Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Diagnostic Stewardship: An Essential Element in a Rapidly Evolving COVID-19 Pandemic

Aditya S. Shah, MBBS; Aaron J. Tande, MD; Douglas W. Challener, MD; John C. O'Horo, MD, MPH; Matthew J. Binnicker, PhD; and Elie F. Berbari, MD

From the Division of Infectious Diseases (A.S.S., A.J.T., D.W.C., J.C.O., E.F.B.), Division of Pulmonary and Critical Care Medicine (J.C.O.), and Department of Laboratory Medicine and Pathology (M.J.B.), Mayo Clinic, Rochester, MN.

On March 11, 2020, the World Health Organization (WHO) declared coronavirus disease 2019 (COVID-19) a global pandemic.[1,2] Mayo Clinic, like many other health systems, moved to identify strategies to mitigate the impact of this pandemic on its patients and community.[3] Testing was a critical part of this response, but early on, Mayo Clinic was hampered by lack of widespread test availability, uncertainty about test interpretation and performance (especially in asymptomatic carriers of the disease), and unclear national guidance on test utilization. Mayo Clinic commissioned a COVID-19 Diagnostic Stewardship Task Force to evaluate the most successful ways to allocate and deploy testing resources. Specifically, this group assessed how to use molecular and serologic testing effectively, efficiently, and safely for our patients, community members, and employees. This process has been a dynamic one, as testing availability and data have become more available, shelter-in-place orders have been relaxed, and health care systems have begun to shift back to non−COVID-19 care.

The task force identified 3 important strategies for effectively developing and implementing medical guidance for using COVID-19 testing: (1) effective and real-time predictive test utilization modeling, (2) development of consensus-based testing guidance using internal and external data, and (3) establishment of a real-time practice group that rapidly implemented and communicated the guidance in our practice and within the community. The task force used active audit, review, feedback, and real-time data analysis as a framework to understand which resources could be used and triaged.

At Mayo Clinic, our approach to the 3 strategies was modeled on the WHO recommendations for key elements of pandemic planning and management, which include rapid planning, execution, evaluation, and adaptation of new workflows and processes.[4] We implemented a widespread testing strategy for our communities and outpatient populations by using drive-through[5] and walk-through test collection sites. Our initial approach was to test as many symptomatic members of the community as possible by using a telephone triage questionnaire that was administered by nurses and an algorithm that was updated frequently as knowledge evolved. For example, as community spread became evident, the initial criterion for a travel requirement was eliminated. This approach allowed testing of extended communities in the upper Midwest, Arizona, and Florida. We also recommended a risk stratification scheme to guide aggressive testing of inpatients. This scheme was based on a synthesis of guidance from the Centers for Disease Control and Prevention, publications from WHO, and internal expert opinion.

A specific area of concern was exposure of health care workers during procedures, and consensus-based guidance was used to inform our approach. Many procedures were paused during the initial days of the shelter-in-place order, but it was critical to develop a pathway to screen asymptomatic patients requiring urgent or emergent care. Initially, less urgent procedures were delayed. For patients requiring an urgent procedure, we recommended a dual testing approach of real-time polymerase chain

reaction (RT-PCR) and a computed tomography (CT) scan of the chest. This more extensive testing was based on uncertainty about use of RT-PCR for asymptomatic patients. Evidence existed for the risk of asymptomatic transmission,[6-9] but data were not available on the sensitivity and specificity of RT-PCR in this asymptomatic population. We attempted to develop a strategy to minimize the risk of these unknowns. Patients had a nasopharyngeal swab collected for RT-PCR 5 days and 48 hours before a procedure, along with a chest CT scan 48 hours before a procedure. Patients receiving chemotherapy had a single nasopharyngeal swab 48 hours before chemotherapy. Using this approach, we were able to provide safe care for patients who did not meet traditional guidance for testing and protect our health care workers from exposure.

Our initial experience in screening asymptomatic patients undergoing unrelated semiurgent hospital procedures provided mixed results. The dual screening approach (chest CT scan in addition to RT-PCR) did not provide additional value. In a series of 628 patients who underwent dual screening, only 1 case of COVID-19 was identified, and that patient already had a positive test result by RT-PCR. On the basis of this experience, we omitted CT imaging from the next version of our screening protocol. We similarly saw no additional benefit of RT-PCR on day 5 before surgery, so we eliminated that screening and now screen patients via RT-PCR only once, 48 hours before a procedure.

Another challenge Mayo Clinic faced was in the care of patients hospitalized for non−COVID-19 illnesses who were discharged to congregate living facilities, including nursing homes. Our approach has been to defer to the policies of the individual congregate care facility. However, this approach may change as we learn more about this rapidly evolving situation. At present, if the receiving facility requires additional testing, patients have another RT-PCR test 48 hours before discharge to the facility.

