



SARS-CoV-2 persistence and infectivity in COVID-19 corpses: a systematic review

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Accepted: 9 August 2022

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Abstract

The persistence and infectivity of SARS-CoV-2 in different postmortem COVID-19 specimens remain unclear despite numerous published studies. This information is essential to improve corpses management related to clinical biosafety and viral transmission in medical staff and the public community. We aim to understand SARS-CoV-2 persistence and infectivity in COVID-19 corpses. We conducted a systematic review according to Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) protocols. A systematic literature search was performed in PubMed, Science Direct Scopus, and Google Scholar databases using specific keywords. We critically reviewed the collected studies and selected the articles that met the criteria. We included 33 scientific papers that involved 491 COVID-19 corpses. The persistence rate and maximum postmortem interval (PMI) range of the SARS-CoV-2 findings were reported in the lungs (138/155, 89.0%; 4 months), followed by the vitreous humor (7/37, 18.9%; 3 months), nasopharynx/oropharynx (156/248, 62.9%; 41 days), abdominal organs (67/110, 60.9%; 17 days), skin (14/24, 58.3%; 17 days), brain (14/31, 45.2%; 17 days), bone marrow (2/2, 100%; 12 days), heart (31/69, 44.9%; 6 days), muscle tissues (9/83, 10.8%; 6 days), trachea (9/20, 45.0%; 5 days), and perioral tissues (21/24, 87.5%; 3.5 days). SARS-CoV-2 infectivity rates in viral culture studies were detected in the lungs (9/15, 60%), trachea (2/4, 50%), oropharynx (1/4, 25%), and perioral (1/4, 25%) at a maximum PMI range of 17 days. The SARS-CoV-2 persists in the human body months after death and should be infectious for weeks. This data should be helpful for postmortem COVID-19 management and viral transmission preventive strategy.

Keywords COVID-19 · SARS-CoV-2 · Postmortem · Persistence · Infectivity

Introduction

Coronavirus disease 2019 (COVID-19) pandemic due to the massive transmission of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection in humans has led to an unexpected situation in global health. Compared to the SARS-CoV, the spike proteins of SARS-CoV-2 have a stronger binding affinity to the angiotensin-converting enzyme 2 (ACE2) receptors, resulting in a higher transmission rate [1]. SARS-CoV-2 persistency in human corpses

also produced caution in postmortem disease management because of the possibility of transmission in medical staff or anyone involved during burial procedures [2]. However, the risk of infection from deceased COVID-19 patients may also be overestimated. Postmortem study is essential to establish the scientific basis for understanding SARS-CoV-2 infection [3].

The reverse-transcription quantitative polymerase chain reaction (RT-qPCR) test upon the respiratory swab specimens of the dead body has high sensitivity and specificity to detect SARS-CoV-2 RNA after COVID-19-related death [4]. The RT-qPCR method also evaluates viral persistency in patients' lungs, heart, and abdominal organs [5]. This method has confirmed the viral persistency in COVID-19 decedents in autopsies with different times of specimen taken after death or postmortem intervals (PMI) [6]. However, the viral infectivity in the dead body only could be measured by viral culture method. Some reports showed that the infectivity of SARS-CoV-2 was detected after recent

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death but null after 12 h [7]. This systematic review collected information from international literature to clarify and understand SARS-CoV-2 persistence and infectivity in COVID-19 corpses.

Methods

We used Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocols. We conducted a systematic literature search from PubMed, Science Direct Scopus, and Google Scholar databases on March 2, 2022. The following terms were used: “COVID-19,” “SARS-CoV-2,” “postmortem,” “post-mortem,” “persistence,” “infectivity,” and “detection” in the title, abstract, and keywords. The references of all articles were screened, reviewed, and cross-checked to find relevant studies. Only papers in English were selected for this study. The inclusion criteria for eligibility were (1) postmortem findings on SARS-CoV-2 persistence or infectivity in the COVID-19 descendants, (2) stated the specimens and postmortem interval of viral detection, (3) original research articles, (4) case reports/series, and (5) research letters. One investigator (SPP) conducted the selection process and extracted the data independently with PRISMA standards of two times repetition to minimize study bias. Two investigators (TH and SPP) verified the data, and the other investigator (RTZ) validated the methodology for qualitative synthesis. This study did not involve the living subjects and thus was exempted from institutional review board approval.

