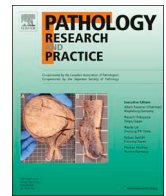




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## Correspondences

## Autopsy of patients with COVID-19: A balance of fear and curiosity



## ARTICLE INFO

## Keywords:

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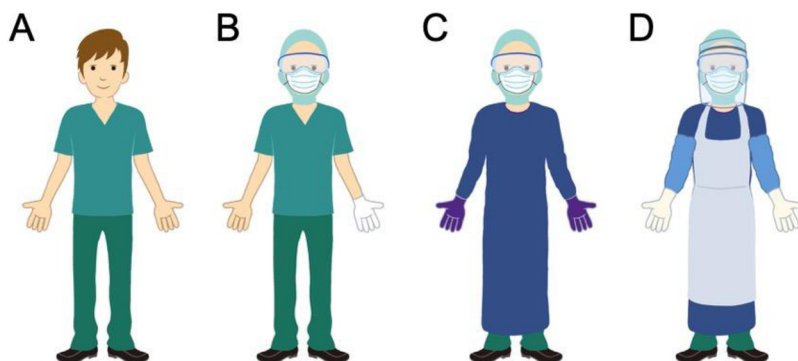
Personal protective equipment (PPE)

Corona virus disease 2019 (COVID-19) disease has become pandemic since December 2019. App. 15 % of those affected undergo a severe disease and 5–6 % are critical (respiratory failure, and/or multiple organ dysfunction/failure). COVID-19 pathogenesis is still not sufficiently understood. Thus, systematic examination is mandatory to comprehend extent and mechanisms of this novel disease. Autopsy is the only opportunity to macroscopically observe organs and take optimal samples for histological and molecular analyses. Thereby, autopsy is very likely superior over postmortem core needle biopsies. Consequently, several reports have recently demonstrated that autopsy based examinations generate important insights into the disease manifestations, the mechanisms of organ failure and the association with viral distribution [1–3].

While most *Coronavirinae* belong to hazard group 2 (HG2), severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has recently been categorized as HG3 like the severe acute respiratory syndrome coronavirus (SARS-CoV) and the Middle East respiratory syndrome coronavirus (MERS-CoV), indicating that it can cause severe human disease and may be a serious hazard to contact persons. Thus, post-mortem examinations in SARS-CoV-2 positive patients have to be considered high-risk infectious autopsies. Several publications and recommendations from official institutions (such as the Robert-Koch-Institut in Berlin for Germany) have generated a debate about weighing risks and benefits of autopsies in COVID-19 cases [4–6]. Institutional

restrictions and personal concerns might be counterproductive and could significantly limit and delay research of this dramatic disease. The main route of transmission is by respiratory droplets released from infected persons. This is not a major concern when handling human remains or performing postmortem procedures. Transmission via surfaces appears less frequent and relevant. Taken together, evidence about the risk of getting infected during autopsies and workup of the specimens is lacking so far.

Here, we report our experience from a series of full autopsies (including brain autopsy) of 17 patients with proven SARS-CoV-2 infection and COVID-19 at the University Medical Center Augsburg [3]. The study was approved by the local institutional review board (approval number 2020-18, April 20, 2020). Autopsies were always conducted by the identical team of four trained physicians without technical assistance between April 4 and 28, 2020, according to recommendations and published best practice for managing cases with HG3 pathogens [4,5]. Personal protective equipment (PPE) used for all autopsies included a surgical scrub suit and rubber boots, a hat to protect hair, safety goggles and a clear visor to protect the face, an FFP3 mask for respiratory protection, a waterproof gown, additional forearm protection, a plastic apron, cut-resistant glass fibre reinforced protective gloves and double surgical gloves as illustrated in Fig. 1. PPE was disposed before leaving the autopsy suite. One physician acted as circulator assistant carrying out auxiliary tasks. Precautions included the use



**Fig. 1.** Systematic layered representation of the personal protective equipment (PPE).

A) Basic layer of surgical scrub suit and rubber boots. B) Surgical hood for hair protection, safety goggles, respiratory protection by an FFP3 mask and cut-proof synthetic mesh gloves. C) Long fluid-resistant isolation gown, first layer of latex/nitrile gloves. D) Face shield, waterproof apron and additional forearm protection, second layer of latex/nitrile gloves.

