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TITLE PAGE

Absence of Severe Acute Respiratory Syndrome-Coronavirus-2 RNA in Human Corneal Tissues

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PURPOSE: To examine corneal tissue for SARS-CoV-2 positivity with regard to implications for tissue procurement, processing, corneal transplantation and ocular surgery on healthy patients. We performed quantitative (q)RT-PCR-testing for SARS-CoV-2 RNA on corneal stroma and endothelium, bulbar conjunctiva, conjunctival fluid swabs, anterior chamber fluid and corneal epithelium of COVID-19 postmortem donors.

METHODS: Included in this study were 10 bulbi of 5 COVID-19 patients who passed away due to respiratory insufficiency. Informed consent and Institutional Review Board approval was obtained prior to this study (241/2020BO2). SARS-CoV-2 was detected via a pharyngeal swab and broncho-alveolar lavage. Tissue procurement and tissue preparation were performed with personal protective equipment (PPE) and the necessary protective measures. qRT-PCR-testing was performed for each of the above mentioned tissues and intraocular fluids.

RESULTS: The qRT-PCRs yielded no viral RNA in the following ocular tissues and intraocular fluid: Corneal stroma and endothelium, bulbar-limbal conjunctiva, conjunctival fluid swabs, anterior chamber fluid and corneal epithelium.

CONCLUSION: In this study no SARS-CoV-2-RNA was detected in conjunctiva, anterior chamber fluid and corneal tissues (endothelium, stroma and epithelium) of COVID-19 donors. This implicates that the risk for SARS-CoV-2 infection via corneal or conjunctival tissue is very low. However, further studies on a higher number of COVID-19 patients are necessary to confirm these results. This might be of high importance for donor tissue procurement, processing and corneal transplantation.

INTRODUCTION:

The ongoing Severe Acute Respiratory Syndrome coronavirus 2 (SARS-CoV-2) pandemic is a global health threat that causes immanent hardships in medical practice involving logistics, patient management, surgery and handling of infectious materials[1-3].One of the first healthcare professionals to raise the alarm was the Chinese ophthalmologist Li Wenliang, who died from coronavirus disease 2019 (COVID-19) at the young age of 33, after being infected by one of his patients[4]. In general, ophthalmologists are at great risk due to close patient contact while performing a significant number of examinations and interventions. Despite the question, whether SARS-CoV-2 has the potential to be transmitted via ocular fluids, it is of special interest for cornea and eye banking specialists to know if corneal tissues are potentially infectious and possibly mediate the transmission of SARS-CoV-2 from corneal donors to recipients. Currently there is a lot of discussion among corneal specialists regarding acute adjustments and changes to standard procedures in tissue procurement, processing and transplantation (personal communication, Tissue transplant Section of the German Ophthalmological Society). A recent study confirmed that SARS-CoV-2 can invade the conjunctival epithelium and cause a full-blown picture of viral conjunctivitis[5]. The objective of this study was to evaluate corneal involvement in COVID-19 postmortem donors in the following tissues: corneal stroma and endothelium, bulbar-limbal conjunctiva, conjunctival fluid swabs, anterior chamber fluid and corneal epithelium. Findings may have implications for corneal transplantation and in particular corneal tissue procurement and processing. Our secondary objective was to describe precautions taken and personal protective equipment (PPE) used during these tissue procurements[6].

MATERIALS AND METHODS:

INFORMED CONSENT, APPROVAL OF INDEPENDENT INSTITUTIONAL REVIEW BOARD

Informed consent, adherence to the Declaration of Helsinki and approval of an independent Ethics Committee (institutional review board) was obtained prior to commencement of study (241/2020BO2).

TISSUE PROCUREMENT

Specific guidelines, assessment of the environment for tissue procurement, and personal protective equipment:

Guidelines for the enucleation team (two persons): To be checked prior to the enucleation of a COVID-19 postmortem donor:

1. Place of enucleation defined as an area and/or room needing permission to access (time spent at location has to be documented);
2. Place of enucleation is not allowed to be used by another person at time of tissue extraction;
3. Any kind of aerosol and/ or turbulence has to be prevented;
4. The necessary equipment has to be discarded after usage and/ or disinfected depending on the specific utensils used;
5. To preclude any kind of self-harm personal protective equipment (PPE) has to be used appropriately. This includes:

- surgical hand disinfection;
- gowns (overalls and apron); double gloves (as indicator system); and hood;
- face mask (FFP-3 level: 0.6µm/ 99% filtration);
- surgical instruments with tray;
- Disposal of infectious wastes in a one-time lockable container; and of sharp utensils in a suitable, second container.