Results

Review of the literature

We identified 187 articles. The duplicated articles were removed from the list, resulting in 94 scientific papers. The remaining 94 papers, including the titles and abstracts, were screened, resulting in 41 articles. A full-text review was carried out to exclude non-eligible articles, thus generating 33 references for qualitative analysis. These 33 eligible references were carefully assessed following the aim of the systematic review. From these studies, we collected 491 samples to analyze critically. We presented the PRISMA flowchart in Fig. 1 and the literature demography in Table 1.

SARS-CoV-2 persistence

We summarized the postmortem SARS-CoV-2 persistence findings of the 33 different studies in Table 2. The viral persistence in different postmortem specimens was generally evaluated by viral RNA detection with RT-qPCR or in situ

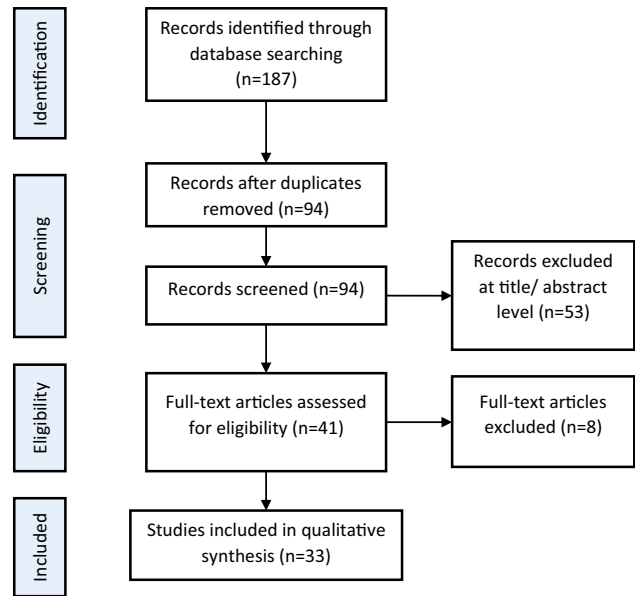


Fig. 1 Postmortem SARS-CoV-2 persistence and infectivity search strategy using PRISMA flowchart

hybridization (ISH). From the results, we classified the nucleic acid detection into several specimen sites: (1) lower respiratory tract, (2) upper respiratory tract, (3) nervous system, (4) abdominal organs, (5) heart, (6) skin, muscle, and skeletal tissue, and (7) other organs. We evaluated the PMI of each site and highlighted the most prolonged viral persistence observed. Significant findings such as viral protein and virion detection were also recorded.

The SARS-CoV-2 RNA in the lower respiratory tract was observed in lung tissue (138/155, 89.0%) and tracheal swab (9/20, 45.0%). The maximum time of viral RNA persistence was detected with RT-qPCR after 4 months in lung tissue specimens of exhumed corpses (4/4, 100%) [31]. This finding is the longest PMI of all studies. The descendants' burial in winter with constant low temperatures should be considered an influencing factor of persistence. Most studies that evaluated SARS-CoV-2 persistence in lung tissue (8/12) found the viral RNA in all samples (100%). The remaining studies (4/12) identified the viral RNA above 40% in the lungs. Viral spike and nucleocapsid protein also could be detected with immunohistochemistry (IHC) examination in lung tissue (37/75, 49.3%; max PMI range was 5 days). In the tracheal swab specimens, the viral persistence was found up to 120 h postmortem (9/20, 45.0%) in 2 studies available [14, 38].

