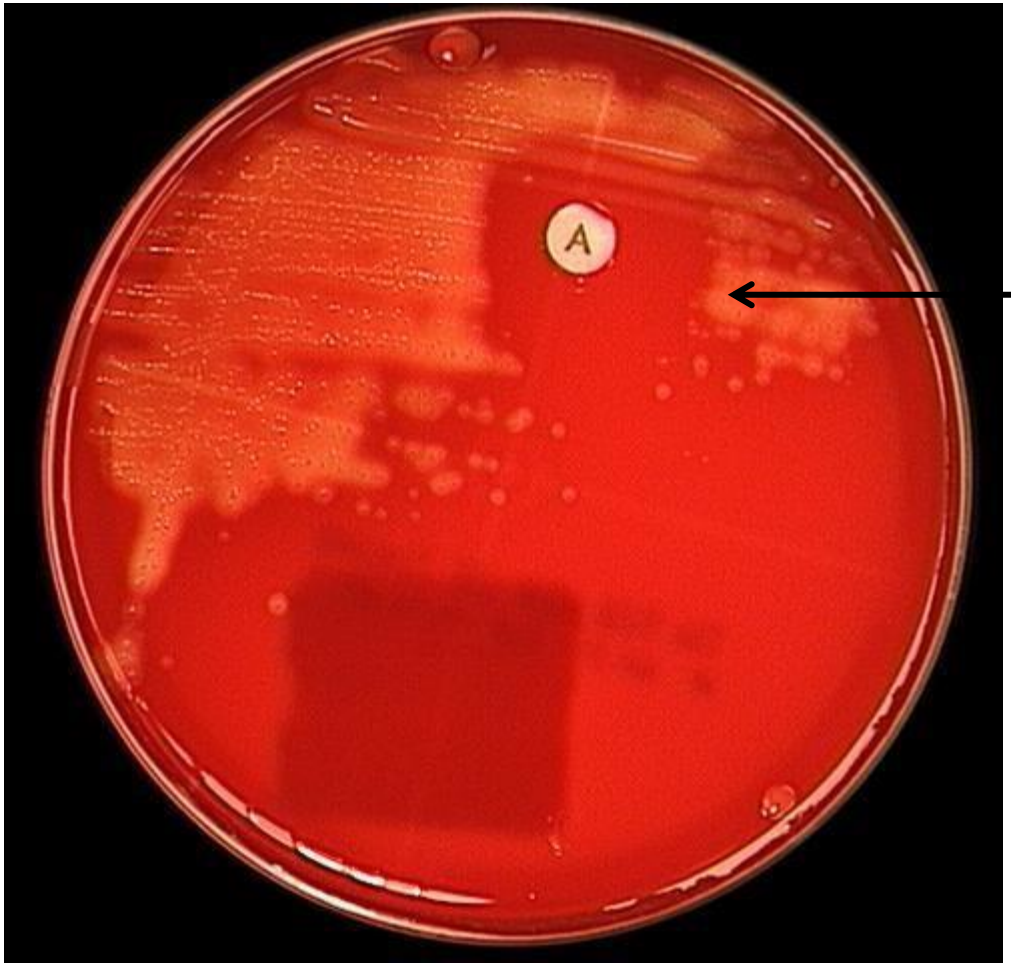


Photo courtesy of Dr. Lesley McGee, CDC

Bacitracin (A) disk and GAS



https://microbeonline.com/wp-content/uploads/2013/05/Bacitracin-disk-test-for-Streptococcus-pyogenes.jpg

GAS PCR

- Literature shows PCR is just as sensitive, or more sensitive than standard culture
- Advantage for clinician- rapid turnaround time (hours vs. 1-3 days)
- Time can offer huge advantage of choosing the right therapeutic therapy up-front

LYRA® Direct Strep Assay

- Quidel: Real-Time PCR
- Detection and differentiation of GAS and group C/G Streptococcus
- Batching of specimens
- ~70 minute result

ARIES® Group A Strep Assay

- Luminex: Real-Time PCR
- Detection of GAS
- Batching: 2 drawers, 6 specimens each
- ~ 2 hours

Xpert® Xpress Strep A

- Cepheid: Real-Time PCR
- Detection of GAS
- Each specimen runs independently
- 24 minutes, or less

illumigene Group A Streptococcus DNA Amplification Assay

- Meridian Bioscience: Loop-mediated Isothermal DNA amplification
- Detection of GAS
- Each specimen runs independently
- >1 hour

