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The risk of transmission of the novel coronavirus (SARS-CoV-2) with human heart valve transplantation: evaluation of cardio-vascular tissues from two consecutive heart donors with asymptomatic COVID-19

R. Jashari · M. Van Esbroeck · J. Vanhaebost · I. Micalessi · A. Kerschen · S. Mastrobuoni

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Abstract We report on two living donors of explanted hearts while receiving heart transplantation that tested positive for SARS-CoV-2 on the day of donation, although clinically asymptomatic. They underwent heart transplantation for ischaemic and hypertrophic obstructive cardiomyopathy, respectively. After evaluation of donor hearts, we cryopreserved and stored two pulmonary valves for clinical application and one aortic valve for research. Light microscopy of myocardium, mitral valve and aortic and pulmonary arterial wall and RT-PCR SARS-CoV-2 test of myocardium, mitral and tricuspid valve and aortic wall for detection of SARS-CoV-2 were performed. Presence of ACE2 in tissues was assessed with immunostaining. Light microscopy revealed a mild eosinophilic myocarditis in the ischemic cardiomyopathy heart, whereas enlarged cardiomyocytes with irregular nucleus and some with cytoplasmic vacuoles in the hypertrophic obstructive cardiomyopathy heart. Aortic and pulmonary wall were histologically normal. Immunostaining revealed diffuse presence of ACE2 in the myocardium of the heart with eosinophilic myocarditis, but only discrete presence in the hypertrophic cardiomyopathy heart. The RT-PCR SARS-CoV-2 test showed no presence of the virus in tested tissues. Despite eosinophilic myocarditis in the ischemic cardiomyopathy heart, no viral traces were found in the myocardium and valve tissues. However, ACE2 was present diffusely in the ischemic cardiomyopathy heart. SARS-CoV-2 could not be detected in the cardiac tissues of these COVID-19 asymptomatic heart donors. In our opinion, clinical application of the valves from these donors presents negligible risk for coronavirus transmission. Nonetheless, considering the uncertainty regarding the risk of virus transmission with the human tissue transplantation, we would not release in any case the pulmonary valve recovered from the eosinophilic myocarditis heart. In contrast, we may consider the release of the pulmonary valve from the dilated cardiomyopathy heart only for a life-threatening situation when no other similar allograft were available.

Keywords Allograft · ACE2 · COVID-19 · Heart transplantation · Heart valves · Homograft · SARS-COV-2 · Tissue banking · Viral transmission

R. Jashari (✉) · S. Mastrobuoni
European Homograft Bank (EHB), UCL St. Luc, Méridien Site, rue du Méridien 100, 1210 Brussels, Belgium
e-mail: rjashari@clstjean.be

M. Van Esbroeck · I. Micalessi
Department of Clinical Sciences, Institute of Tropical Medicine, Antwerp, Belgium

J. Vanhaebost · A. Kerschen
Department of Pathology and Legal Medicine, Belgium and Morphology Research Group, Institute of Experimental and Clinical Research, UCL St. Luc, Brussels, Belgium

Introduction

The Coronavirus outbreak in December 2019 in Wuhan, China, has spread around the World, provoking a pandemic and a global Public Health emergency (ECDC 2020(1)). So far, 33 502 430 of confirmed patients in 235 Countries with 1 004 421 deaths have been reported by the WHO on the 30th of September 2020 (WHO the 30th of September 2020).

The International Coronaviridae Study Group (CSG) of the International Committee on Taxonomy of Viruses have classified single-strained RNA virus and named Severe Acute Respiratory Syndrome Coronavirus-2 (*SARS-CoV-2*) that was isolated from the patient with severe atypical pneumonia and connected with cluster of acute respiratory illness cases from Wuhan (Gorbalenya 2020).

As the number of persons presenting with COVID-19 was seriously increasing from day to day, the fear of the disease transmission with substances of human origin (SoHO) increased in importance in the early 2020 (ECDC 2020(1)). Hence, WHO, ECDC and the National Competent Authorities (NCA) recommended very strict evaluation of the recent contact history of potential donors, excluding all potentially infected persons. These measures were implemented as per the 1st of March 2020. Furthermore, all potential organ, tissue and cell donors have been mandatory tested for SARS-CoV-2 since the 15th of March 2020 (recommendation of the Belgian NCA, the other EU countries and Switzerland). However, so far there is no clear evidence of the disease transmission from person to person with the human blood, plasma, cell, tissue or organ transplantation (ECDC 2020(2)). In the same sense, some publications have reported no viral presence in the breast milk (Chen 2020, Kam 2020).

The estimated incubation of SARS-CoV-2 is 5–6 days, with range to 14 days (Lauer 2020). Accordingly, recommendations of the NCA and the ECDC were to defer all potential donors for a minimum of 14 days, if there was evidence of any contact with the person that suffered of, or was in contact with other person(s) in risk for the novel coronavirus infection. Hence, delaying the organ, tissue, cell and blood donation for 21–28 days from any potential donor with unclear COVID-19 contact history seems a logical decision (in same line with the recommendations of the Belgian NCA of the 1st of March 2020).