Enucleation and preparation protocols:

A routine tissue procurement protocol for corneal banking was employed for the left globe of each donor. The respective right globe was kept naïve during the enucleation and preparation steps.

Enucleation:

The enucleation was performed at the designated COVID-19 autopsy room of the Institute for Pathology and Neuro-pathology of the University Hospital of Tuebingen. The average time of death to retrieval was 21 hours.

The following steps were performed:

- Final check of the set of instruments;

- Double check identity of postmortem donor and consent form;
- Confirm cause of death (COVID-19);
- Documentation of donor side (right/left), place, and time of enucleation;
- Proper usage of PPE including fitting test of FFP-3/ N-95;
- Inspection of body bag and corpus;
- Preparation of transport media and vessel (left globe: sterile gauze, 10mL NaCl, 10 mL gentamicinsulfate (5mg/mL); right globe: sterile gauze, 10mL NaCl; mark each vessel: COVID-19 donor tissue);
- Flushing of the superior and inferior fornix of the left globe (Betaisodona®; 1:10 diluted in sterile NaCl equivalent to 1% of free iodine, flushing with sterile NaCl after 5 min), periocular wiping with Betaisodona®; right globe is kept naive;
- Appropriate usage of provided drape, vessel and PPE;
- Perform enucleation with provided single-use surgical set (eyelid blocker, forceps, scissors, hooks) to obtain an intact globe with conjunctivae (5-10mm);
- Prosthesis selection, insertion and closure of palpebral fissures;
- Transfer of each globe into specific transport vessel and a re-lockable container marked “COVID-19 donor tissue”;
- Disposal of used PPE and potentially infectious materials.

Transport:

- Transport via re-lockable, marked container (“COVID-19 donor tissue”);
- Temperature is recorded and kept between 33.8°F to 50°F (+1 to +10°C) using cooling packs and box avoiding contact to ice (Libero T1, Elpro, Switzerland); direct preparation and further testing of donor tissue or storage at 42.8°F (6°C);

Preparation:

The preparation was performed at a BSL2 laboratory (under a sterile workbench) of the Institute for Medical Virology of the University of Tuebingen. The average time of death to preservation was 31 hours. The following steps were performed:

- Use of PPE including fitting test of FFP-3/ N-95;
- Disinfection of the sterile workbench (Descosept-AF, desiccation of 15 min);
- Disinfection of globe (left) in diluted iodine solution (5 min in Betaisadona® (7.5 %, Braun, #3864154)/ NaCl (250 ml, Fresenius Kabi, PZN-00809049) 1:20) and thorough rinse (in 50 mL NaCl); right globe is kept naïve;
- Preparation of a corneoscleral donor tissues/fluids (surgical set: surgical forceps,15 mm trephine, 30G-cannulas, Kolibri-forceps, Vannas-scissors, Westcott-scissors, hockey knife and vacuum holder) and extraction of tissue samples for quantitative Reverse Transcription-Polymerase Chain Reaction (qRT-PCR) testing on SARS-CoV-2 RNA (4 samples per type of tissue/fluid: corneal stroma and endothelium, bulbar conjunctiva, conjunctival fluid swabs, anterior chamber fluid and corneal epithelium);

RNA extraction and quantitative Reverse Transcription-Polymerase Chain Reaction based on quality approved protocols with controls:

- Addition of 600µL RLT (1mL RLT, 10µL ß-mercapto-ethanol RNeasy Kit, QiaCube, QiaSymphony DSP Virus/ Pathogen Kit, Qiagen, Hilden, Germany;) and one 5mm-steel ball (Qiagen #69989) to each sample;
- Dissolution in ball mill (Fa. Retsch, 2min, level 100);
- Purification in shredder pillar (Qiagen (#79656), ↺ centrifugation at 2min at 14.000rpm; addition of same volume of 70% EtOH with DEPC-H2O , non-vortex mix, 700µL for RNeasy spin column, ↺ centrifugation at 15sec at 14.000rpm, repeat with remaining RLT/EtOH mix);
- qRT-PCR using RealStar SARS-CoV-2 RT-PCR Kit 1.0 (altona Diagnostics GmbH, Hamburg, Germany) and LightMix® Modular SARS-CoV (COVID19) kit (TIB Molbiol Syntheselabor GmbH, Berlin, Germany).

