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COVID-19 Testing in the Era of Modern Neurosurgery: Mitigating Risk in Our Vulnerable Patient Populations

Daniel M. Aaronson[1], David M. Poetker[2], Christopher M. Long[2], Nathan T. Zwagerman[1]

■ BACKGROUND: **The respiratory illness identified as coronavirus disease 2019 (COVID-19) has resulted in a pandemic illness that has changed the face of healthcare. As the COVID-19 pandemic continues, patients have continued to require neurosurgical interventions, and the endoscopic endonasal approach for surgery has continued to be a mainstay treatment of pituitary tumors and anterior skull base lesions.**

■ METHODS: **We sought to highlight the current lack of recommendations regarding testing protocols for neurosurgical patients.**

■ RESULTS: **We implemented a novel testing protocol for our patient populations at increased risk and have proposed a model that can be used at other institutions to mitigate the risk of complications associated with some forms of COVID-19 testing.**

■ CONCLUSION: **Patients with anterior skull base defects may be at risk with current COVID-19 testing protocols, and may benefit from alternative specimen collection strategies.**

INTRODUCTION

The respiratory illness identified as coronavirus disease 2019 (COVID-19) was declared a pandemic by the World Health Organization (WHO) in March 2020.[1] COVID-19 is caused by SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2). The Centers for Disease Control and Prevention (CDC) has identified >7 million cases with >200,000 deaths from COVID-19 as of September 29, 2020.[2] The demographics of the disease have continued to shift, with more recent reports showing increasing case counts in young adults.[3] As the COVID-19 pandemic has continued, patients have continued to require neurosurgical interventions, and the endoscopic endonasal approach (EEA) for surgery has continued to be a mainstay treatment of pituitary tumors and anterior skull base lesions. We identified our EEA patients, in addition to other neurosurgical populations, as a subset of patients vulnerable to possible intracranial damage resulting from the current standards for COVID-19 testing. We then implemented a novel testing protocol for our patient populations at increased risk and have proposed a model that can be used at other institutions to reduce the risk of complications associated with COVID-19 testing.

CURRENT STRATEGIES AND TESTING PROTOCOL

Various public health strategies have been used by different countries in attempts to stem the spread of COVID-19. Paramount to most containment strategies has been the widespread availability of accurate testing.[4-9] In the early stages of the COVID-19 pandemic, the CDC advised that the preferred method of specimen collection was the nasopharyngeal (NP) swab,[10] with the recommendation echoed by the WHO.[11] By April 29, 2020, the CDC had altered the language of their guidelines for specimen collection to remove the preference for NP swabs and listing collection guidelines for nasal mid-turbinate (NMT) swabs and anterior nares (AN) specimens. As of October 8, 2020, the guidelines also included language for the collection of oral saliva specimens. The most current guidelines from the WHO still recommend a combined NP and oropharyngeal swab specimen for most patients.[12] At our own institution, NP swabs were still the standard of care for specimen collection in many patient settings, although the desire to switch to primary NMT swabs had been previously expressed.

Key words
- Cerebrospinal fluid leak
- COVID-19
- Endoscopic endonasal approach
- SARS-CoV-2
- Transsphenoidal

Abbreviations and Acronyms
AN: Anterior nares
CDC: Centers for Disease Control and Prevention
COVID-19: Coronavirus disease 2019
EEA: Endoscopic endonasal approach
NMT: Nasal mid-turbinate
NP: Nasopharyngeal
WHO: World Health Organization

From the Departments of [1]Neurosurgery and [2]Otolaryngology and Communication Sciences, Medical College of Wisconsin, Milwaukee, Wisconsin, USA

To whom correspondence should be addressed: Daniel M. Aaronson, M.D. [E-mail: daaronson@mcw.edu]

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CURRENT STATE OF THE LITERATURE

Existing studies of the COVID-19 pandemic in relation to patients undergoing anterior skull base surgery are sparse. The current literature in peer-reviewed journals has included descriptions of triaging of patients best treated with an EEA,[13-15] the recommended personal protective equipment for surgeons performing EEA surgery,[16-20] case reports of COVID-19–positive patients who had undergone an EEA,[21,22] a compendium of anecdotes from physician teams around the world,[23] and studies that sought to quantify the aerosolization patterns during endoscopic instrumentation.[24-26] To the best of our knowledge, no currently reported studies have described COVID-19 testing protocols nor highlighted the risks involved for patients who have previously undergone an EEA or have other anterior skull base defects.