The viral RNA was detected in the upper respiratory tract specimens in nasopharyngeal/ oropharyngeal (156/248, 62.9%) and nasal septal (3/6, 50.0%) swabs with RT-qPCR. In a case report study [12], the maximum PMI was 41 days, detected primarily from a nasopharyngeal swab. The case

Table 1 Demography of references included in the systematic review

Article	Study country	Death cases (N)	Sex	Mean age (years)	Median age (years)	Age range (years)
Aschman et al. [8]	Germany	43	31 males, 11 females	n/a	72	n/a
Beltempo et al. [9]	Italy	1	1 male	60	n/a	n/a
Berezowska et al. [10]	Switzerland	12	7 males, 5 females	n/a	73	35–96
Bogdanovic et al. [11]	Serbia	1	1 male	56	n/a	n/a
Bonelli et al. [12]	Italy	1	1 male	41	n/a	n/a
Casagrande et al. [13]	Germany	11	5 males, 6 females	68.5	n/a	n/a
Dell'Aquila et al. [14]	Italy	12	4 males, 8 females	82.3	n/a	54–93
Diao et al. [15]	China	6	n/a	n/a	n/a	n/a
Dorward et al. [16]	UK	11	10 male, 1 female	76.8	n/a	n/a
Ducloyer et al. [17]	France	1	1 male	75	n/a	n/a
Fuest et al. [18]	Germany	23	16 males, 7 females	72	n/a	n/a
Grassi et al. [19]	Italy	29	n/a	69	n/a	n/a
Heinrich et al. [20]	Germany	11	8 males, 3 females	n/a	n/a	52–90
Jurek et al. [21]	Poland	2	1 male, 1 female	90	n/a	89–91
Kurabi et al. [22]	USA	6	3 males, 3 females	n/a	65	44–91
List et al. [23]	Austria	16	10 males, 6 females	n/a	79	53–93
Zito Marino et al. [24]	Italy	27	15 males, 12 females	66.7	n/a	n/a
Matschke et al. [25]	Germany	27	n/a	n/a	n/a	n/a
Matsumoto et al. [26]	Japan	12	7 males, 5 females	71	n/a	n/a
Musso et al. [27]	Italy	16	n/a	n/a	n/a	n/a
Mwananyanda et al. [28]	Zambia	58	48 males, 10 females	n/a	48	n/a
Nagasawa et al. [29]	Japan	5	3 males, 2 females	70	n/a	58–78
Penkava et al. [30]	Germany	20	14 males, 6 females	n/a	69	44–95
Plenzig et al. [31]	Germany	2	2 females	n/a	n/a	n/a
Plenzig et al. (2) [32]	Germany	4	3 males, 1 female	81	n/a	65–88
Remmelink et al. [33]	Belgium	17	12 males, 5 females	n/a	72	62–77
Sablone et al. [34]	Italy	5	4 males, 1 female	63.8	n/a	44–84
Schröder et al. [35]	Germany	33	n/a	79	n/a	55–99
Sekulic et al. [36]	USA	2	2 males	n/a	n/a	54–81
Servadei et al. [37]	Italy	27	15 males, 12 females	76.2	n/a	n/a
Wong et al. [38]	Germany	8	5 males, 3 females	68	n/a	n/a
Yang et al. [39]	China	12	n/a	65	n/a	42–87
Zacharias et al. [40]	Austria	30	14 males, 16 females	n/a	79	65–93
Total		491				

n/a, data not available

described a 41-year-old Ukrainian man who drowned after swimming in the sea. The patient showed no COVID-19 symptoms before death with no specific antemortem diagnosis. The body was stored in a cold room at 4 °C. Another case report study found the second most extended PMI in 35 days [9]. The decedent was a 60-year-old man with a confirmed COVID-19 as the primary cause of death. Before taking nasopharyngeal swabs, the patient was transported to a local crematorium and placed in a refrigerator (−4 °C) for 35 days. The other studies [22, 38] examined the nasal septal specimens and found a maximum PMI range of 3 h.

