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Precautions in postmortem examinations in Covid-19 - Related deaths: Recommendations from Germany

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ABSTRACT

The Covid-19 pandemic is also a considerable risk for forensic workers, among other healthcare providers. The risk of contamination is serious in post-mortem procedures. SARS-CoV2 is a microorganism classified as Hazard Group 3. However, the lack of adequate scientific work on Covid-19 should prompt us to be even more cautious when handling potentially infected persons or materials. Before starting the post-mortem investigation a risk assessment should be carried out and the suitability of facilities, personnel and equipment should be evaluated. An autopsy room conforming to BSL 3 standards would be ideal but is not mandatory. For suspicious or approved cases however a number of procedural changes must be made concerning the body's removal, storage and inspection procedures. Facilities, equipment and training issues need to be revised against existing and potential risks of infection. In addition to proper ventilation and insulation, personal protective equipment, aerosol reduction measures and disinfection applications are required.

As of yet it is still unclear how long this public health issue, which has grown to become a pandemic, will last. This article highlights preventive measures to be taken into consideration in post-mortem processes when a Covid-19 infection is suspected or confirmed.

It should be noted that there is no standard guide yet in this regard. A guide should be created according to international standards and revised according to changing conditions.

1. Introduction

Infections are a constant threat to forensic experts working on the deceased.[1] Autopsy rooms are a potential source of infection.[2,3] In England between 1970 and 1989, they were ranked first regarding accident location in infectious diseases caused by laboratory accidents of autopsy employees.[3] While scientific studies on Covid19 are still insufficient, it is certain that attention should be paid to autopsy procedures. With the disease becoming a pandemic that affects the whole world, many healthcare workers were affected by the disease and preventive measures have become more important. For this reason, this article draws attention to the protection of autopsy workers from infection. When post-mortem examinations are not carried out properly, staff (doctors, pathologists, nurses, those interested in analysis) will not only be exposed to infection themselves, but might also transmit it to others.

2. Covid-19 findings

There are many historical examples of outbreaks of large proportions of diseases that threaten human health. These are viral diseases such as AIDS, Ebola, acute respiratory syndrome (SARS) and in the present - Covid-19. Covid-19 is a disease of the coronavirus family. Although it is still too early for detailed data related to this virus that progresses as a pandemic, it is a viral disease that spreads quickly and can cause serious complications including death. Covid-19 is suspected when the patient has been in a high-risk area 14 days before the onset of the disease, has been in contact with a SARS-CoV-2 virus positive patient, and shows symptoms of sudden onset including fever and lower respiratory infection. Among the clinical findings of Covid-19 are signs of lower respiratory tract infection, such as fever, cough, as well as shortness of breath. Computed tomography (CT) is characterized by multiple irregular shadows especially around the lung and interstitial changes in the

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lung periphery in the early period. This condition then turns into ground glass opacity and infiltration in both lungs. It is stated that the number of white blood cells in the early stage of the disease is normal or decreased, while the number of lymphocytes will gradually decrease.[4]

Information about the course of the disease is not yet clear. Therefore, the following points about Covid-19 should be taken into account in post mortem processes.

3. Postmortem examinations and preventive measures

The virus is transmitted by respiratory droplets, infected people and surface contact.[5–9] There is no evidence yet that the virus is airborne. Unlike other Coronavirinae, SARS-CoV-2 is categorized as a Hazard Group 3 (HG3) organism, such as SARS and MERS agents.[10] Therefore, the minimum measures to be taken should be appropriate to this level. In addition, the place where the autopsy will be performed should have sufficient equipment and the personnel performing the autopsy should have sufficient information.

Autopsy can be performed in patients with confirmed or suspected Covid-19 or necessary patients when the forensics expert is not aware of a possible infection.

