

A Framework for Maintaining a Fully Operational Autopsy Service at a Large Academic Teaching Institution During a Global Pandemic

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Abstract

The COVID-19 pandemic created new challenges in health care, and pathology departments have led with innovations in testing and education. While the medical community and public showed great interest in gross and histologic findings in COVID-affected patients, paradoxically many autopsy services nationwide closed due to uncertainties surrounding the proximity to infected patient tissue, shortages in personal protective equipment, and pressures to discontinue perceived nonessential hospital operations. These disruptions furthermore negatively impacted pathology trainee education. The autopsy division at Northwestern Memorial Hospital, with the belief that a fully functioning autopsy service is especially crucial at this time, adopted a framework for continuing at full capacity for both clinical care and education. New operations were modeled on national protocols by the Centers for Disease Control and Prevention and the College of American Pathologists, and the service continually adjusted policies to reflect rapidly changing guidelines and feedback from trainees and staff. Between January and December 2020, we performed 182 adult autopsies including 45 COVID-19 autopsies. Twelve residents, 4 staff, and 5 attendings rotated through the service. In exit interviews, participants expressed: (1) improved comfort managing both COVID-related and general autopsies; (2) sense of personal safety on service (despite the increased risk of exposure); (3) belief that both COVID-related and general autopsies contributed to their personal education and to the medical community. There have been zero known autopsy-related COVID-19 infections to date. We hope that our innovative autopsy service restructuring can serve as a framework for other academic programs during the current and in future pandemics.

Keywords

COVID-19, autopsy, academic, resident, pandemic, education

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Introduction

The first officially recognized case of novel coronavirus SARS-CoV-2 infection in the United States was announced in Washington state on January 21, 2020.¹ On January 23rd, a second case was recognized in Illinois; this case led to the first known person-to-person transmission, from patient to her husband, who had not travelled outside the United States.² On January 30th, the World Health Organization (WHO) declared a Global Health Emergency,³ and one day later, Alex Azar, Secretary of Health and Human Services, declared a public health emergency in the United States, effective at 5 PM on

February 2nd.⁴ On March 11th, the WHO recognized COVID-19, the illness caused by SARS-CoV-2, as a global pandemic.⁵

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At Northwestern Memorial Hospital (NMH) in Chicago, Illinois, we watched the developing pandemic with an eye toward how this would impact both patient care and residency education. Northwestern Memorial Hospital is the flagship hospital of the Northwestern Medicine (NM) health system which serves patients at over 200 sites across the Chicago region. This 894-bed academic medical center is the primary teaching affiliate for the Feinberg School of Medicine and hosts 27 medical residency programs including the Northwestern Pathology Residency Program. All anatomic pathology residents rotate through the busy autopsy service at NMH, which performs approximately 300 autopsies a year, including perinatal, adult, and limited cases from across all 10 NM-affiliated hospitals.⁶

In February of 2020, as COVID-19 continued to spread across the globe and as we saw its early impact in the Chicago region, we began ongoing conversations regarding how, and if, to adapt our autopsy service to include the performance of autopsies on decedents infected or possibly infected by SARS-CoV-2. This process involved ongoing conversations with autopsy staff (pathologists assistants and autopsy technicians), attending autopsy pathologists and neuropathologists, departmental and residency leadership, hospital leadership, and residents. In addition, our patient-facing colleagues from Pulmonary and Critical Care medicine began to inquire whether we could provide them with additional insight into the pathophysiology of the very ill patients they were treating in the medical intensive care unit.

Important considerations discussed included the adequacy of our autopsy facilities, the system-wide availability of personal protective equipment (PPE), and our ability to protect the safety of staff, residents, and attending physicians. Additionally, our autopsy service is actively engaged in the acquisition of central nervous system tissue for neurodegenerative research and tumor banking. Locally, the majority of autopsy services temporarily shut down; if we were unable to remain open, we would have had difficulty honoring the wishes of research participants to include their brain and/or spinal cord tissue in ongoing studies and tissue banks.

Materials and Methods

Objectives

In light of the clinical uncertainties surrounding the COVID-19 pandemic, safety guidelines emphasizing minimizing exposure risk, and rapid changes to everyday practice, our aims were to: (1) evaluate the need for an active autopsy service during the public health crisis, (2) develop an evidence-based assessment for the safety and feasibility of accommodating COVID-19 autopsy cases at our institution, (3) obtain trainee and staff feedback to ensure consensus regarding the perception of safety and educational and clinical value of performing these autopsies.

