

Modified Method to Perform Autopsy Safely During the COVID-19 Pandemic

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ABSTRACT

During autopsies, pathologists, pathology residents and their support staff in the autopsy suite face potential risk of being exposed to SARS-CoV-2 because some procedures such as lung dissection may produce aerosols. In addition to follow the CDC guidelines for postmortem examination, we modified the method of organ dissection and evisceration for additional mitigation of risk. The lung weight was calculated by subtracting the weight of the formalin by volume from the weight of the lung after formalin fixation. 272 autopsies, including 27 COVID-19-positive cases, were performed from Feb. 2020 to Jan. 2021. None of 22 autopsy personnel were infected with COVID-19. The calculated lung weights (537.2 ± 42.5 grams) were not significantly different from the fresh lung weights (541.3 ± 43 grams, $p=0.95$). We conclude that autopsies may be performed safely during COVID-19 pandemic. The autopsy method shared here may be useful for future respiratory infectious diseases.

KEYWORDS: Autopsy; COVID-19; Lung Weight; Skull Opening; Sars-Cov-2; Autopsy Protocol

INTRODUCTION

Most are now quite familiar with the background of coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which was first identified in Wuhan, China, in late 2019.¹ It is a highly contagious virus, transmitted primarily through inhalation of respiratory droplets.

The pathogenesis and clinical course of COVID-19 are still not fully understood. Historically, postmortem examination has helped in understanding the pathogenesis, epidemiology, and natural course of disease, and COVID-19 is no exception. Autopsy has already begun to provide valuable insights, and it is very likely that the findings of gross and histologic examinations and the research that stems from the samples pathologists collected will arm us to combat this deadly disease. Therefore, it is critically important to continue performing autopsies during COVID-19 pandemic.

Pathologists perform autopsies with pathology residents during their training, and the pathologists, pathology residents and their support staff in the autopsy suite face

potential risk of being exposed to SARS-CoV-2. In our health care system, at the beginning of the pandemic when relatively little was understood about SARS-CoV-2 virus, we modified our usual practices to enhance protections from airborne infectious agents, and taught pathology residents and staff about the modified protocol for performing autopsies. All autopsies were performed in a single site with the modified procedures, and here this protocol used at Rhode Island Hospital (RIH) and Brown University is shared. We hope it will be beneficial for pathology residents, physicians, and staff in other institutions who perform autopsies.

METHODS

Morgue requirement

The morgue should have negative pressure with no air recirculation to adjacent spaces and the air should be exhausted outside of the building. The minimum air changes per hour (ACH) are 6 for the existing morgues and 12 for renovated or new morgues per the Centers for Disease Control and Prevention (CDC) guidelines. Please see more details at the CDC website.²

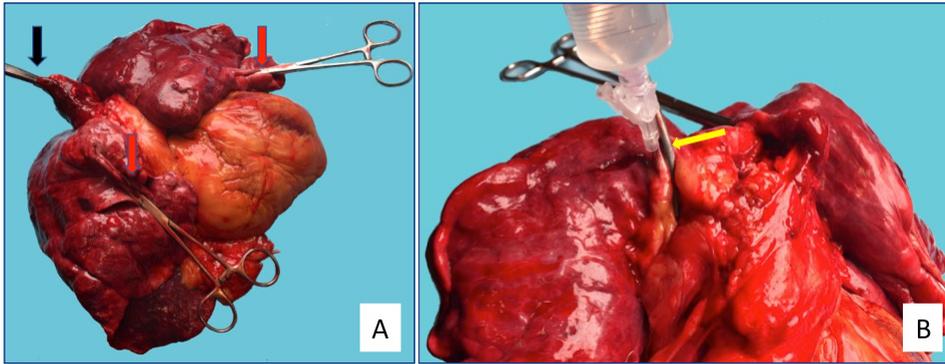
Personal protective equipment (PPE)

We followed CDC guidelines for PPE, including use of NIOSH-certified disposable N-95 respirators and/or battery-powered air-purifying respirators (PAPRs)/controlled air-purifying respirators (CAPRs) with HEPA filters, surgical caps, long sleeve disposable water resistant gowns, shoe covers, and double surgical gloves. Please see additional details at the CDC website.³

Performing Autopsies

If a COVID-19-positive status had not already been established within a week before the time death, we performed postmortem SARS-CoV-2 testing prior to starting the autopsy. Out of an abundance of caution, nasal swabs were performed inside the negative pressure area (with appropriate PPE), even though, per CDC guidelines, a negative pressure room is not required to perform nasopharyngeal swabs.² The reason for this was to avoid any possible contamination of the morgue storage cooler and common areas, which have the potential to expose nursing staff, transporter staff, and funeral home staff.