Without starting postmortem operations;

- Standard and pathogen-specific measures should be planned by performing a risk assessment before autopsy.
- All staff providing forensic services should be informed. It is important that the personnel performing the autopsy are trained for the autopsy of the HG3 pathogen group.
- Only the necessary personnel should be in the places where autopsy/external examination is performed.
- Although not available at the time of writing this article, prophylactic treatments or vaccines, if any, should be given.[1,4]

3.1. Moving and storage of the corpses[1,4,11,12]

- The mouth and face of the body should be covered with a surgical mask before carrying. The corpse should be placed in a corpse bag, which can be closed completely with a minimum manipulation so as not to leak body fluids.
- Disposable gloves should be used when handling the body bag.
- The corpse should be stored in a morgue environment, the ventilation of which is separated from other units, and then the morgue cabinet should be disinfected.
- The bag used for storing and carrying the body should be disinfected before disposal of medical waste or if it is to be reused.

3.2. External Examination and autopsy procedures[1,4,11–13]

Unless necessary, diagnosis should be made using external examination and diagnostic tests instead of autopsy. When making an autopsy decision, the possibilities of the center and whether it can be directed to another center should be taken into consideration. It is highly recommended to support the diagnosis with radiological methods such as X-ray, CT. However, if the radiology service is to be taken from the external center, the decision should be made considering the risk of contamination.

However, if diagnosis cannot be made by tests and imaging, a full postmortem examination should be started. Visible contamination must be completely removed before disinfection after taking necessary samples for diagnosis; cleaning procedures should be followed for blood and body fluid contaminants;

- The surfaces of the objects should be wiped with 1000 mg/L chlorine disinfectant or effective chlorine cloths and rinsed with clean water after waiting for 30 min. The disinfection procedure should be done three times a day (repeat when contamination is suspected);
- Clean areas, then contaminated areas should be wiped first: object surfaces that are not touched frequently should be wiped and then object surfaces that are touched frequently should be wiped (When cleaning an object surface, replace the used wiper with a new one.

3.2.1. Physical Requirements[10,14–19]

- It is recommended to use BSL 3 autopsy suit for diagnosed or suspected Covid-19 cases. During the SARS epidemic, a hall of BSL 3 standards was put to use in China and was effective. The limited availability of BSL 3 autopsy suites and conforming facilities however can be a concern. The following points of guidance should be considered in all facilities:
- Make sure that the autopsy room and morgue location, ventilation and wastewater systems will not threaten public health. Autopsy should not be performed in centers that do not have detached ventilation and hepa filters, or whose drainage does not undergo a treatment process, or at least not in the city's wastewater treatment system.
- It should be ensured that the autopsy room is well ventilated. In ideal conditions, the autopsy room must be in a separate building from the buildings used for other purposes, or the ventilation system must be completely separated. However, an independent ventilated autopsy room is not mandatory for HG3 infections.
- It is ideal that the air flow is in the autopsy room from top to bottom. Down-draft autopsy tables will also be useful.
- In the autopsy room, taps and doors should be automatic and warning signs should be placed on the doors.
- The autopsy room must have negative pressure and air flow from the outside of the room. It should be one-way from top to bottom and from clean areas to dirty areas and dirty air should be filtered.
- Air flow should be prevented with airtight door system and all windows of the hall should be closed.
- There should be showers suitable for the use of the personnel in the clean area near the autopsy room. Emergency eye showers should be easily accessible in autopsy rooms.

3.2.2. Autopsy Practice[1–3,10–12,14–16,18–23]

- If possible, a single table hall should be preferred. It is recommended that no other autopsy be performed simultaneously in multi-table salons.
- All materials required for autopsy should be prepared before the autopsy begins.
- Only one person should work in each body cavity.
- Minimally invasive autopsy can be performed to obtain the necessary samples in those with widespread signs of infection. However, in this case, autopsy should be supported by postmortem imaging.
- When full autopsy is required, techniques where the organs are less manipulated and left in place, unless the autopsy technique is required.
- An injury should be avoided when working with sharp tools, and a sufficient number of scalpels and other cutters should be prepared before starting the autopsy. Appropriate tools should be used when replacing the scalpel tips. When they are used, they should be removed from the table.
- The use of disposable materials should be given as much attention as possible, infected wastes and non-reusable materials should be burned.
- Avoid aerosol producing behavior, such as using pressurized water.
- The ribs should not be cut from the bony parts; they should be cut immediately from the medial part of the costachondral junction with attention.