Review of Current Guidelines

An extensive review of current global and national guidelines included: the World Health Organization's (WHO) "Infection Prevention and Control for the safe management of a dead body in the context of COVID-19," the Centers for Disease Control and Prevention's (CDC) "Collection and Submission of Post-mortem Specimens from Deceased Persons with Known or Suspected COVID-19," the CDC's "Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Settings (2007)," and the College of American Pathologists's (CAP) "COVID-19 Autopsy Guideline Statement from the CAP Autopsy Committee."⁷⁻¹⁰

Review of Institutional Capabilities

Information regarding the specific engineering design of the Northwestern Memorial Hospital autopsy suite was obtained from Facilities Management and compared to the CDC and WHO guidelines.

Communication Within and Outside of Autopsy Division

Multiple meetings were arranged between all autopsy and neuropathology attendings as well as autopsy staff and management to discuss the feasibility of maintaining the autopsy service and the needed changes to the Standard Operating Procedure (SOP). As each change to the SOP was introduced, a written updated SOP was approved by the attending pathologists.

We had an open dialogue with residents rotating on the autopsy service during the initial transition period to assess trainees' attitudes, concerns, and questions regarding performing autopsies during the pandemic. After preliminary discussions and assessments were completed within the division, Autopsy Division leadership presented the proposed changes to the pathology residents en masse by a virtual Zoom conference (Zoom Video Communications, Inc., Version 5.0.2). Trainees were made aware of all changes in a comprehensive and systematic fashion. Further concerns and questions were addressed at the end of the presentation in an open forum.

Evaluation of Resident Experience

An Autopsy Exit Survey was distributed to residents rotating on the autopsy service during the pandemic who were affected by changes to the workflow. The survey was hosted and responses were anonymously collected on Microsoft Forms.¹¹ Questions tracked how many cases (both typical autopsies and COVID-19 autopsies) residents performed and asked trainees to rate their confidence, sense of safety, and perceptions about autopsy while on service during the pandemic.

Statistical Analyses

The data analyses and visualizations were conducted using Excel (Microsoft Office Professional Plus 2019/2016 Products,

Version 16.43) and the R programming language, specifically packages: tidyverse, readxl, janitor, lubridate, ggthemes, and RColorBrewer.¹² Calculations included simple summary statistics (mean, median, range) as well as Student *t* test.

Results

Despite the possible exposure risk and recommendations to socially distance, it was clear from review of the national guidelines and assessment of our own clinical and research obligations that it would be possible and even necessary to maintain the autopsy service at NMH. College of American Pathologists' COVID-19 autopsy statement reiterated the importance of autopsy, specifically during the pandemic, as it may provide crucial information about the pathophysiology of a novel disease and help guide therapy and clinical management. By March of 2020, treating physicians in the Division of Pulmonary and Critical Care Medicine expressed strong interest in any information we could glean from autopsy to help in the difficult management of their critically ill patients. Not directly related to COVID-19, our neuropathology service relies on the support of autopsy staff, facilities, and equipment for acquiring central nervous system samples for neurodegenerative research and tumor banking. The CAP guidelines emphasize that any institution deciding to suspend autopsy services should find a local alternative so that vital services can continue to serve patients, their families, and the health care system at large. The Autopsy Division at NMH already served as the consultation center for multiple satellite NM-affiliated hospitals. A discontinuation of our autopsy division would have precluded the completion of hospital autopsies and the collection of research tissue for the patients of NMH and a large portion of patients in the Chicago region, limiting both resident education and the possible elucidation of COVID-19 pathophysiology that could benefit the medical community at large.

As it became clear in March of 2020 that COVID-19 autopsy cases were likely to be requested, attending pathologists discussed the logistics of performing these crucial autopsies. The current literature and capabilities of our facilities were reviewed. World Health Organization, CDC, and CAP guidelines highlighted minimal requirements for autopsy facilities, equipment, and PPE necessary for the performance of COVID-19 autopsies. Additional recommendations for preprocedural changes, changes to the typical autopsy procedure, and additional testing were also outlined. Upon review, it was determined that the facilities, equipment, and PPE supply used by the NMH Autopsy Division actually already exceeded the requirements outlined by national and international guidelines (Table 1).