DISCUSSION

COVID-19 is a global pandemic that has posed many unique challenges to the medical community and the world at large. As the rates have continued to increase in many areas of the world and as the capacity for testing has expanded, it has become clear that testing for COVID-19 has become a mainstay in our ability to provide medical care to our patients. Many hospitals routinely test for COVID-19 before all inpatient admissions and elective surgical procedures and for pregnant women admitted to labor and delivery units.[27,28] With no definite end to the pandemic in sight and uncertain timing regarding the widespread delivery of a vaccine in our future, we should expect COVID-19 testing to continue to be a part of routine patient care. Various testing methods exist, and although the best testing specimen collection strategy is still under debate, respiratory tract specimens have been shown to have the highest levels of detection of SARS-CoV-2.[29] Oral saliva samples are being examined more closely, and although the initial evaluations have been promising,[30-32] these tests have not been accepted for widespread use in most hospital settings.

With the current testing strategies in place, we must also be mindful of the anatomic considerations and possible complications of specimen collection to test for COVID-19. The current NP collection recommendations from the CDC are to be performed "through the nostril parallel to the palate … until resistance is encountered or the distance is equivalent to that from the ear to the nostril of the patient, indicating contact with the nasopharynx. The swab should reach a depth equal to the distance from the nostrils to the outer opening of the ear."[33] With many tests performed still with NP collection, we theorized that this specimen collection method could result in the depth required to traverse the skull base and for the swab to cross into the intracranial space in the case of a patient with skull base defects. These defects could be congenital, acquired as the result of trauma or tumor erosion through bony structures, or iatrogenic through either nasal or skull base surgery. Injury can occur through the cribriform plate, sphenoid sinus, or, even, the clivus. Such injuries can result in a cerebrospinal fluid leak, parenchymal damage to brain tissue itself, or vascular damage, leading to hemorrhage or stroke.

We do not believe these concerns to be unfounded, because a strong record exists in the literature of intracranial complications resulting from intranasal interventions in the course of treatment for patients with skull base defects. These complications have usually resulted from inadvertent intracranial nasogastric tube insertion in patients who have either undergone an EEA[34-38] or other intranasal procedures[39] or after trauma with skull base fractures.[40,41] In the case of intracranial nasogastric insertion, however, the diagnosis can be made rapidly with intracranial imaging studies using either skull radiography or computed tomography, because the nasogastric tubes will usually be left in place. The additional danger with NP testing is that the injury can be caused transiently, with immediate removal of the offending foreign body, which could make detection and diagnosis more difficult. Close to the time of the submission of our article, the first case of a cerebrospinal leak as a result of routine COVID-19 testing before an elective surgery in a patient with a remote history of nasal surgery was reported.[42]

It has been reported that significant rationing of neurosurgical services occurred at the onset of the pandemic, with ≤80% of institutions reporting a decrease in their ability to provide services,[43] with those centers with lower resources before the pandemic most affected. These included hospitals that reported an inability to provide neurosurgical care to all patients with legitimate medical need and, even, cases of neurosurgical emergencies that went untreated.[43] Owing to the ongoing need for neurosurgical care during the pandemic, in our tertiary care setting, which includes our level 1 trauma center, we implemented the following testing guidelines to mitigate the risk in our vulnerable patient populations and minimize the delay in medically indicated care:

1. Trauma patients who arrive intubated or are intubated soon after arrival who require routine testing before admission
   A. Should undergo only NMT, AN, or oral saliva testing per acceptable institutional protocols, unless the report of the computed tomography scan of the head is available and has excluded the diagnosis of skull base fractures
2. Trauma patients with confirmed skull base fractures
   A. Should undergo only NMT, AN, or oral saliva testing per acceptable institutional protocols
3. Postoperative anterior skull base patients and patients who have undergone EEA
   A. Should receive formal education on COVID-19 testing postoperatively
   B. No COVID-19 testing should be performed during the first 2 weeks after skull base surgery
   C. After week 2, only NMT, AN, or oral saliva testing per acceptable institutional protocols should be used
   D. After week 6, assuming complete healing has been confirmed via endoscopy, any test method is appropriate
4. Preoperative anterior skull base patients and patients who will undergo EEA with identified bony erosion
   A. Only NMT, AN, or oral saliva testing should be used per acceptable institutional protocols
5. In these patient populations with a high clinical suspicion of COVID-19 for whom a NP swab collection has been requested after NMT, AN, or oral saliva testing has resulted in a negative test
   A. Consultation should be made with a qualified ear, nose, and throat surgeon to consider performing NP testing under direct endoscopic visualization

CONCLUSIONS

As the COVID-19 pandemic continues to be a public health crisis, testing has continued to be paramount to management strategies. As testing has become more ubiquitous in multiple healthcare settings, it is imperative to identify and protect those patient populations that might be at risk of complications from some of the current specimen collection protocols for testing for COVID-19. We identified multiple patient populations that could have anterior skull base defects and recommend alternative specimen collection strategies, including NMT, anterior nasal, and/or oral saliva testing be used for these patients to prevent the serious complications that can arise.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Daniel M. Aaronson: Conceptualization, Writing — original draft, Writing — review & editing. **David M. Poetker:** Writing — review & editing. **Christopher M. Long:** Writing — review & editing. **Nathan T. Zwagerman:** Supervision, Writing — review & editing.