- Blunt tip scissors should be preferred during autopsy. Specially designed oscillating saws with vacuum should be used during the opening of the head, which causes less dust to spread around.
- At the end of the autopsy, as few stitches as possible should be sutured to minimize the possibility of the needle sticking during closure.
- The labels showing the special situation should be affixed to all containers, the containers should be disinfected with a suitable substance and kept with clean gloves.
- Before being discharged in the drainage system, fecal material and other sewage are to be disinfected with chlorine-containing disinfectant (Active chlorine must be more than 40 mg/L for the first application) for at least 1.5 h.
- The total residual chlorine concentration in the disinfected sewage system should reach 10 mg/L.
- After removing spillages, disinfect surfaces of contaminated media or objects;
- Containers containing infected substances should be cleaned with disinfectant containing 5000 mg/L active chlorine for 30 min;
- Collected infected substances should be disposed of as medical waste;
- Used single-use products must be disposed of correctly by being placed in medical waste bags with double layers. Firstly, the woven items should be put in a disposable, water-soluble plastic bag and the bag should be properly tied. Then this bag should be put in another plastic bag and then the second bag, tied, should be placed in a yellow fabric bag and sealed.
- Vehicles involved in the transportation of COVID-19 victims should be cleaned with chlorine-containing disinfectant (1000 mg/L active chlorine), which should remain on the surfaces for at least 30 min before being washed/wiped.

3.3. Personal protective equipment (PPE)[4,10,18,24]

- Scrubs and fluid-resistant or impervious clothing should be worn and the wrist covered. Dissecting personnel should also wear a waterproof apron.
- At autopsy, double layer surgical gloves should be worn and the wrist should be pulled over the apron. In addition, cut-proof synthetic mesh gloves must be worn between the gloves. Rubber boots or shoe covers must be worn.
- In autopsy, special clothes with Powered, air-purifying respirators (PAPRs) with HEPA filters and life support system should be worn, and the outer surface of the clothes should be disinfected while leaving the working environment. In cases where this cannot be achieved, disposable protective coveralls should be worn with PAPRs HEPA filter masks. If a mask of this nature cannot be provided, the face should be protected with a face shield or goggles, bones and masks with N95/FFP2 or higher.

3.3.1. Occupational exposure related to COVID-19[4,22]

- routes of exposure and what to do in case of exposure are listed below
  - Intact skin and damaged skin exposure: Remove contaminated substances, apply 0.5% iodophor or 75% alcohol to the skin and keep it for 3 min; wash with high flow water
  - Exposure of mucous membranes such as eyes: Wash with plenty of normal saline or 0.05% iodophor for disinfection.
  - Sharp object injuries: Tighten blood from the proximal end to the distal end, wash the wound with running water, disinfect with 75% alcohol or 0.5% iodophor.
  - Direct contact with respiratory system: Immediately leave the insulating area, gargle with normal saline or 0.05% iodophor, clean the inside of the nose with cotton containing 75% alcohol.
- Evacuate from the isolation area and enter the designated isolation room
- Report to the relevant departments
- Isolate and observe skin-free exposures for 14 days. If there are symptoms, notify the relevant departments in a timely manner.