Importantly, NMH had the benefit of an autopsy suite which more than met the minimum safety requirements recommended by the CDC and WHO. The suite itself is negative pressure compared to the surrounding rooms and spaces, and there are 16.5 air exchanges per hour. The autopsy suite air is 100% exhausted to the outside through a dedicated lab exhaust

system located on the roof of the building, and the air supply is 100% outside air provided through high-efficiency particulate air filtering. In addition, the air distribution system of the autopsy suite is designed to create a form of laminar flow, with a column of air directed toward the decedent and away from staff (Table 1).

Autopsy faculty, trainees, and staff continued strict PPE use including: surgical scrubs, surgical caps, shoe covers, waterproof gown, double gloves, and full face shield. N95 masks were worn for all autopsy cases. No specific safety modifications to non-COVID-19 autopsy procedures were made since all personnel were in appropriate PPE for all cases and to minimize unnecessary disruptions to autopsy operations (Table 1).

COVID-19 autopsies were performed with great caution. A precautionary sign was posted on the door of the autopsy suite during COVID-19-specific procedures. Personnel was limited to one technologist, one pathologist assistant, one resident, and one attending pathologist; additional residents and students were permitted in non-COVID-19 cases only. Craniotomy and brain examination as well as spinal cord removal were deferred out of concern of generating aerosolized particles; examination of the entire surface of the intestinal mucosa was only performed if it was deemed directly related to the cause of death because of reports of COVID-19-related gastrointestinal symptoms; lungs were removed and fixed in formalin for 24 to 48 hours prior to serial sectioning and examination in order to minimize exposure (Table 2).

These initial comprehensive restrictions were quickly adopted but continually evaluated as understanding of the virus evolved. After discussion between autopsy and neuropathology faculty, the importance of a thorough examination of the brain was appreciated in light of the prevalence of anosmia in COVID-19 patients and increasing reports of neuropsychiatric symptoms. Shortly thereafter, our Creutzfeldt-Jakob Disease autopsy brain protocol was adapted and used on COVID-19 decedents. A plastic head tent was used for removal of the brain in COVID-19 cases, with only one staff member present at time of brain removal. However, the risk of aerosolization during spine removal continues to be deemed too high, and spinal cords are not removed in COVID-19 cases (Table 2).

Routine sampling of all major organs continued, including: routine sampling of heart, trachea, lung, pulmonary lymph nodes, thyroid, aorta, kidneys, spleen, liver, gallbladder, pancreas, small and large bowel, gonads, bone, skin, muscle, and breast. Routine brain sections were collected at the discretion of neuropathology. In COVID-19 cases, we performed more comprehensive lung sampling including 2 sections per lobe (10 sections total) with additional sections of pulmonary emboli or other lesions. Small and large bowel sections were predominantly deferred in COVID-19 cases. Beginning in May of 2020, tissue from a subset of cases was collected for frozen tissue banking (for potential future research), including rolled sections of leptomeninges, right frontal cortex, pons, right mesial temporal lobe, right bronchus, left bronchus, lung, left ventricle of the heart, small bowel, large bowel, liver, pancreas,

Table 1. Assessing Guidelines for Facilities and Equipment for COVID-19 Autopsies.

	WHO guidelines	CDC guidelines	CAP guidelines	NMH capacity/practice
Facilities	<ul style="list-style-type: none"> Natural ventilation, ≥ 160 L/s/patient air flow or Negative pressure rooms with 12 ACH and controlled direction of air flow 	<ul style="list-style-type: none"> AIRs: (1) negative pressure to surrounding areas, (2) min 6 ACH for existing structures and 12 ACH for renovated/new structures, and (3) air exhausted directly outside or through a HEPA filter Certified Class II Biosafety Cabinet 	<ul style="list-style-type: none"> per CDC guidelines and: Confirm functioning of all engineering controls 	<ul style="list-style-type: none"> Negative pressure room, 16.5 ACH Room air exhausted to the outdoors, supply air 100% from outside through HEPA filtering Laminar air flow toward decedent and away from staff Updated facilities with adequate lighting and surfaces
Equipment	<ul style="list-style-type: none"> Adequate lighting Easily-disinfected surfaces and instruments 	<ul style="list-style-type: none"> Surgical scrubs, shoe covers, and surgical cap Fluid-resistant or impermeable isolation gown Waterproof apron Double surgical gloves with layer of cut-proof synthetic mesh gloves Goggles or face shield NIOSH-approved disposable N95 or higher respirator 	<ul style="list-style-type: none"> per CDC guidelines and: Assess need for and procure any needed equipment per CDC guidelines and: Document updated fit testing for N95 respirators per OSHA Recommend updated training on personal protective equipment for participating individuals 	<ul style="list-style-type: none"> Surgical scrubs, surgical cap, shoe covers Waterproof gown Double gloves Full face shield, N95 mask with documented fit testing for all participants
Personal protective equipment	<ul style="list-style-type: none"> Scrub suit Long-sleeved fluid-resistant gown Glove (2 pairs or 1 pair autopsy gloves) Face shield (preferable) or goggles Boots N95 			