Comparison of Methods

	Rapid antigen	Culture	Laboratory Molecular	POCT Molecular
Fast	X			X
Convenient	X			X
Actionable results	X	X	X	X
POCT- friendly	X			X
Little/No subjectivity		X	X	X
LIS/EMR interfaced			X	X
High sensitivity/specificity		X	X	X
Low Cost	X	X		

IDSA GUIDELINES

Clinical Practice Guideline for the Diagnosis and Management of Group A Streptococcal Pharyngitis: 2012 Update by the Infectious Diseases Society of America

Stanford T. Shulman,[1] Alan L. Bisno,[2] Herbert W. Clegg,[3] Michael A. Gerber,[4] Edward L. Kaplan,[5] Grace Lee,[6] Judith M. Martin,[7] and Chris Van Beneden[8]

[1]Department of Pediatrics, Division of Infectious Diseases, Ann & Robert H. Lurie Children's Hospital, Northwestern University Feinberg School of Medicine, Chicago, Illinois; [2]Department of Medicine, University of Miami Miller School of Medicine, Miami Veterans Affairs Healthcare System, Miami, Florida; [3]Department of Pediatrics, Hemby Children's Hospital and Eastover Pediatrics, Charlotte, North Carolina; [4]Department of Pediatrics, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio; [5]Department of Pediatrics, University of Minnesota Medical School, Minneapolis, Minnesota; [6]Division of Infectious Diseases, Boston Children's Hospital, Boston, Massachusetts; [7]Department of Pediatrics, University of Pittsburgh, Pittsburgh, Pennsylvania; and [8]Respiratory Diseases Branch, National Center for Immunization and Respiratory Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia

The guideline is intended for use by healthcare providers who care for adult and pediatric patients with group A streptococcal pharyngitis. The guideline updates the 2002 Infectious Diseases Society of America guideline and discusses diagnosis and management, and recommendations are provided regarding antibiotic choices and dosing. Penicillin or amoxicillin remain the treatments of choice, and recommendations are made for the penicillin-allergic patient, which now include clindamycin.