3.4. Final Disinfection Procedures[1,4,11,22,25,26]

- Medical waste resulting from COVID-19 treatment/autopsy should be disposed of correctly considering it is associated with an infectious disease;
- Reusable medical devices used on SARS-CoV-2 patients should be disinfected according to the disinfection procedures;
- Medical textile products must be disinfected according to SARS-CoV-2 procedures;
- Surfaces of objects (instruments and devices, including instrument table, operating table, operating bed, etc.);
  - Visible blood/body fluids should be completely removed before disinfection (in accordance with procedures for the disposal of blood and bodily fluid spills).
  - All surfaces should be treated with a disinfectant containing 1000 mg/L active chlorine with the disinfectant being left on the surface for at least 30 min to have an effect.
- Circulated air: the fan filter unit (FFU) should be closed. Disinfect the air by irradiating with an ultraviolet lamp for at least 1 h. Turn on FFU to automatically clean the air for at least 2 h.
- Dead care: Fill all openings or wounds of the patient such as mouth, nose, ears, anus and tracheotomy openings using cotton or gauze soaked in 3000–5000 mg/L chlorine-containing disinfectant or 0.5% peroxyacetic acid; After washing the corpse, it should be sprayed with a 1/10 disinfectant-water solution, put it in the corpse bag and close it, and again, spray a washing solution of 1/10 disinfectant-water.
- Wrap: Wrap the body in a double-layer cloth treated with disinfectant and place it in a double-layer, leak-proof body bag treated with chlorine-containing disinfectant; The body bag should then be placed in the coffin and sealed. The coffin should be sealed and the burial depth should be at least 2 m.
- In environments that are not accessible to ready-made disinfectants, in Covid 19 cases, laundry water solutions, soap, detergents, etc. prepared daily can be used in disinfection processes. In addition, chlorhexidine or iodines can be used as an antiseptic. In addition, 70% isopropyl alcohol with chlorine hexidine can be used for decontamination of hands. Ready-to-use washing waters containing 5% chlorine can be used to prepare solutions for disinfection purposes. The solutions should be prepared daily as two separate solutions of 1/10 (1 part of 5% washing and 9 parts of water) and 1/100 (1 part of 5% washing and 99 parts of water). In the disinfection of the funeral transported vehicles, after the disposal of the funeral waste, 15 min exposure should be provided with 1/10 washing water solution. During the removal of infected blood and body fluids that are spilled on the floor, 1/10 bleach solution is poured on the material, and after 15 min, the infected material is thrown in a medical waste bin with a cloth soaked with 1/100 washing water solution. Then, the surface from which the infected material is removed is washed with soapy water. Autopsy table and the tools used for autopsy should be washed with 1/10 washing solution. Tools used in autopsy should be sterilized with an autoclave, if possible. As another method, viruses can be killed by treating boiling water for 20 min.

4. Conclusion

Considering that autopsy may be required in patients who die due to Covid-19, biosafety measures should be kept at the highest level before, during and after autopsy in these patients with a high risk of

contamination. Considering that there may be continuous outbreaks at different times for different biological reasons, a standard guide in this regard should be created according to international standards and revised according to changing conditions.

Declaration of competing interest

No conflict of interest and financial disclosure were declared by the authors.