The postmortem case series [25] investigated SARS-CoV-2 RNA in the brain, especially in the fresh frozen paraffin-embedded (FFPE) of the frontal lobe and medulla oblongata tissue. The study was conducted in Hamburg, Germany, between March 13 and April 24, 2020. We highlighted the 27 samples to be investigated with RT-qPCR and found the viral RNA in 13/27 samples (48.1%). However, the author did not mention the maximum time of PMI of the 27 RT-qPCR samples, instead of the median PMI of 3.3 days, including other corpses that had undergone different diagnostic procedures. IHC procedure of the brain also detected

Table 2 SARS-CoV-2 persistence findings in postmortem studies

Article	Postmortem specimen	Mean PMI	Median PMI	PMI	Diagnostic method	Positive postmortem cases	Other findings
Aschman et al. [8]	Lung tissue	n/a	45 h	< 6 days	RT-qPCR	38/43 (88%)	RT-qPCR detected viral RNA in the heart (10/42), quadriceps (7/41), and deltoid (2/42) tissues
Beltempo et al. [9]	Nasopharyngeal and oropharyngeal swab	n/a	n/a	35 days	RT-qPCR	1/1 (100%)	
Berezowska et al. [10]	FFPE tissue of lung	27 h	14 h	6.5–70 h	RT-qPCR	12/12 (100%)	IHC detected viral spike protein in lung tissue (6/12). ISH detected viral mRNA in lung tissue (3/5)
Bogdanovic et al. [11]	Vitreous humor	n/a	n/a	3 months	RT-qPCR	1/1 (100%)	
Bonelli et al. [12]	Nasopharyngeal swab	n/a	n/a	41 days	RT-qPCR	1/1 (100%)	
Casagrande et al. [13]	Corneal disc	2.7 days	n/a	n/a	RT-qPCR	6/11 (67%)	
Dell'Aquila et al. [14]	Nasopharyngeal swab	43.92 h	n/a	12–120 h	RT-qPCR	7/12 (58%)	RT-qPCR detected viral RNA in tracheal swab (3/12), and lung swab (5/12)
Diao et al. [15]	Kidney tissue	n/a	n/a	0–24 h	ISH	6/6 (100%)	IHC detected viral nucleocapsid and spike protein (6/6)
Dorward et al. [16]	Lung tissue	n/a	19.3 h	n/a	RT-qPCR	11/11 (100%)	
Ducloyer et al. [17]	Nasopharyngeal swab	n/a	n/a	48 h	RT-qPCR	1/1 (100%)	
Fuest et al. [18]	Nasopharyngeal swab	34.5 h	n/a	n/a	RT-qPCR	4/23 (17%)	12/23 deceased patients tested negative in the last RT-qPCR test
Grassi et al. [19]	Nasopharyngeal swab	4.7 days	n/a	n/a	RT-qPCR	13/29 (45%)	
Heinrich et al. [20]	Nasopharyngeal swab	n/a	5.7 h	2.9–32 h	RT-qPCR	11/11 (100%)	RT-qPCR detected viral RNA after death within 0 h (9/11), 12 h (10/11), 24 h (10/11), 36 h (11/11), 60 h (11/11), 72 h (11/11), 96 h (11/11) and 168 h (11/11)
Jurek et al. [21]	Bone marrow	n/a	n/a	12 days	RT-qPCR	2/2 (100%)	
Kurabi et al. [22]	Middle ear	n/a	n/a	3 h	RT-qPCR	3/6 (50%)	RT-qPCR detected viral RNA in nasal septal mucosa (3/6)
List et al. [23]	Aqueous humor and vitreous humor	n/a	21.5 h	4–53 h	RT-qPCR	0/16 (0%)	
Zito Marino et al. [24]	FFPE tissue of lung	n/a	n/a	3–5 days	RT-qPCR	27/27 (100%)	ISH detected viral RNA in lung FFPE tissue (12/27)
Matschke et al. [25]	FFPE tissue from the frontal lobe	3.3 days	n/a	n/a	RT-qPCR	13/27 (48%)	IHC detected viral spike (14/40) and nucleocapsid (8/40) proteins in the brain
Matsumoto et al. [26]	Nasopharyngeal swab	67.67 h	n/a	< 240 h	RT-qPCR	7/7 (100%)	
Musso et al. [27]	Lung tissue	n/a	n/a	24–78 days	RT-qPCR	12/16 (75%)	
Mwananyanda et al. [28]	Nasopharyngeal swab	n/a	n/a	< 48 h	RT-qPCR	58/58 (100%)	
Nagasawa et al. [29]	Nasopharyngeal swab	n/a	n/a	2–11 days	RT-qPCR	5/5 (100%)	
Penkava et al. [30]	Conjunctival swabs	n/a	n/a	19–78 h	RT-qPCR	10/20 (50%)	RT-qPCR detected viral RNA in vitreous swab (6/20)