**Table 1**

Systematic comparison of recommended and reported safety measures (personal protective equipment, PPE) for autopsy studies with COVID-19 patients.

PPE	Barton LM et al. (5)	Menter T et al. (1)	Hanley B et al. (4)	CDC	RKI	Schaller et al. (3)
Surgical scrub shirt, pants	+					+
Rubber shoes/boots	+	+	+ (with metal toecaps)	+	+	+
Surgical hood	+	+	+	+		+
N95 mask, FFP2/3 mask	+	+	+	+	+	+
Eye protection (goggles/face shield)	+	+	+	+	+	+
Cut-proof synthetic mesh gloves			+	+		+
Waterproof gown	+	hazmat suit	+	+	+	+
Gloves	+	+	+	+ (2 pairs)	+ (at least one pair)	+ (2 pairs)
Waterproof apron			+	+	+	+
Negative pressure autopsy suite / isolation room	+	+		+		
Reverse flow air handling system	+	+		+		+
Shower room	+					
Miscellaneous	disposable body suit	handsaw for skull	electric bone saw with vacuum			IQ-Air Healthpro 250 NE room air purifier
	shoe covers	2 h before autopsy, instillation of 4% phosphate buffered formalin into mouth, nose, pharynx				
	3 M Versaflow powered air purifying respirators with M-Series headgear					

Abbreviations: PPE, personal protective equipment; CDC, Centers for Disease Control and Prevention, Atlanta, Georgia, USA; RKI, Robert-Koch-Institute, Berlin, Germany.

of a separate autopsy suite with whole room ventilation (IQ-Air Healthpro 250 NE, Switzerland). Postmortem testing for SARS-CoV-2 was done by antisense strand based reverse transcriptase polymerase chain reaction (RT-PCR) from nasopharyngeal, tracheal and bronchial swabs in all cases. At time of autopsy, 16 out of 17 patients were positive for SARS-CoV-2 at least at one site of the respiratory tract. After the last autopsy using the outlined PPE, all four physicians did not show any symptoms and were repeatedly tested negative for SARS-CoV-2 by oropharyngeal swabs and RT-PCR on May 8 and May 11, 2020. Serological testing by two different test kits (anti-SARS-CoV2 IgA and anti-SARS-CoV2 IgG, Euroimmun, Germany; Elecys anti-SARS-CoV2 IgG/IgM, Roche, Switzerland) was also negative for all four.

In summary, we describe an autopsy procedure applicable to cases of COVID-19 and provide first evidence that postmortem examinations can be conducted safely in those patients when applying appropriate PPE. This report is the first of its kind on analyses of autopsy personnel tested negative by RT-PCR and serology. Our observations indicate that the risk of SARS-CoV-2 infection during autopsy might be overestimated and restrictions on postmortem examinations could be reconsidered. However, a systematic risk assessment for full autopsy, workup and examination of the specimens is still not available and needs to be completed. This is of particular interest since different pathologists/working groups in a number of different countries follow different standard operating procedures for autopsy of COVID-19 patients (Table 1). Taken together, it appears to be common sense to protect autopsy personnel during the procedure at least in the same

fashion as personnel on wards specific for SARS-CoV-2 positive patients.

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### CRediT authorship contribution statement

**Klaus Hirschbühl:** Methodology, Investigation, Writing - original draft. **Tina Schaller:** Methodology, Investigation, Formal analysis. **Elisabeth Kling:** Methodology, Investigation. **Bruno Märkl:** Conceptualization, Investigation, Resources, Writing - original draft, Visualization. **Rainer Claus:** Conceptualization, Methodology, Investigation, Writing - original draft, Supervision.

### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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