DNAse digest with RNAse-Free DNase Set (#79254), purification with RNeasy Mini Kit (Qiagen #74106):

- Dissolution of lyophilized DNAse in RNAse free water (550µL);
- Addition of RW1 buffer (↺ centrifugation at 15sec at 14.000rpm, wash column) and of DNAse (10µL) to RDD buffer (70µL), non-vortex mix, centrifugation;
- Addition of DNAse mix to center of column (15min RT);
- Add RW1 buffer (350µL) to column (↺ centrifugation at 15sec at 14.000rpm), RPE (500µL, ↺ centrifugation at 15sec at 14.000rpm, wash column);
- Transfer column to 2nd collection tube (↺ centrifugation at 1min at 14.000rpm) and new Eppendorf tube/ micro-reaction vessel;
- Add RNAse free water (30-50µL, ↺ centrifugation at 1min at 14.000rpm);
- Second addition of RNAse free water (30-50µL, ↺ centrifugation at 1min at 14.000rpm) in case of >30µg RNA.

quantitative Reverse Transcription-Polymerase Chain Reaction:

- 10 µl of the RNA, positive or negative control were used for qRT-PCR with the LightMix® SarbecoV E-gene Kit (TIB MOLBIOL, 40-0776-96) in combination with the Roche LightCycler® Multiplex RNA Virus Master (Roche, 07083173001). The positive Control was supplied with the LightMix Kit and contained all diagnostic targets (E gene, N gene and RdRP) of SARS and SARS-CoV-2. As negative control the water supplied with the Roche Master kit was used. The reaction mix was prepared as described in the manual.
- Data analysis was performed as described in LightCycler II operator's manual, in brief, color compensation was selected for multiplex assays and the

"Second Derivative Maximum method" was used. The results were shown in FAM channel.

- According to the producers manual, the sensitivity is 5.2 copies per reaction. A hole genome, synthetic RNA control (Twist Bioscience, #MT007544.1) was also used in qRT-PCR; a consecutive dilution showed, that down to 10 copies per reaction SARS-CoV-2 was detectable (linear correlation) (data not shown). The cut-off was defined as recommended in the LightMix Kit manual: C_P value for 10 copies (35.48 ± 0.2) plus 1 cycle and resulted in a C_P-cut-off value of 36.48.

Postmortem pulmonary tissue samples from COVID-19 deceased were tested for SARS-CoV-2 RNA via RT-PCR. All tested samples had positive SARS-CoV-2 results (unpublished data). Whether these samples were still infectious or not was not evaluated.

The interim guidance of the Centers for Disease Control and Prevention states concerning "Collection and Submission of Postmortem Specimens from Deceased Persons with Known or Suspected COVID-19": No data are currently available on the frequency of detection of SARS-CoV-2, the virus that causes COVID-19, by RT-PCR on postmortem swabs collected at different durations after death. If COVID-19 testing on postmortem swab specimens is being considered for a suspected COVID-19 case, SARS-CoV-2 RNA may still be detected up to 3 days postmortem and possibly longer based on available data from experiences with MERS-CoV and SARS-CoV; however sensitivity may be reduced with a longer postmortem interval, and duration of illness may need to be considered in interpreting a negative result[7]. Per the United States Food and Drug Administration, respiratory viruses, in general, are not known to be transmitted by transplantation of human cell, tissue, or cellular

or tissue-based product and there have been no reported cases of SARS-CoV, MERS-CoV, or any other coronavirus transmission via transplantation of ocular tissue[8]. European agencies advance a similar view as the US-centric agencies. This is outlined in the European CDC Technical Report "Infection prevention and control for COVID-19 in healthcare settings – first update, 12 March 2020". It references the "World Health Organization Interim Guidance for Collection and Submission of Postmortem Specimens from Deceased Persons Under Investigation (PUI) for COVID-19, 19 February 2020" (cited 11 March 2020; available from: https://www.cdc.gov/coronavirus/2019-ncov/hcp/guidance-postmortem-specimens.html).

Histopathology:

A histopathological macroscopic and microscopic examination using standard hematoxylin and eosin stains was performed on the extracted tissues.

Donor characteristics and clinical aspects of COVID-19:

The age of the donors ranged from 74 to 89 (mean: 80 years; 1 female; 4 male). Past medical history included: arterial hypertension in all and diabetes mellitus in one patient. All donors were on anti-hypertensive drug regimens. One patient received in addition anti-hyperglycemic treatment. Three patients were on angiotensin-converting enzyme (ACE) inhibitor class of medications, one patient was on an angiotensin-receptor blocker (ARB) and another one on the anti-hyperglycemic agent of the biguanide class (metformin). The mean time of hospitalization prior to demise was 15 days (±12.9 SD; range: 1-32 days)[Tab1a].