Table 2 (continued)

Article	Postmortem specimen	Mean PMI	Median PMI	PMI	Diagnostic method	Positive postmortem cases	Other findings
Plenzig et al. [31]	Lung tissue	n/a	n/a	4 months	RT-qPCR	2/2 (100%)	
Plenzig et al. (2) [32]	Lung tissue	n/a	n/a	1–17 days	RT-qPCR	4/4 (100%)	RT-qPCR detected viral RNA from the kidney (1/2), small intestine (1/4), and brain (1/4) tissue
Remmelink et al. [33]	Lung tissue	n/a	n/a	< 5 days	RT-qPCR	16/17 (94%)	RT-qPCR detected viral RNA in the heart (14/17), liver (14/17), bowel (14/17), spleen (11/17), and kidney (10/17). IHC detected viral protein in the lung (11/17)
Sablone et al. [34]	Nasopharyngeal swab	n/a	n/a	22–27 days	RT-qPCR	5/5 (100%)	RT-qPCR detected viral RNA in respiratory tract swabs and multiorgan biopsies (5/5)
Schröder et al. [35]	Nasopharyngeal swab	3.5 days	n/a	0–17 days	RT-qPCR	24/33 (72%)	RT-qPCR detected viral RNA in perioral swabs (21/24), body bag (6/24), hands (14/24), wrists (14/24), shoulder & hips (13/24)
Sekulic et al. [36]	FFPE tissue of lung	n/a	n/a	29–39 h	RT-qPCR	2/2 (100%)	RT-qPCR detected viral RNA in FFPE tissue of the lymph node (2/2), bronchus, spleen, and heart (1/2)
Servadei et al. [37]	Nasopharyngeal swab	n/a	n/a	2 h	RT-qPCR	19/27 (70%)	RT-qPCR detected viral RNA after death within 12 h (16/27) and 24 h (18/27)
Wong et al. [38]	FFPE tissue of the lung	n/a	35.5 h	20–48 h	RT-qPCR	8/8 (100%)	RT-qPCR detected viral RNA in FFPE tissue of the salivary gland and tonsil (7/8), trachea (6/8), thyroid (6/8), heart (6/8), stomach (3/8), kidney, liver, spleen, and adrenal gland (2/8)
Yang et al. [39]	Testes	n/a	n/a	1 h	RT-qPCR	1/12 (8.3%)	
Zacharias et al. [40]	Nasopharyngeal swab	n/a	23 h	8–124 h	RT-qPCR	11/11 (100%)	

n/a data not available

viral spike (14/40, 35%) and nucleocapsid (8/40, 20%) protein in this period. Another study [32] revealed viral RNA persistence up to 17 days after death (1/4, 25.0%) as the most extended PMI observed in the brain.

SARS-CoV-2 RNA had been detected in the abdominal organs, including the kidney (19/29, 65.5%), gastro-intestine (18/29, 62.1%), liver (16/25, 64.0%), and spleen (14/27, 51.9%) with a maximum PMI range of 17 days after death. In another original study [15], the viral spike and nucleocapsid protein were observed in kidney tissue (6/6, 100%) 24 h after death. The cases were COVID-19 deaths with acute kidney injury (AKI). In this study, six corpses underwent an ISH test, and the result showed that all kidney tissues expressed positive signals for Probe-V-nCoV2019-S and Probe-V-nCoV2019-S-sense. This finding confirmed that the virus directly infects human kidney tubules and replicates in vivo.