Abbreviations: ACH, air changes per hour; AIRs, airborne infection isolation rooms; CDC, Centers for Disease Control and Prevention; CAP, College of American Pathologists; HEPA, high-efficiency particulate air; NIOSH, National Institute for Occupational Safety and Health; NMH, Northwestern Memorial Hospital; OSHA, Occupational Safety and Health Administration; WHO, World Health Organization.

Table 2. Assessing Guidelines for Personnel and Procedures for COVID-19 Autopsies.

	WHO guidelines	CDC guidelines	CAP guidelines	NMH capacity/practice
Personnel	<ul style="list-style-type: none"> Minimum number of participants 	<ul style="list-style-type: none"> Minimum number of participants Logbook of all participants of autopsies and cleaning procedures (for future follow-up) 	<ul style="list-style-type: none"> Minimum number of personnel Record of all personnel present for future reference Observers/students should not participate 	<ul style="list-style-type: none"> One technologist, one pathologist assistant, one resident, and one attending pathologist Additional residents and students permitted in non-COVID-19 cases only
Pre-procedure	<ul style="list-style-type: none"> (none given) 	<ul style="list-style-type: none"> (none given) 	<ul style="list-style-type: none"> COVID-19 and PUJ reported to appropriate entity (eg, department of health, local medical examiner/coroner) Medical records of all cases screened for possible features of COVID-19 Communication with clinical team Consent for autopsy (none given) 	<ul style="list-style-type: none"> Review of medical history and autopsy consent for all decedents prior to autopsy Cases with history of COVID-19 reported to the medical examiner Cases with dementia reviewed by neuropathology for possible CJD
Changes to procedure	<ul style="list-style-type: none"> (none given) 	<ul style="list-style-type: none"> Precautionary sign on entry door Avoid AGP, eg, oscillating bone saw or use a vacuum shroud 		<ul style="list-style-type: none"> Precautionary sign posted on door for COVID-19-specific procedures Plastic head tent for removal of brain in COVID-19 cases (only one staff member present) Spinal cords no longer routinely removed Lungs inflated with formalin and fixed for 24 to 48 hours prior to sectioning Mucosal surface of bowel not routinely examined in COVID-19 cases

Abbreviations: AGP, aerosol-generating procedure; CAP, College of American Pathologists; CDC, Centers for Disease Control and Prevention; CJD, Creutzfeldt-Jakob disease; NMH, Northwestern Memorial Hospital; PUJ, person under investigation; WHO, World Health Organization.

Table 3. Assessing Guidelines for Environmental Cleaning and Control for COVID-19 Autopsies.

WHO guidelines	CDC guidelines	CAP guidelines	NMH capacity/practice
<ul style="list-style-type: none"> – Surfaces cleaned with soap and water (or commercially prepared detergent solution) – Instruments cleaned/disinfected immediately after autopsy – After cleaning, disinfect at least 1 minute with a min concentration of 0.1% bleach, or 70% ethanol. OR hospital-grade disinfectant with label claim against emerging viruses, per manufacturer's instructions – Clinical waste handled and disposed of according to legal requirements – Mortuary clean and properly ventilated at all times 	<ul style="list-style-type: none"> – Keep ventilation systems active while cleaning – Clean surface first – Apply EPA-approved disinfectants for use against COVID-19, per manufacturer's instructions 	(none given)	<ul style="list-style-type: none"> – Previously established cleaning protocols examined in light of CDC and WHO recommendations for both product and procedure and found to be adequate – Admission to the suite for 2 hours following COVID-19 autopsy strongly discouraged – COVID-19 autopsies performed as last autopsy of day when feasible

Abbreviations: CAP, College of American Pathologists; CDC, Centers for Disease Control and Prevention; EPA, Environmental Protection Agency; NMH, Northwestern Memorial Hospital; WHO, World Health Organization.

kidney, spleen, and iliopsoas muscle. No additional consent beyond the broad routine autopsy consent was obtained for any cases.