All patients had initially unspecific symptoms which progressed to a full picture of COVID-19 with distinct dyspnea. Pharyngeal swabs and bronchoalveolar lavage fluid were tested positive for SARS-CoV-2-RNA by qRT-PCR. Coinfection by HSV, CMV,

RSV, parainfluenza, and influenza were excluded through qRT-PCR. The type of care included supportive, respiratory intubation and machine-assisted support including extracorporeal membrane oxygenation (ECMO) and continuous venovenous hemofiltration[Tab1b]. Supportive care was administered to all patients, respiratory ventilation to 4 patients and machine-assisted support to 3 patients (1x ECMO and 2x hemofiltration). Organ system involvement was extensive in all cases and included the respiratory, gastrointestinal and urogenital systems. The respiratory system was involved in all cases extending to Acute Respiratory Distress Syndrome in all and complicated by pleural effusion in two, atrial fibrillation in one and myocardial infarction in three patients. A life-threatening organ dysfunction was diagnosed in all patients leading to the involvement of the gastrointestinal and genitourinary systems. Acute liver failure was seen in two and acute kidney failure in all patients. Multi-organ dysfunction syndrome was finally diagnosed in 3 patients. Laboratory parameters showed a leukocytosis combined with lymphopenia in 2 and a reduced hemoglobin concentration in 4 cases.

RESULTS:

We report here the absence of SARS-CoV-2 RNA in corneal tissues obtained from COVID-19 postmortem donors using qRT-PCR. All tissue samples tested negative for SARS-CoV-2 viral RNA amplyfing the viral S and E genes[Tab2]. All internal positive and negative controls were valid and included in each set of analyses. In addition, there was no difference noted in SARS-CoV-2 RNA detection between the routine tissue procurement protocol for corneal banking employed for the left globe of each donor and the respective right globe which was kept naïve during the enucleation and preparation steps.

The macroscopic and microscopic histopathological examinations performed confirmed in all globes normal extra- and intraocular morphology without histological signs of inflammation.

DISCUSSION:

Recent studies suggest that clinical manifestations of ocular surface disease of COVID-19 are not common and are usually limited to the conjunctiva[5,11-13]. To our knowledge our study may be the first suggesting the absence of SARS-CoV-2 RNA in conjunctiva and corneal tissue in COVID-19 cadaveric donors. Recently, a case of viral conjunctivitis of SARS-CoV-2 has been reported[5]. In addition, its RNA has been detected in tears and conjunctival secretions[11]. This suggests that the clinical spectrum of an ocular SARS-CoV-2 involvement might potentially be of greater extent.

Related to the current Centers for Disease Control and Prevention interim guidance we would like to point out that false negative testing may be due to timing of PCR testing, testing capability, postmortem interval and length of hospitalization/ duration of disease (see also [14]). In addition, no test has been validated to date for testing in cadaveric donors. We note here that qRT-PCR was done on COVID-19 cadaveric donor tissues and fluids. Thus, a false negative result might be more likely than during the acute phase of the disease. However, the number of eligible cases was limited because of informed consent of the next of kin or the patient himself prior to demise.

Therefore, future independent studies analyzing higher numbers of postmortem COVID-19 donors for SARS-CoV-2 RNA in ocular tissues are necessary and warranted. Furthermore, to clarify possible modes of transmission through

conjunctiva or ocular tissues evidence of viral replication and cytopathology in living subjects suffering from COVID-19 should be analyzed in all phases of disease.

To our current knowledge, SARS-CoV-2 viral replication as well as its lytic activity restricts to epithelia. Therefore, corneal epithelial cells could potentially host the virus and when transplanted within corneal transplants may transmit virus to the recipients of these transplants. This motivated us to analyze different types of corneal tissues and anatomically related fluids of COVID-19 tissue donors for presence of SARS-CoV-2 RNA.

So far, little is known on the clinical spectrum of ocular disease caused by SARS-CoV-2 infection[9,10]. However, several modes of transmission of SARS-CoV-2 involving ocular tissue and tears are being discussed[11-13]. The angiotensin-converting enzyme 2 (ACE-2) receptor has been found to be a binding site of SARS-CoV-2[15]. Separately, the presence of ACE-2 receptor has been noted in ocular tissues[15-18].