Mayo Clinic Laboratories have continued to develop greater testing capacity, but as in institutions elsewhere in the country, this capacity could be quickly consumed without a comprehensive strategy for rational utilization targeted at areas of highest need. The real-time practice group helped with guidance in this situation. The ordering and approval of RT-PCR testing was limited to a team from infectious diseases for patients who were hospitalized (and not tested) for more than 24 hours or who had recent negative test results. In so doing, we hoped to encourage earlier testing of hospitalized patients to limit exposures of health care workers and to minimize low-yield repeat testing. For outpatients, we established systems to restrict ordering to predefined locations, which are managed by general internal medicine staff in conjunction with infectious disease specialists.

The task force has various projects underway or planned, and challenges remain. Currently, we are evaluating outpatient data with the goal of potentially modifying and enhancing our testing criteria and algorithms. A future project will assess the use of broad-spectrum antibacterial agents for patients with COVID-19 to determine effects on patient outcomes and to ensure proper antimicrobial stewardship. Serologic studies have presented new challenges in diagnosis. Currently, serologic testing can be used to help identify previously infected individuals and to facilitate contact tracing; however, its other uses, such as for risk stratification, remain less clear and are active areas of work for the task force.

The task force has made our testing guidelines available in the decision support tool "AskMayoExpert" for both internal and external users (https://askmayoexpert.mayoclinic.org/navigator/covid-19?nocmcache=si&_ga=2.85660316.44375615.1589219577-708962653.1589219577) and will continue to update this guidance regularly. In the future, it will be important to develop more nuanced testing strategies that account for pretest probability and local disease prevalence (once these factors are more clearly known) and that also consider patients' individual risk factors and demographic characteristics. These new strategies and information for appropriate use of testing will be particularly important in planning for a potential second wave of COVID-19 cases even as regional and national case numbers

Mayo Clin Proc. ■ September 2020;95(9S):S17-S19 ■ https://doi.org/10.1016/j.mayocp.2020.05.039
www.mayoclinicproceedings.org

decline after the first wave of the COVID-19 pandemic.

ACKNOWLEDGMENTS

Editing, proofreading, and reference verification were provided by Scientific Publications, Mayo Clinic.

This supplement is sponsored by Mayo Clinic Foundation for Medical Education and Research and is authored by experts from multiple Departments and Divisions at Mayo Clinic.

Potential Competing Interests: Dr O'Horo serves as a consultant for Elsevier (outside the submitted work). Dr Binnicker is an advisory board member of DiaSorin Molecular and received payment for presentation of an educational webinar from Abbott Molecular (outside the submitted work). Dr Berbari has received consulting fee or honorarium from *UpToDate*. The other authors report no competing interests.

Correspondence: Address to Aditya S. Shah, MBBS, Division of Infectious Diseases, Mayo Clinic, 200 First St SW, Rochester, MN 55905 (shah.aditya@mayo.edu; Twitter: @IDdocAdi).

ORCID

Aditya S. Shah: https://orcid.org/0000-0002-2023-394X; Aaron J. Tande: https://orcid.org/0000-0001-9775-7082; Douglas W. Challener: https://orcid.org/0000-0002-6964-9639; John C. O'Horo: https://orcid.org/0000-0002-0880-4498

REFERENCES

1. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet*. 2020;395(10223):497-506.
2. WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020. World Health Organization website. https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19—11-march-2020. Accessed May 7, 2020.
3. Shah A, Kashyap R, Tosh P, Sampathkumar P, O'Horo JC. Guide to understanding the 2019 novel coronavirus. *Mayo Clin. Proc.* 2020;95(4):646-652.
4. Critical preparedness, readiness and response actions for COVID-19. World Health Organization website. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/critical-preparedness-readiness-and-response-actions-for-covid-19. Accessed May 7, 2020.
5. Shah A, Challener D, Tande AJ, et al. Drive-through testing: a unique, efficient method of collecting large volume of specimens during the SARS-CoV-2 (COVID-19) pandemic. *Mayo Clin Proc*. 2020;95(7):1420-1425.
6. Aguilar JB, Faust JS, Westafer LM, Gutierrez JB. A model describing COVID-19 community transmission taking into account asymptomatic carriers and risk mitigation [published online ahead of print August 11, 2020]. *medRxiv*, https://doi.org/10.1101/2020.03.18.20037994.
7. Bai Y, Yao L, Wei T, et al. Presumed asymptomatic carrier transmission of COVID-19. *JAMA*. 2020;323(14):1406-1407.
8. COVID-19 in Iceland — Statistics from 7 May 2020. The Directorate of Health and The Department of Civil Protection and Emergency Management. https://www.covid.is/data. Accessed May 7, 2020.
9. Gandhi M, Yokoe DS, Havlir DV. Asymptomatic transmission, the Achilles' heel of current strategies to control Covid-19. *N Engl J Med*. 2020;382(22):2158-2160.