The appropriateness of previously established cleaning protocols was examined in light of CDC and WHO recommendations for both products and procedures and found to be adequate. Admission to the suite for 2 hours following COVID-19 autopsies was strongly discouraged. COVID-19 autopsies were performed as the last autopsy of the day when feasible, followed by terminal cleaning (Table 3).

For each significant change to our SOPs, attendings met remotely to discuss the risks versus benefits of each procedure, and new SOPs were written and universally approved. Disagreement regarding the necessity or safety of performing any procedure, such as brain removal, was considered sufficient to preclude performance of that procedure. However, over the course of several weeks of conversations, SOPs describing the above precautions were agreed upon by all, and our COVID-19 autopsies became standardized.

In keeping with recommendations to perform SARS-CoV-2 testing on all decedents even as testing capabilities were limited nationwide, our autopsy testing protocol evolved quickly throughout the initial stages of the pandemic. At the time of Northwestern's initial cases, commercial test kits, particularly nasopharyngeal swabs, were in limited supply and needed by our patient-facing colleagues. We adopted a modified bronchoalveolar lavage (BAL) technique to obtain fluid samples from decedents' lungs and obtained permission to run these samples alongside clinically obtained samples. At that time, each polymerase-chain reaction run had additional sample capacity, and we felt confident that this usage did not interfere with clinical needs. We started testing all adults at time of autopsy using this modified BAL technique on March 31, 2020. The first clinically diagnosed COVID-19 autopsy case was performed on April 10, 2020, but the patient was not retested at the time of autopsy. On the subsequent 2 COVID-19 cases, the

results of the modified BAL test were compared to premortem testing, and it quickly became apparent that our modified BAL technique had poor sensitivity. By April 17, 2020, our institution had an adequate supply of nasopharyngeal swabs, and the modified BAL technique was discontinued in favor of commercially available testing. We continued to test all adult decedents consented for autopsy, regardless of COVID-19 status at time of death, to capture persons infected but not diagnosed. To date, there has been one positive COVID-19 test result at time of autopsy which was undiagnosed premortem. Of note, fetal and neonatal decedents are not routinely tested except in the context of maternal COVID-19 infection.

Beginning in April of 2020, testing of all decedents was performed using the Abbott ID Now, a point of care nucleic acid detection system with results available within 20 minutes of obtaining specimens. One nasal and one oral swab were obtained on each decedent. Due to the rapid turnaround time, SARS-CoV-2 positivity status was known prior to the start of each case, which assisted in determining the necessary level of safety precautions.

Although clinical and autopsy-specific guidelines support minimizing numbers of people involved in infectious cases, CAP guidelines still maintain that this should not be at the expense of education. Pathology trainees are encouraged to stay involved in all aspects of autopsy operations at their institution due to this rare opportunity to make new discoveries and train in the time of a novel public health crisis. The Northwestern Pathology Residency Program trains 23 residents in anatomic and/or clinical pathology. A minimum of 3 months on the autopsy service is required for anatomic pathology trainees and crucial for accruing the minimum case number for participating in the written board examinations, as well as for sufficient mastery of autopsy in preparation for future independent practice.

In order to communicate the significant change, reaffirm the significance and safety of performing hospital autopsies, and