References

1. Keten A, Tümer AR, Odabaşı AB, Keten D. Kırım Kongo Kanamalı Ateşi Olgularında postmortem İncelemelerde enfeksiyondan Korunma. *Bull Leg Med*. 2008;13(3):128–132.
2. Ertan A, Akyıldız EÜ. Postmortem incelemeler sırasında enfeksiyondan korunmak için alınması gereken önlemler. *Turkiye Klin J Forensic Med Forensic Sci*. 2008;5(1):24–30.
3. Grist NR, Emslie JAN. Association of Clinical Pathologists' surveys of infection in British clinical laboratories, 1970-1989. *J Clin Pathol*. 1994. https://doi.org/10.1136/jcp.47.5.391.
4. Liang Tingbo, Cai Hongliu, Chen Yu, et al. *Handbook of COVID-19 prevention and treatment*. 2020.
5. Liu J, Liao X, Qian S, et al. Community transmission of severe acute respiratory syndrome coronavirus 2, Shenzhen, China. *Emerg Infect Dis*. 2020. https://doi.org/10.3201/eid2606.200239, 2020.
6. Chan JFW, Yuan S, Kok KH, et al. A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. *Lancet*. 2020. https://doi.org/10.1016/S0140-6736(20)30154-9.
7. Li Q, Guan X, Wu P, et al. Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *N Engl J Med*. 2020. https://doi.org/10.1056/NEJMoa2001316.
8. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet*. 2020. https://doi.org/10.1016/S0140-6736(20)30183-5.
9. Ong SWX, Tan YK, Chia PY, et al. Air, surface environmental, and personal protective equipment contamination by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) from a symptomatic patient. *JAMA, J Am Med Assoc*. 2020. https://doi.org/10.1001/jama.2020.3227.
10. Hanley B, Lucas SB, Youd E, Swift B, Osborn M. Autopsy in suspected COVID-19 cases. *J Clin Pathol*. 2020. https://doi.org/10.1136/jclinpath-2020-206522.
11. Riddell LA, Sherrard J. Blood-borne virus infection: the occupational risks. *Int J STD AIDS*. 2000. https://doi.org/10.1258/0956462001914986.
12. Hardin NJ. Infection control at autopsy: a guide for pathologists and autopsy personnel. In: *Current Diagnostic Pathology*. 2000. https://doi.org/10.1054/cdip.2000.0021.
13. Dalgıç M, Tuğcu H, Can Ö, Özaslan A. Otopside Biyogüvenlik. *Adli Tıp Derg*. 2004;18(2):61–66.
14. Sirohiwal BL, Pk P, Sharma L, Chawla H. Design and layout of mortuary complex for a medical college and peripheral hospitals. *Forensic Res*. 2011. https://doi.org/10.4172/2157-7145.1000102e.
15. NHS. *Scottish Health Planning Note 20 Facilities for Mortuary and Post-Mortem Room Services Design and Briefing Guidance*. 2015 (January).
16. Lucas S. Autopsies of people with high-risk infections. In: *The Hospital Autopsy*. CRC Press; 2010:71–89.
17. US Department of Health and Human Services, Centers for Disease Control and Prevention. *Biosafety in Microbiological and Biomedical Laboratories (BMBL)*. fifth ed. 2009.
18. Osborn M, Lucas S, Stewart R, Swift B, Youd E. Briefing on COVID-19 Autopsy practice relating to possible cases of COVID-19 (2019-nCov , novel coronavirus from China 2019/2020). *R Coll Pathol*. 2020;19:1–14. February.
19. Li L, Gu J, Shi X, et al. Biosafety level 3 laboratory for autopsies of patients with severe acute respiratory syndrome: Principles, practices, and prospects. *Clin Infect Dis*. 2005. https://doi.org/10.1086/432720.
20. Castillo P, Martínez MJ, Ussene E, et al. Validity of a minimally invasive autopsy for cause of death determination in adults in Mozambique: an observational study. *PLoS Med*. 2016. https://doi.org/10.1371/journal.pmed.1002171.
21. National Health Commission of the People's Republic of China. Protocols for prevention and control of COVID-19 (6th Version) [EB/OL].(2020-03-09)[2020-04-15]. http://www.nhc.gov.cn/jkj/s3577/202003/4856d5b0458141fa9f376853224d41d7.shtml.
22. National health commission and National administration of traditional Chinese medicine of the people's Republic of China. Protocols for diagnosis and treatment of COVID-19 (7th trial Version) [EB/OL]].(2020-03-04) [2020-04-15]. http://www.nhc.gov.cn/yzygj/s7653p/202003/46c9294a7dfe4cef80dc7f5912eb1989.shtml.
23. Chinese Center for Disease Control and Prevention. Guidelines for investigation and management of close contacts of COVID-19 patients [EB/OL]. (2020-03-09)[2020-04-15]. http://www.chinacdc.cn/jkzt/crb/zl/szkb_11803/jszl_11815/202003/t20200309_214241.html.
24. Hanzlick R, Nolte K, Dejong J. The medical examiner/coroner's guide for contaminated deceased body management. *Am J Forensic Med Pathol*. 2009;30(4):327–338. https://doi.org/10.1097/PAF.0b013e31819d208c.
25. Sharma BR, Reader MD. Autopsy Room : a potential source of infection at work place in developing countries. *Am J Infect Dis*. 2005;1(1):25–33. https://doi.org/10.3844/ajidsp.2005.25.33.
26. Chinese Center for Disease Control and Prevention. Guidelines for epidemiological investigation of COVID-19 [EB/OL]. (2020-03-09)[2020-05-15]. http://www.chinacdc.cn/jkzt/crb/zl/szkb_11803/jszl_11815/202003/t20200309_214241.html.