Figure 1. Heart and lung block. **(A)** Heart and lung block with hemostat clamps. Black arrow indicates the trachea. Red arrows indicate lung culture sites. **(B)** Formalin was injecting into the bronchus. Yellow arrow indicates a hemostat clamp occluding the bronchus.



We limited the number of personnel working in the morgue up to three individuals and performed only one autopsy at a time. If more than one autopsy was performed in a day, one hour was allowed to elapse between cases to allow for complete air exchange, based on the calculation that our morgue's ACH of 34 requires less than 20 minutes to achieve airborne contaminant removal at 99.9% efficiency (see the CDC website for additional details⁴). In our modified procedure, the up-to-three individuals performing the autopsy did not exit the negative pressure area after starting the autopsy until the case was complete. To allow this, everything was prepared for the entire procedure before donning PPE and bringing the body.

Our procedure was additionally modified to reduce the risk of exposure to pulmonary droplets and to reduce the time exposed to fresh tissue. We cross-clamped the trachea with two hemostat clamps and cut the trachea between the two clamps (**Figure 1A**), then separated the heart and lungs from the other organs, creating two blocks, which were placed into two separate large containers of formalin. When lung cultures or fresh lung tissues were needed, we clipped the lung tissue with two hemostat clamps and cut the lung tissue between the two clamps. In this way, aerosolization was limited. To reduce aerosol generation during the infusion of formalin into the bronchus, the lungs were inflated by injection of the formalin into bronchi or the lung parenchyma with a needle and syringe after the left and right bronchi were clamped by hemostat clamps (**Figure 1B**). The amount of formalin injected on each side was recorded. The solid organs were carefully sectioned at intervals while submerged in formalin to help with fixation. The stomach and bowels were opened and rinsed while wearing PAPRs/CAPRs. After 48 hours of fixation, the organs were completely dissected and examined grossly.

Opening the skull with an oscillating saw is considered an aerosol-generating procedure. In cases where it was felt necessary to examine the brain for definitive postmortem diagnosis, modified procedures were devised to provide

additional protection for our pathology assistants, pathology residents and pathologists. The skull may be opened in a wood or metal frame covered by a clear plastic bag, in a clear plastic bag without the wood or metal frame or by using a saw with a bone dust vacuum collector.

After autopsy

We followed institutional and CDC guidelines to remove PPE and to clean the morgue. A full hour was allowed to elapse before any personnel could enter the

morgue without PPE and respiratory protection (N95 respirator or higher) to allow for complete air exchange (based on an ACH of 34 as described above). Please see more details at the CDC website.²

Lung weights

The lung weight was calculated by the weight of lung after formalin fixation minus the amount of formalin injected. To evaluate the feasibility, we measured the lung weights before and after 48-hour fixation. The calculated weights were compared with the fresh lung weight. Three non-COVID patients were from Rhode Island Hospital. The protocol was approved by Rhode Island Hospital IRB committee.

Statistics

The lung weight was analyzed by using Student's t test.

RESULTS

Autopsy cases performed

We performed 272 autopsies from February 2020 to January 2021, including 27 COVID-19-positive autopsies. None of the 15 pathology residents, 5 attending pathologists, or 2 pathology assistants on the autopsy service were infected with COVID-19.

Lung weights

In order to reduce the release of respiratory droplets from the fresh lungs, we did not obtain the fresh lung weights in COVID-19 positive cases. The lung weight was calculated by the weight of lung after formalin fixation minus the amount of formalin injected. The density of 10% formalin is about 1 g/cm.³ If 100 ml formalin was injected, we deducted 100 grams from the lung weight after formalin fixation.