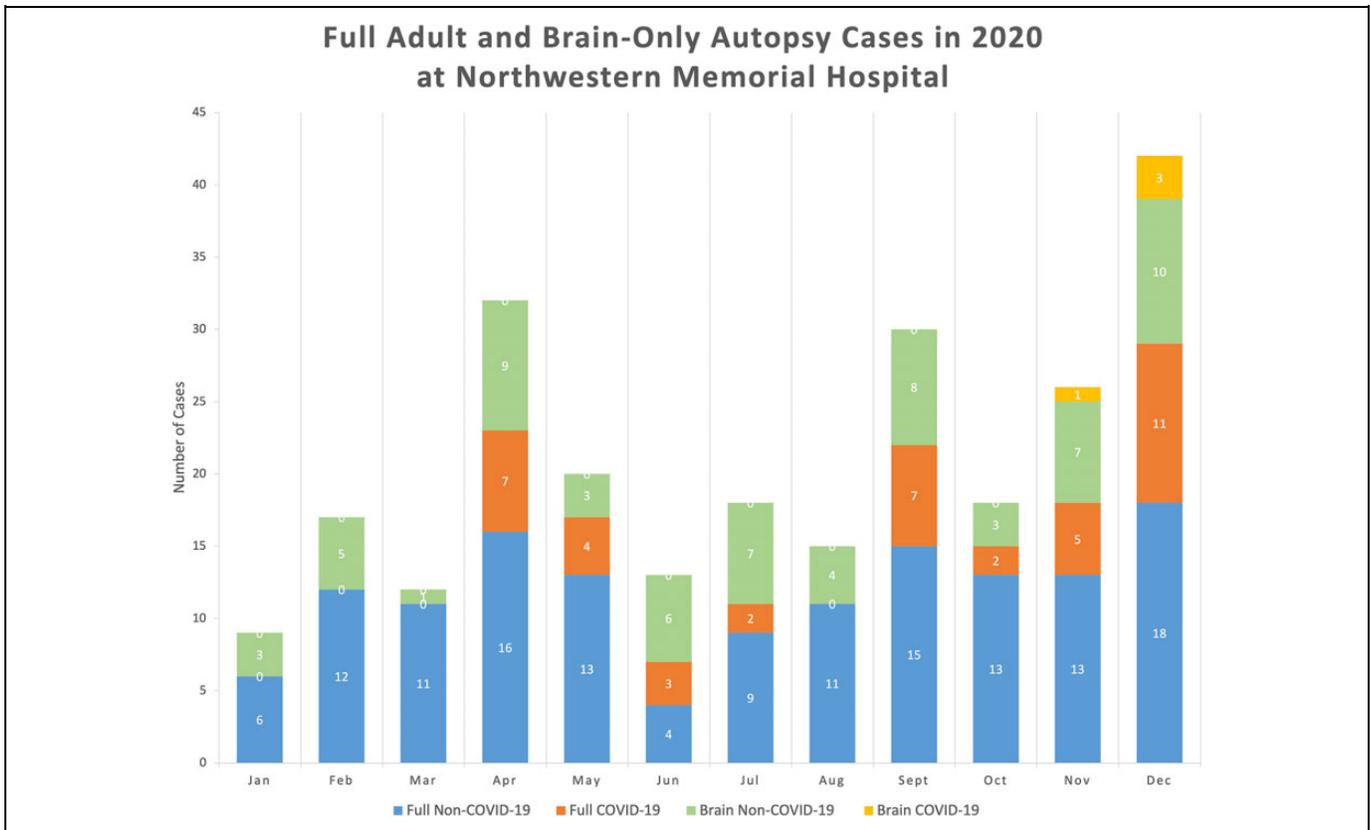


Figure 1. From January to December 2020, 12 residents, 4 staff members, and 5 faculty have been on the autopsy service. There were 41 full adult COVID-19 autopsies and 141 non-COVID-19 full adult autopsies. Seventy brain-only autopsies, most for research purposes, were performed during this time; in 4 of these cases the decedents were also positive for COVID-19. The first COVID-19 case was performed on April 10, 2020.

respond to questions and concerns, the Autopsy Division leadership scheduled a dedicated conference on April 17, 2020, for all resident trainees. At this virtual forum, the importance of autopsies and reasons to keep the service open were outlined as above. Significant changes to procedures were also reviewed so all trainees would know what to expect on service. Most importantly, the perceived relative low risk of contracting the virus from a deceased patient despite the numerous unknowns was emphasized. The WHO guidelines regarding safe management of deceased bodies affirm that infectious risk from COVID-19 autopsies is minimal. Based on the current medical literature, spread of the COVID-19 virus occurs between people primarily by droplets and aerosols, as well as via direct contact and, to a lesser degree, fomites. Bodies of the deceased are generally considered most infectious in cases of hemorrhagic fevers (eg, Ebola and Marburg viruses) and cholera, but less infectious in the case of respiratory pathogens. Since the COVID-19 virus causes an acute respiratory illness predominantly affecting the lungs, most of the cadaver presents minimal infectious risk. At the time of our division's transition and even to date, there is no definitive evidence worldwide of persons having contracted COVID-19 from exposure to COVID-19 affected decedents.⁷

From January to December 2020, 12 residents, 4 staff members, and 5 faculty have been on the autopsy service. During

this time, 41 full adult COVID-19 autopsies and 141 non-COVID-19 full adult autopsies were performed. Seventy brain-only autopsies, most for research purposes, were performed during this time; in 4 of these cases the decedents were also positive for SARS-CoV-2 (Figure 1).