Due to these uncertainties regarding a possible transmission, we have adapted our tissue procurement process for the collection of COVID-19 positive patients according to the current guidelines and described it in detail in the context of this study. Even though the increased safety precautions mean an increased expenditure of time and material, we recommend taking them into account. No SARS-CoV-2 infection occurred in our collection team during this study.

In conclusion, this study shows the absence of SARS-CoV-2 RNA in postmortem COVID-19 donors in corneal tissues and anatomically related fluids. This implicates that the risk for SARS-CoV-2 infection via corneal or conjunctival tissue may be very low and suggests that SARS-CoV-2 transmission via ocular tissue may be an unlikely event. Taking into account the limitations of this study, it suggests a low risk

for viral transmission due to tissue procurement and processing of donor tissue for corneal transplantation surgery from individuals succumbed to SARS-CoV-2.

REFERENCES:

1. Keil SD, Ragan I, Yonemura S, et al. Inactivation of severe acute respiratory syndrome coronavirus 2 in plasma and platelet products using a riboflavin and ultraviolet light-based photochemical treatment. *Vox Sang.* 2020 Apr 20. doi: 10.1111/vox.12937. [Epub ahead of print]

2. CDC COVID-19 Response Team. Characteristics of Health Care Personnel with COVID-19 - United States, February 12-April 9, 2020. *MMWR Morb Mortal Wkly Rep.* 2020 Apr 17;69(15):477-481. doi: 10.15585/mmwr.mm6915e6.

3. Judson TJ, Odisho AY, Neinstein AB, et al. Rapid Design and Implementation of an Integrated Patient Self-Triage and Self-Scheduling Tool for COVID-19. *J Am Med Inform Assoc.* 2020 Apr 8. pii: ocaa051. doi: 10.1093/jamia/ocaa051. [Epub ahead of print]

4. Hu K, Patel J, Patel BC. Ophthalmic Manifestations Of Coronavirus (COVID-19). *StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing*; 2020-. 2020 Apr 13.

5. Chen L, Liu M, Zhang Z, et al. Ocular manifestations of a hospitalised patient with confirmed 2019 novel coronavirus disease. *Br J Ophthalmol*. 2020 Apr 7. pii: bjophthalmol-2020-316304. doi: 10.1136/bjophthalmol-2020-316304. [Epub ahead of print]

6. Barton LM, Duval EJ, Stroberg E, et al. COVID-19 Autopsies, Oklahoma, USA. *Am J Clin Pathol.* 2020 Apr 10. pii: aqaa062. doi: 10.1093/ajcp/aqaa062. [Epub ahead of print]

7. Centers for Disease Control and Prevention. Collection and Submission of Postmortem Specimens from Deceased Persons with Known or Suspected COVID-19. (2020) Available from: https://www.cdc.gov/coronavirus/2019-ncov/hcp/guidance-postmortem-specimens.html

8. Food and Drug Administration. Updated Information for Human Cell, Tissue, or Cellular or Tissue-based Product (HCT/P) Establishments Regarding the Coronavirus Disease 2019 Pandemic (April 1, 2020). Available from: https://www.fda.gov/vaccines-blood-biologics/safety-availability-biologics/updated-information-human-cell-tissue-or-cellular-or-tissue-based-product-hctp-establishments

9. Gérard D, Henry S, Thomas B. SARS-CoV-2: A new aetiology for atypical lymphocytes. *Br J Haematol.* 2020 Apr 20. doi: 10.1111/bjh.16730. [Epub ahead of print]

10. Di Mascio D, Khalil A, Saccone G, et al. Outcome of Coronavirus spectrum infections (SARS, MERS, COVID 1 -19) during pregnancy: a systematic review and meta-analysis. *Am J Obstet Gynecol* MFM. 2020 Mar 25:100107. doi: 10.1016/j.ajogmf.2020.100107. [Epub ahead of print]

11. Xia J, Tong J, Liu M, et al. Evaluation of coronavirus in tears and conjunctival secretions of patients with SARS-CoV-2 infection. *J Med Virol*. 2020 Feb 26. doi: 10.1002/jmv.25725. [Epub ahead of print]

12. Peng Y, Zhou YH. Is novel coronavirus disease (COVID-19) transmitted through conjunctiva? *J Med Virol*. 2020 Mar 16. doi: 10.1002/jmv.25753. [Epub ahead of print]

13. Liu Z, Sun CB. Conjunctiva is not a preferred gateway of entry for SARS-CoV-2 to infect respiratory tract. *J Med Virol*. 2020 Apr 10. doi: 10.1002/jmv.25859. [Epub ahead of print]

14. Irene C Kuo. (2020) A Rashomon Moment? Ocular Involvement and COVID-19. Ophthalmology, S0161-6420(20)30404-8. doi: 10.1016/j.ophtha.2020.04.027. Online ahead of print.