I. How Should the Diagnosis of GAS Pharyngitis Be Established?

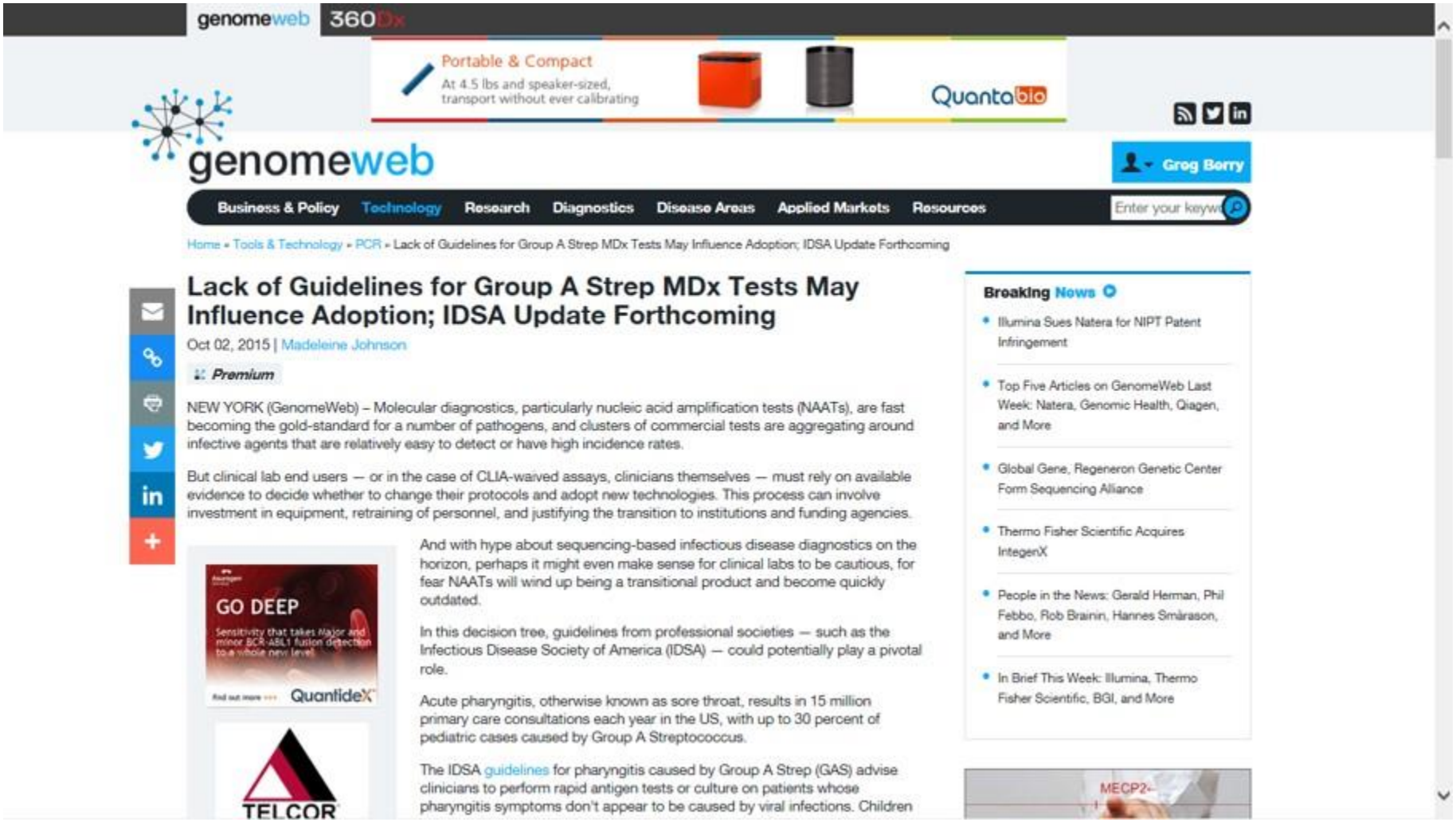
Recommendations

1. Swabbing the throat and testing for GAS pharyngitis by rapid antigen detection test (RADT) and/or culture should be performed because the clinical features alone do not reliably discriminate between GAS and viral pharyngitis except when overt viral features like rhinorrhea, cough, oral ulcers, and/or hoarseness are present. In children and adolescents, negative RADT tests should be backed up by a throat culture (strong, high). Positive RADTs do not necessitate a back-up culture because they are highly specific (strong, high).

I. How Should the Diagnosis of GAS Pharyngitis Be Established?

2. Routine use of back-up throat cultures for those with a negative RADT is not necessary for adults in usual circumstances, because of the low incidence of GAS pharyngitis in adults and because the risk of subsequent acute rheumatic fever is generally exceptionally low in adults with acute pharyngitis (strong, moderate). Physicians who wish to ensure they are achieving maximal sensitivity in diagnosis may continue to use conventional throat culture or to back up negative RADTs with a culture.

Where is the PCR recommendation?



Where is the PCR recommendation?

- IDSA guidelines issued in 2012- no FDA approved molecular tests on the market at that time

- Stanford Shulman, chair of the guideline committee and a professor of pediatrics and infectious diseases at Northwestern University Feinberg School of Medicine:
  - "I think the committee will need to take a new look at the field given what has happened in the last few years in terms of the development of molecular testing,“
  - This research on new molecular diagnostic tests "should be taken into account when guidelines are redeveloped," he said.

What test methodology is best for you?

- What patient population are you testing?
  - adult vs. pediatrics
  - Inpatient vs. outpatient
- What are your clinician's needs?
  - Will new methodologies actually change their practice?
- What is your expected turnaround time?
  - Does it need to be improved?
- Cost and reimbursement
  - In general, molecular assays cost more, but reimbursement is higher
- Administrative buy-in
  - Reagent budgets will increase, so do they understand the benefit?

Overall conclusions

- GAS continues to be a burden on the healthcare system
- Newer molecular techniques have now joined traditional methods (rapid antigen testing, culture) for GAS testing
- Molecular options are now available at point-of-care
  - Substantially reduce TAT
- Guidelines have not yet been updated to reflect this new technology, but this will likely occur in the near future

Questions?

Presented by:
Gregory J. Berry, Ph.D., D(ABMM)
Assistant Professor, Pathology and Laboratory Medicine
Zucker School of Medicine at Hofstra/Northwell
Director, Molecular Diagnostics/ Asst. Director, Infectious Disease Diagnostics
Northwell Health Laboratories

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