Eleven residents and 3 staff members completed the autopsy exit survey. All participants rated their level of comfort donning PPE as high both before and after their most recent time on autopsy (4.6/5.0 vs 5.0/5.0, P value = .14). There was an improved reported comfort in performing general hospital autopsies, though the difference was not significant (3.9/5.0 vs 4.6/5.0, P value = .13). There was, however, a significant improvement in people's reported comfort handling and performing COVID-19 autopsies (3.4/5.0 vs 4.4/5.0, P value = .03) (Table 4).

Among all participants, both residents and staff members, the general feeling regarding having to participate in a COVID-19 autopsy ranged from "1 = Not excited at all" to "5 = Really looking forward to it," averaging 3.5/5.0. After actually performing autopsies during the pandemic, the majority of participants rated their feeling of personal safety between "3 = It was probably ok" and "5 = Not at all worried," averaging 4.5/5.0 (Table 4).

All participants, both trainees and autopsy staff, overwhelmingly rated both typical hospital and COVID-19 autopsies as

Table 4. Experiences of Trainees and Staff on Autopsy Service at NMH From January Until December 2020.

	Before (rated 1-5)	After (rated 1-5)	
Comfort properly donning PPE	4.6	5.0	$P = .14$
Comfort performing a typical hospital autopsy	3.9	4.6	$P = .13$
Comfort performing a COVID-19 autopsy	3.4	4.4	$P = .03$
General feelings (including safety) regarding COVID-19 autopsies	3.4	4.5	$P = .01$

Abbreviations: NMH, Northwestern Memorial Hospital; PPE, personal protective equipment.

Table 5. Attitudes Regarding Relevance of General and COVID-19 Autopsies Among Trainees and Staff on Autopsy Service at NMH From January Until December 2020.

	General (rated 1-5)	COVID-19 (rated 1-5)	
Importance to trainee education	4.6	4.5	$P = .56$
Importance to hospital and medical community	4.6	4.5	$P = .72$

Abbreviation: NMH, Northwestern Memorial Hospital.

crucial to both trainee education and also to the hospital and medical community at large (Table 5).

Discussion

Autopsies have historically filled an important role in deepening our understanding of diseases in addition to providing an important service to decedents' families and clinical caretakers. In the current COVID-19 pandemic, the necessity of autopsy findings and tissue sampling to shed clarity on the novel coronavirus comes alongside strict recommendations to socially distance and minimize nonessential procedures. Uncertainties regarding best practices have created new challenges for pathology departments everywhere, in some places forcing autopsy divisions to temporarily close. Our experience at NM outlines a basic framework for other institutions during the current public health crisis and for future disruptions.

An honest determination has to be made of whether autopsies can be performed in adherence with the most up-to-date safety guidelines while balancing service and requests from our patient-facing counterparts and obligations to education and training. Most important in this determination is a comprehensive review of any available national or international professional and public health recommendations. Our own thorough review of the WHO, CDC, and CAP guidelines provided invaluable guidance on minimum facility specifications, equipment needs, PPE requirements, and additional changes to autopsy procedures. At Northwestern, we were fortunate that the most recent update to autopsy facilities already met or exceeded the stated COVID-19 guidelines.

Once an assessment is completed of the safety goals and where the current engineering capabilities and procedures are, necessary changes should be quickly outlined and specifically written in an updated SOP. This intentional process forces a granular review and systematic revisions. In many aspects of

pathology practice, having a correct and relevant SOP ensures consistent quality of results for patients and safety for all participating personnel. This is especially important during times of rapid change and potentially hazardous circumstances like in the current COVID-19 pandemic.

Finally, open and frequent communication among all involved parties is crucial to a seamless transition and continued success of an active autopsy service. Inclusive discussions with autopsy leadership, faculty, and staff were important to solicit major concerns during the formulation of the new SOP. As these are the people most experienced with the service and most affected by changes, major decisions should start with and be refined by this core group.

Specific to our large academic training institution, intentional communication with our group of pathology trainees was also necessary to our success. At NMH, the Autopsy Division could function independently without trainees for only a limited amount of time. Our large case load would in time exhaust our autopsy staff's and attendings' capacity. Furthermore, in keeping with the professional recommendation by CAP, trainees participated in COVID-19 autopsies as much as possible to take advantage of this once-in-a-lifetime opportunity to gain new skills and knowledge. Based on our experience, we recommend that institutions present a coherent case for maintaining resident involvement in autopsy during a pandemic. This includes reassurances regarding safety, review of current recommendations, and specifying procedural changes for trainees coming onto service. Such communication highlights the thought put into the changes and provides reassurance to pacify all real or exaggerated concerns. We found that a proactive approach to addressing potential resident concerns was successful in alleviating resident anxiety and providing a smooth transition to pandemic-era autopsy service.