15. Walls AC, Park YJ, Tortorici MA, et al. Structure, Function, and Antigenicity of the SARS-CoV-2 Spike Glycoprotein. *Cell.* 2020 Apr 16;181(2):281-292.e6. doi: 10.1016/j.cell.2020.02.058. Epub 2020 Mar 9.

16. Senanayake Pd, Drazba J, Shadrach K, et al. Angiotensin II and its receptor subtypes in the human retina. *Invest Ophthalmol Vis Sci*. 2007 Jul;48(7):3301-11.

17. Wagner J, Jan Danser AH, Derkx FH, et al. Demonstration of renin mRNA, angiotensinogen mRNA, and angiotensin converting enzyme mRNA expression in the human eye: evidence for an intraocular renin-angiotensin system. Br J Ophthalmol. 1996 Feb;80(2):159-63.

18. Demurtas P, Di Girolamo N, Corrias M, et al. Immunohistochemical analysis of angiotensin converting enzyme in Sardinian pterygium. *Histol Histopathol.* 2013 Jun;28(6):759-66. doi: 10.14670/HH-28.759. Epub 2012 Dec 4.

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Tab. 1a COVID-19 patient characteristics							
Pat. ID	Age	Sex	Time of hospitalization (d)	PMH		PDH	
				aHTN	DM	aHT	AGT
1	75	male	9	yes	no	metoprolol	n/a
2	78	male	8	yes	yes	HCT, bisoprolol, lercanidipine, candesartan	metformin
3	87	female	1	yes	no	torasemide, ramipril	n/a
4	89	male	25	yes	no	ramipril, torasemide, thiazide	n/a
5	74	male	32	yes	no	Ramipril, bisoprolol	n/a

COVID-19: Coronavirus disease 2019

ID: Identification number

d: Days

PMH: Past Medical History

aHTN: Arterial hypertension

DM: Diabetes mellitus

PDH: Past Drug History

aHT: Anti-hypertensive treatment

HCT: Hydrochlorothiazide

AGT: Anti-glycemic treatment

Tab. 1b COVID-19 patients: Type of care and organ system involvement									
Pat. ID	Type of care				Organ system involvement				
	Supportive	Intubation	ECMO	Vv-Hemofiltration	ARDS	Sepsis	Liver Failure	Kidney Failure	MODS
1	yes	yes	yes	yes	yes	yes	yes	yes	yes
2	yes	yes	no	yes	yes	yes	yes	yes	yes
3	yes	no	no	no	yes	yes	no	yes	yes
4	yes	yes	no	yes	yes	yes	no	yes	no
5	yes	yes	no	no	yes	yes	no	yes	no

ECMO: Extracorporeal membrane oxygenation

Vv: venovenous

ARDS: Acute Respiratory Distress Syndrome

MODS: Multiple Organ Dysfunction Syndrome

Tab. 2 COVID-19 postmortem donor tissues and SARS-CoV-2 qRT-PCR results				
Type of ocular tissue/ fluid	qRT-PCR for SARS-CoV-2 RNA on right eye	RNA yields (mean, ±SD in ng/µL)	qRT-PCR for SARS-CoV-2 RNA on left eye*	RNA yields (mean, ±SD in ng/µL)
Conjunctival fluid swabs	vRNA undetectable	46.8±33.9	vRNA undetectable	51.4±29.3
Bulbar conjunctiva	vRNA undetectable	13.9±7.8	vRNA undetectable	49.6±81.7
Corneal epithelium	vRNA undetectable	52.4±45.4	vRNA undetectable	16.2±10.6
Corneal stroma and endothelium	vRNA undetectable	16.3±19.7	vRNA undetectable	19.5±14.0
Anterior chamber fluid	vRNA undetectable	6.5±11.7	vRNA undetectable	7.1±12.1

*Received routine procedure of tissue procurement for corneal banking

SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus 2

qRT-PCR: quantitative Reverse Transcriptase-Polymerase Chain Reaction (S-/E-genes, positive/ internal controls)

vRNA: viral RNA

SD: Standard deviation

Total No. of COVID-19 postmortem donors: N = 5