The persistence of viral RNA was reported generally in postmortem heart tissue (31/69, 44.9%) with the PMI up to 6 days. However, a case-control study [8] found no viral protein in heart muscles with the IHC test during this period. In the same study, the viral RNA was found in skeletal muscle of quadriceps (7/41, 17.1%) and deltoid (2/42, 4.8%) tissue with RT-qPCR. The maximum PMI range was 6 days. Another study [21] detected viral RNA in the bone marrow (2/2, 100%) at 12 days postmortem using the real-time loop-mediated isothermal amplification (RT-LAMP) method and confirmed with agarose gel electrophoresis. At skin level, a study of deceased bodies of COVID-19 decedents reported the RNA persisted in swab specimens of hands (14/24, 58.3%), wrists (14/24, 58.3%), shoulders and hips (13/24, 54.16%), and body bag surface (6/24, 25%) with PMI of 0–17 days [35]. The longest PMI observed in skin swabs was 9 days.

The SARS-CoV-2 RNA also had been identified in other organs. The sites (persistence rate; maximum PMI range) were the vitreous humor (7/37, 18.9; 3 months), perioral (21/24, 87.5%; 17 days), conjunctiva (10/20, 50%; 78 h), tonsils (7/8, 87.5%; 48 h), adrenal glands (2/8, 25%; 48 h), thyroid glands (6/8, 75%; 48 h), hilar and peribronchial lymph node (2/2, 100%; 39 h), middle ear (3/6, 50.0%; 3 h), and testes (1/12, 8.3%; 1 h). An immersive long PMI (up to 3 months) was reported in a study of vitreous humor sample [11]. The case was a 56-year-old man who died after having fever, cough, and shortness of breath with no history of travel abroad for a long time, and the autopsy was conducted 3 months later. No additional information was available about the environmental condition in this case.

SARS-CoV-2 infectivity

Four of 33 references in the systematic review investigated the viability and infectivity of SARS-CoV-2 in postmortem specimens using the viral culture method (Table 3). The first study [40] found that the cultivation was positive in 7 of 11 lung tissue swabs at a PMI range of 14–68 h (median 25 h). The cases were Caucasians, with a median age of 79 years (range 65–93 years), and 56% were male. The median disease duration (the interval between the first RT-qPCR confirmation and death) was 9 days (range 3–34 days).

The second study [32] on cell culture was conducted from four COVID-19 corpses. The research detected the cytopathogenic effect (CPE) as the sign of SARS-CoV-2 infectivity. The CPE was observed in the lungs (2/4, 50%), trachea (2/4, 50%), oropharynx (1/4, 25%), and perioral (1/4, 25%) tissue. The PMI of the two cases was 4 days (case 1: positive for the lungs, trachea, and oropharynx) and 17 days (case 2: positive for the lungs, trachea, and perioral). In case 2, where

Table 3 SARS-CoV-2 infectivity findings in postmortem studies

Article	Postmortem specimen	Mean PMI	Median PMI	PMI	Diagnostic method	Positive postmortem cases	Other findings
Zacharias et al. [40]	Lung tissue	n/a	25 h	14–68 h	Viral culture	7/11 (64%)	
Plenzig et al. (2) [32]	Lung tissue	n/a	n/a	1–17 days	Viral culture	2/4 (50%)	Positive culture in trachea (2/4), perioral (1/4), and oropharynx (1/4)
Plenzig et al. [31]	Lung tissue	n/a	n/a	4 months	Viral culture	0/2 (0%)	
Schröder et al. [35]	Perioral swab	n/a	n/a	0–5 days	Viral culture	0/11 (0%)	No positive culture in the hands (0/5), wrist (0/6), shoulder and hips (0/6), and body bag (0/2)

n/a data not available

the longest PMI of infectious SARS-CoV-2 was found, the patient was an 82-year-old woman contacted by relatives who showed flu-like symptoms. Then, she developed fever, dyspnea, and cough 2 days before death. Her husband found she was dead on the floor in the living room. The RT-qPCR diagnosis was made 2 days after death from a tracheal swab. An autopsy was taken on day 17, and the cause of death was COVID-19 with a severe pre-existing medical condition.