Exit interviews showed that our residents of all levels successfully participated in COVID-19 autopsies. Attitudes

regarding having to participate in autopsies on possibly infected decedents initially covered the entire range from “Not excited at all” to “Really looking forward to it,” but overwhelmingly, all participants agreed that autopsies (both typical and COVID-19) were important to both education and the medical community at large. Furthermore, this experience improved trainees’ comfort with all aspects of safe cadaver handling and autopsy procedures, and significantly improved confidence handling COVID-19 cases.

Leaving adequate time for an open forum discussion, addressing and validating apprehensions, and exit surveys which collect anonymous opinions reflect a willingness to continually address concerns and optimize the experience for trainees.

In light of the challenges placed on health care systems and pathology practices both nationally and globally, we admit that our flagship academic institution is fortunate to have state of the art facilities, adequate PPE supplies, and adequate personnel. More information is needed to explore how to most effectively meet engineering challenges, affordably improve existing structures and equipment, and sustainably allocate scarce PPE resources if necessary. We believe that our outlined framework of (1) systematic review of guidelines and current capabilities, (2) immediate and intentional adaptation of SOP, and (3) consistent communication can serve as a guideline for other institutions during the current pandemic and in unforeseen future pandemics or public health emergencies.

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References

1. First Travel-related Case of 2019 Novel Coronavirus Detected in United States. Centers for Disease Control and Prevention. Published January 21, 2020. Accessed February 4, 2021. <https://www.cdc.gov/media/releases/2020/p0121-novel-coronavirus-travel-case.html>.
2. Ghinai I, McPherson TD, Hunter JC, et al. First known person-to-person transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in the USA. *Lancet*. 2020;395:1137-1144.
3. Statement on the second meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (2019-nCoV). World Health Organization. Published January 30, 2020. Accessed February 4, 2021. [https://www.who.int/news/item/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-\(2005\)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-\(2019-ncov\)](https://www.who.int/news/item/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov)).
4. Secretary Azar Declares Public Health Emergency for United States for 2019 Novel Coronavirus. U.S. Department of Health & Human Services. Published January 31, 2020. Accessed February 4, 2021. <https://www.hhs.gov/about/news/2020/01/31/secretary-azar-declares-public-health-emergency-us-2019-novel-coronavirus.html>.
5. WHO Director-General’s opening remarks at the media briefing on COVID-19—11 March 2020. World Health Organization. Published March 11, 2020. Accessed February 4, 2021. <https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19—11-march-2020>.
6. About Our Health System. Northwestern Medicine. Accessed February 4, 2021. <https://www.nm.org/about-us/northwestern-medicine-newsroom/media-relations/about-our-health-system>.
7. Infection prevention and control for the safe management of a dead body in the context of COVID-19: interim guidance, 24 March 2020. World Health Organization. Published March 24, 2020. Accessed February 4, 2021. <https://apps.who.int/iris/handle/10665/331538>.
8. Collection and Submission of Postmortem Specimens from Deceased Persons with Confirmed or Suspected COVID-19. Updated December 2, 2020. Accessed February 4, 2021. <https://www.cdc.gov/coronavirus/2019-ncov/hcp/guidance-postmortem-specimens.html>.
9. Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Settings. 2007. Centers for Disease Control and Prevention. Updated July 22, 2019. Accessed February 4, 2021. <https://www.cdc.gov/infectioncontrol/guidelines/isolation/index.html>.
10. Autopsy Committee releases COVID-19 Autopsy Guideline Statement. College of American Pathologists. Published May 5, 2020. Updated February 2, 2021. Accessed February 4, 2021. <https://documents.cap.org/documents/COVID-Autopsy-Statement.pdf>.
11. Autopsy Exit Poll. Northwestern Department of Pathology. Published August 27, 2020. Accessed February 28, 2021. <https://forms.office.com/Pages/ResponsePage.aspx?id=YdN2fXeCCEekd2ToNmzRvNRcWxwJtWtFjb3SdCmKhPFUOE5KMIE4Q0NLT0MzRkM5WFE0UDDUQ0NFNy4u>.
12. R Core Team. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing; Published 2020. Accessed February 4, 2021. <https://www.R-project.org/>.