REFERENCES

1. Cucinotta D, Vanelli M. WHO declares COVID-19 a pandemic. *Acta Biomed*. 2020;91:157-160.
2. Centers for Disease Control and Prevention. COVID Data Tracker. Coronavirus Disease 2019 (COVID-19) in the U.S. 2020. Available at: https://covid.cdc.gov/covid-data-tracker/?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fcases-updates%2Fcases-in-us.html#cases_casesinlast7days. Accessed September 28, 2020.
3. Salvatore PP, Sula E, Coyle JP, et al. Recent increase in COVID-19 cases reported among adults aged 18-22 years—United States, May 31-September 5, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69:1419-1424.
4. Gandhi M, Yokoe DS, Havlir DV. Asymptomatic transmission, the Achilles' heel of current strategies to control COVID-19. *N Engl J Med*. 2020;382:2158-2160.
5. Mina MJ, Parker R, Larremore DB. Rethinking COVID-19 test sensitivity—a strategy for containment. *N Engl J Med*. 2020;383:e120.
6. World Health Organization. COVID-19 Strategic Preparedness and Response Plan: Operational Planning Guidelines to Support Country Preparedness and Response. Available at: https://www.who.int/docs/default-source/coronaviruse/covid-19-sprp-unct-guidelines.pdf. Accessed September 28, 2020.
7. Salathe M, Althaus CL, Neher R, et al. COVID-19 epidemic in Switzerland: on the importance of testing, contact tracing and isolation. *Swiss Med Wkly*. 2020;150:w20225.
8. Tromberg BJ, Schwetz TA, Perez-Stable EJ, et al. Rapid scaling up of COVID-19 diagnostic testing in the United States—the NIH RADx Initiative. *N Engl J Med*. 2020;383:1071-1077.
9. Walker P, Whittaker C, Watson O, et al. *Imperial College COVID-19 Response Team. Report 12: The Global Impact of COVID-19 and Strategies for Mitigation and Suppression*. London, UK: Imperial College London; 2020. Available at: https://doi.org/10.25561/77735. Accessed September 28, 2020.
10. Centers for Disease Control and Prevention. Coronavirus Disease 2019 (COVID-19). Available at: http://web.archive.org/web/20200427153311/https://www.cdc.gov/coronavirus/2019-nCoV/lab/guidelines-clinical-specimens.html. Accessed September 28, 2020.
11. World Health Organization. Laboratory testing of 2019 novel coronavirus (2019-nCoV) in suspected human cases: interim guidance. Available at: https://www.who.int/publications/i/item/10665-331501. Accessed September 28, 2020.
12. World Health Organization. Diagnostic testing for SARS-CoV-2: interim guidance, 11 September 2020. Available at: https://www.who.int/publications/i/item/diagnostic-testing-for-sars-cov-2. Accessed September 28, 2020.
13. Turri-Zanoni M, Battaglia P, Karligkiotis A, Locatelli D, Castelnuovo P. Managing care for patients with sinonasal and anterior skull base cancers during the COVID-19 pandemic. *Head Neck*. 2020;42:1503-1506.
14. Ramakrishna R, Zadeh G, Sheehan JP, Aghi MK. Inpatient and outpatient case prioritization for patients with neuro-oncologic disease amid the COVID-19 pandemic: general guidance for neuro-oncology practitioners from the AANS/CNS Tumor Section and Society for Neuro-Oncology. *J Neurooncol*. 2020;147:525-529.
15. Penner F, Grottoli S, Lanotte MMR, Garbossa D, Zenga F. Pituitary surgery during COVID-19: a first hand experience and evaluation. *J Endocrinol Invest*. 2021;44:635-636.
16. Solari D, Bove I, Esposito F, Cappabianca P, Cavallo LM. The nose lid for the endoscopic endonasal procedures during COVID-19 era: technical note. *Acta Neurochir (Wien)*. 2020;162:2335-2339.
17. Maharaj SH. The nasal tent: an adjuvant for performing endoscopic endonasal surgery in the COVID era and beyond. *Eur Arch Otorhinolaryngol*. 2020;277:2929-2931.
18. Helman SN, Soriano RM, Tomov ML, et al. Ventilated upper airway endoscopic endonasal procedure mask: surgical safety in the COVID-19 era. *Oper Neurosurg (Hagerstown)*. 2020;19:271-280.
19. D'Amico RS, Khatri D, Kwan K, et al. Coronavirus neurosurgical/head and neck drape to prevent aerosolization of coronavirus disease 2019 (COVID-19): the Lenox Hill Hospital/Northwell health solution. *World Neurosurg*. 2020;142:314-317.
20. Mattogno P, Rigante M, Lauretti L, et al. Transnasal endoscopic skull base surgery during COVID-19 pandemic: algorithm of management in an Italian reference COVID center. *Acta Neurochir*. 2020;162:1783-1785.
21. Zhu W, Huang X, Zhao H, Jiang X. A COVID-19 patient who underwent endonasal endoscopic pituitary adenoma resection: a case report. *Neurosurgery*. 2020;87:E140-E146.
22. Talmor G, Grube JG, Eloy JA, Liu JK, Hsueh WD. Nasoseptal flap necrosis after endoscopic skull base surgery in the setting of COVID-19 pandemic. *World Neurosurg*. 2020;140:374-377.
23. Patel ZM, Fernandez-Miranda J, Hwang PH, et al. Precautions for endoscopic transnasal skull base surgery during the COVID-19 pandemic. *Neurosurgery*. 2020;87:E66-E67.
24. Sharma D, Rubel KE, Ye MJ, et al. Cadaveric simulation of endoscopic endonasal procedures: analysis of droplet splatter patterns during the COVID-19 pandemic. *Otolaryngol Head Neck Surg*. 2020;163:145-150.
25. Murr AT, Lenze NR, Gelpi MW, et al. Quantification of aerosol concentrations during endonasal instrumentation in the clinic setting. *Laryngoscope*. 2021;131:E1415-E1421.
26. Murr A, Lenze NR, Brown WC, et al. Quantification of aerosol particle concentrations during endoscopic sinonasal surgery in the operating room [e-pub ahead of print]. *Am J Rhinol Allergy* https://doi.org/10.1177/1945892420962335, accessed September 28, 2020.
27. Johnson JD, Melvin E, Srinivas SK, et al. COVID-19 testing, personal protective equipment, and staffing strategies vary at obstetrics centers across the country. *Am J Perinatol*. 2020;37:1482-1484.
28. Sutton D, Fuchs K, D'Alton M, Goffman D. Universal screening for SARS-CoV-2 in women admitted for delivery. *N Engl J Med*. 2020;382:2163-2164.
29. Boger B, Fachi MM, Vilhena RO, Cobre AF, Tonin FS, Pontarolo R. Systematic review with meta-analysis of the accuracy of diagnostic tests for COVID-19. *Am J Infect Control*. 2021;49:21-29.
30. Azzi L, Carcano G, Gianfagna F, et al. Saliva is a reliable tool to detect SARS-CoV-2. *J Infect*. 2020;81:e45-e50.
31. Procop GW, Shrestha NK, Vogel S, et al. A direct comparison of enhanced saliva to