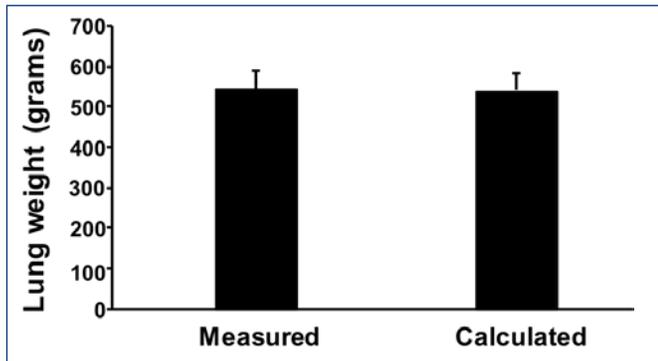
To evaluate the lung weight accuracy, we compared the fresh lung weights with the calculated lung weights in three non-COVID patients (**Table 1**). The fresh lung weights were 541.3±43 grams, whereas the calculated weights were

Table 1. Lung weight in grams

		Fresh weight	Injected formalin (ml)	Weight measured after injection	Weight calculated	Average of calculated weight	P value
Patient 1	Right	523	50	572	522	520	
			100	618	518		
			150	670	520		
Patient 1	Left	364	50	413	363	363	
			100	463	363		
			150	512	362		
Patient 2	Right	664	50	715	665	662	
			100	762	662		
			150	810	660		
Patient 2	Left	516	50	563	513	512	
			100	612	512		
			150	661	511		
Patient 3	Right	630	130	751	621	621	
	Left	551	90	635	545		
	Average	541.3				537.2	P=0.95
	SE	43.0				42.5	

Figure 2. Lung weights

The lung weight was calculated by the weight of lung after formalin fixation minus the weight of formalin injected by volume. The density of 10% formalin is about 1 g/cm³. If 100 ml formalin was injected, we deducted 100 grams from the lung weight after formalin fixation. The calculated lung weights were compared with the fresh lung weights. There was no statistically significant difference between the calculated lung weights and the fresh lung weights, indicating that it is feasible to use the calculated lung weight after formalin fixation.



537.2±42.5 grams. The difference was not statistically significant (Figure 2), indicating that it is feasible to use the calculated lung weight after formalin fixation.

DISCUSSION

The autopsy is an important medical procedure, and may be helpful in determination of the cause of death, comparison between clinical diagnosis and postmortem diagnosis, and identification of new diseases. In our institution, the pathology residents, working with the attending staff and pathology assistants, review the clinical history, perform external examination of the body, eviscerate (usually with assistance of a pathology assistant) and dissect the organs, identify any gross abnormalities, review microscopic slides and draft the final report. During the external examination of the

body, organ evisceration, organ dissection, and examination of gross organs, pathology residents, pathologists and staff may be exposed to a variety of infectious diseases, including COVID-19. In this paper, we describe a method that was developed to perform autopsies safely during COVID-19 pandemic.

We treated all autopsies as potential COVID-19-positive cases, as the sensitivity of the nasopharyngeal swab for the postmortem detection of SARS-CoV-2 was not yet fully understood. For instance, one study showed that the sensitivity of naso-

pharyngeal swab for COVID-19 testing in asymptomatic and mild COVID-19 infection was 44.5%.⁵ On our autopsy service, we had one case with multiple negative SARS-CoV-2 PCR tests on pre-mortem and post-mortem nasopharyngeal swabs. However, SARS-CoV-2 was detected in the lung tissues by the CDC (this further testing was prompted by clinical suspicion and classic histopathologic findings).

Based on our evaluation of post-fixation lung weights, our modified procedure included calculation of lung weights by subtracting the amount of injected formalin by volume. Although the calculated weight was slightly lower than the real measurements, the difference was not statistically significant and was felt to be negligible in its effect on the pathological interpretation. The lower calculated weight may be due to leakage around the needle at the time of formalin injection, or leakage of formalin from the tissue during fixation.

During the COVID-19 pandemic, modified autopsy protocols have been reported. For example, in a Brazil study, minimally invasive autopsies, also known as minimally invasive tissue sampling, were used.⁶ One study from India used a hand-held hammer and chisel to open the cranial cavity.⁷ We felt that it was safe to open the skull in a wood or metal frame covered by a clear plastic bag or in a clear plastic bag without the wood or metal frame by using an electrical saw.

We conclude that autopsy may be performed safely by pathology residents, pathologists and staff during the COVID-19 pandemic. This autopsy method may also be useful for other infectious diseases transmitted by respiratory droplets in the future. Our pathology residents, autopsy pathologists and staff have now also had the opportunity to receive COVID-19 vaccination, further reducing the risk of infection. However, new variants may occur at any time and uncertainty remains regarding the efficacy of vaccines in preventing infection in new variants of COVID-19. Therefore, we plan to continue following our newly-designed protocol for autopsies until the risk of COVID-19 infection has largely subsided.

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