The third study [31] was conducted on two long-buried exhumed corpses. The cases were patients who confirmed positive COVID-19 antemortem by PCR (case 1) and rapid antigen test (case 2). The postmortem viral RNA was found positive in lung tissue exhumation after 4 months (case 1) and 3 months 26 days (case 2). However, no viable virus was found in the cell culture observation of both cases, so the infectivity was not measurable. The viability of SARS-CoV-2 was also undetected from another cell culture study [35] of the body surface and the body environment swab specimens at PMI of 5 days.

Discussion

Investigating SARS-CoV-2 persistence and infectivity on postmortem COVID-19 corpses is essential to ensure a preferable strategy for safely handling deceased patients. Despite a widely reported viral persistence [41], there is still limited evidence of viral infectivity after death, while some strict protocols have been established in medical and community settings to prevent viral transmission from the dead body [42–45]. This systematic review critically collects and observes viral persistence and infectivity in different postmortem COVID-19 specimens from published scientific papers. We highlight the most extended postmortem interval and some demographical information of the selected cases to present the updated condition.

SARS-CoV-2 RNA and structural protein persistence are observed in most COVID-19 dead bodies. The leading site is the respiratory tract, particularly the lungs and the pharynx. RT-qPCR might still detect the viral RNA in the lung months after the death, and the RNA is generally persistent for hours to weeks in other organs. This feature extends the 9-day persistence duration of other coronaviruses, including severe acute respiratory syndrome coronavirus (SARS-CoV) and middle east respiratory syndrome coronavirus (MERS-CoV) in the inanimate surface [46]. However, the viral RNA or protein solely cannot infect another human cell. The detection of the remaining postmortem RNA is explained by the rates of residual RNA replication, its catabolic degradation, and the cytotoxic activity of formerly living infected cells [47]. There is also evidence that lower temperature and humidity may prolong viral RNA degradation in the human body [48].

This finding may explain the long PMI of detectable RNA in the long-stored or buried corpses in such conditions.

The SARS-CoV-2 infectivity is still detected until 17 days after the death, particularly in the lung, trachea, and perioral of one postmortem case that was immediately sent to the cooling chamber [32]. This finding should be explained by the increased stability of SARS-CoV-2 at a lower temperature [48]. The Ct value below 34 in the RT-qPCR test (in this case, 20.88) may also increase the probability of positive cell culture [49]. However, the evidence of viral infection from specimens taken at the body surface is null, but postmortem management's safety procedures are still very considered [50]. A higher precaution is needed in handling pre-cooled corpse autopsies.

The limitation of this study is primarily due to the design of the selected studies. The data might have biases because of the studies' non-uniformity included in the review and the minimal samples per specimen targets. The cases may also not represent the general population, mainly drawing specific study populations. Here we describe the updated findings as preferable as a precaution in handling COVID-19 corpses in the fields.

Conclusion

This systematic review explains the SARS-CoV-2 persistence and infectivity in corpses. The virus may persist months after death and remain viable and infectious for weeks postmortem under certain conditions. This study helps to give a clearer image of SARS-CoV-2 in the dead body and improves the importance of using a precaution safety procedure for medical staff in different postmortem settings. We recommend further study focusing on the access of external and internal factors that increase the viral transmission and infection rate from COVID-19 corpses in different environmental conditions.

Key points

1. The SARS-CoV-2 is still detected four months after death and remains viable and infectious for 17 days postmortem.

Acknowledgements SPP is involved in study design, data collection and analyses, and manuscript drafting. TH verified the data and validated the concept. RTZ validated the methodology for qualitative synthesis. All authors read and approved the final manuscript.

Declarations

Ethics approval This study did not involve the living subjects and thus exempted from institutional ethical review board approval.

Conflict of interest The authors declare no competing interests.

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