nasopharyngeal swab for the detection of SARS-CoV-2 in symptomatic patients. *J Clin Microbiol*. 2020;58:e01946-20.

32. Rao M, Rashid FA, Sabri F, et al. Comparing nasopharyngeal swab and early morning saliva for the identification of SARS-CoV-2. *Clin Infect Dis*. 2021:e352-e356.

33. Centers for Disease Control and Prevention. Information for Laboratories About Coronavirus (COVID-19). Available at: https://www.cdc.gov/coronavirus/2019-ncov/lab/guidelines-clinical-specimens.html. Accessed September 29, 2020.

34. Bhattacharyya N, Gopal HV. Examining the safety of nasogastric tube placement after endoscopic sinus surgery. *Ann Otol Rhinol Laryngol*. 1998;107:662-664.

35. Guerra B, Slade TL, Kelly PJ. Intracranial introduction of a nasogastric tube in a patient with a pituitary tumor. *Surg Neurol*. 1979;12:135-136.

36. Hande A, Nagpal R. Intracranial malposition of nasogastric tube following transnasal transsphenoidal operation. *Br J Neurosurg*. 1991;5:205-207.

37. Hanna AS, Grindle CR, Patel AA, Rosen MR, Evans JJ. Inadvertent insertion of nasogastric tube into the brain stem and spinal cord after endoscopic skull base surgery. *Am J Otolaryngol*. 2012;33:178-180.

38. Zhang X, Ji T, Chen L, Yang J, Huang G. Nasogastric tube feeding into brain after endoscopic endonasal transsphenoidal surgery. *World Neurosurg*. 2019;132:4-6.

39. Obiorah S, Moldovan K, Doberstein C. Intracranial insertion of a nasogastric tube following septoplasty: case report and literature review. *Interdisciplinary Neurosurgery*. 2020;22:100879.

40. Chandra R, Kumar P. Intracranial introduction of a nasogastric tube in a patient with severe craniofacial trauma. *Neurol India*. 2010;58:804-805.

41. Roka YB, Shrestha M, Puri PR, Aryal S. Fatal inadvertent intracranial insertion of a nasogastric tube. *Neurol India*. 2010;58:802-804.

42. Sullivan CB, Schwalje AT, Jensen M, et al. Cerebrospinal fluid leak after nasal swab testing for coronavirus disease 2019. *JAMA Otolaryngol Head Neck Surg*. 2020;146:1179-1181.

43. Mathiesen T, Arraez M, Asser T, et al. A snapshot of European neurosurgery December 2019 vs. March 2020: just before and during the COVID-19 pandemic. *Acta Neurochir*. 2020;162:2221-2233.

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