So far, the viral RNA presence has been demonstrated by some authors in the respiratory tract specimens, faeces, whole blood, serum, saliva, and urine of the symptomatic patients (Yong 2020, Chang 2020, To 2020). Similarly, some COVID-19 patients with conjunctivitis had detectable viral RNA in tears and conjunctival secretions (Xia 2020). However, information about the predilection, presentation and prognosis of COVID-19 in the solid organ transplantation is scarce and has not been adequately reported so far (Aslam and Mehra 2020).

Effects of COVID-19 in deterioration of the cardiovascular system, such as hypertension, tachi- and/or bradi-arrhythmias, ECG modifications and ventricular impairment with reduction of left ventricular (LV) function and the necessity for LV assistance have been reported (Xiong et al. 2020). Clerkin described myocardial injury in 7.2% of the patients with COVID-19, whereas the abnormal myocardial function was identified in 22% of those requiring the ICU treatment (echography, increase of troponin, modified ECG), (Clerkin et al. 2020). Chen et al. have reported high expression of the angiotensin-converting enzyme (ACE2) in pericytes of the adult human hearts, which indicates an intrinsic susceptibility of hearts to SARS-CoV-2 infection. Furthermore, some patients with basic heart failure exhibited increased expression of ACE2 and might present high risk for heart attack and progressing to severe condition after infection (Chen 2020).

Despite clear evidence of transmission of SARS-CoV-2 from person to person via droplets, uncertainties about the presence of virus in blood and bodily fluids of an asymptomatic donor of SoHO might be considered a potential threat to their viral safety (ECDC 2020(1)).

Transmission of coronavirus through the organ, tissue and cell transplantation remains largely unclear. Hence, to avoid the risk of viral transmission, selection of the tissue donors is at stake (for organ transplantation a minimal risk is acceptable as they are considered as “life-saving”, whereas for the tissue transplantation the “no risk” principle is mandatory, as they are considered as “life improving” for the patients). Although testing for COVID-19 became mandatory in the whole European Union as per the 15th of March 2020, it is not always possible to exclude with certainty the presence of the virus in the early phase of contamination (incubation, pre-

symptomatic period). Indeed, viremia during the incubation period, the asymptomatic course of infection and after symptom resolution, has not been documented (ECDC 2020(1), Nandini 2020). Despite high fears of the person-to-person transmission, based on the current knowledge, the risk of COVID-19 transmission through SoHO appears to be only theoretical.

The cardiovascular tissue establishments (CVTE) worldwide were confronted with serious decrease of the donation activity in the beginning of outbreak of pandemic (our TE experienced a decrease of donations of approximately 25% in March and approximately 45% in April 2020 compared to the same period of 2019 (personal, unpublished data)). In contrast, the number of demands for heart valves and vascular allograft remained almost unchanged. Some life threatening situations, such as the valve endocarditis with annular abscesses, hypoplastic left heart syndrome (HLHS) in new born children, vascular trauma, cancer invasion of the vascular tree with high risk of massive bleeding etc., are some of the situation where the human tissue grafts are the preferred options of many cardiac and vascular surgeons.

Systematic testing of all potential DBD (donors after brain death) and DCD (donors after cardiac death) for SARS-CoV-2 became a mandatory requirement prior to their acceptance instead of deferral that could have further worsen the availability of some "essential" tissues. However, in case of the heart donation from the transplant patients with end stage heart failure (RHT donors, recipients of heart transplantation) without any COVID-19 symptoms and without a contact history, waiting for the coronavirus testing report that may take several hours/days, it might have resulted in a "lost chance of life", as the heart transplantation is usually an emergent situation. Also, seen the complexity of the multi-organ donation, heart transplantation becomes an extremely urgent procedure for some patients and needs to be carried out as soon as possible. The consequence being that SARS-CoV-2 test results are not available before the procedure of transplantation. Nonetheless, asymptomatic status does not necessarily mean absence of infection.

Case presentation

We report on two consecutive cases of heart donation (for valves) from recipients of heart transplantation: the explanted hearts ("domino" hearts) were sent to our TE for valve allografts, while the patients received a donor heart from brain death donors. The first patient was a 59 years old male with end stage heart failure for ischemic cardiomyopathy while the second one was a 56 years old female with end stage heart failure for hypertrophic obstructive cardiomyopathy. In both cases, the contact and clinical history were negative for COVID-19. Prior to transplantation, blood samples were taken for conventional mandatory serology tests for human tissues aimed for human application (HIV, HBV, HCV, triple-NAT HIV/HBV/HCV, Syphilis, HTLV), as previously reported (Jashari 2010). Further, both patients were tested for SARS-CoV-2 (by means of a nasopharyngeal swab) at hospital admission immediately before transplantation. Initial information regarding these potential donors transmitted from the transplant centre to our TE showed no evidence of clinical and contact history for COVID-19 in both cases and no other contraindications for tissue donation. The two consecutive donated hearts arrived in two consecutive days at our TE on the March 17th and 18th, 2020 from the same donor centre. Due to the time constraint of 24 h following cardiac arrest, both hearts were immediately processed after arrival at our TE. Both donated hearts were dissected in the class A cleanroom, background class B/C of our TE as previously reported (Jashari 2010). Unfortunately, both patients resulted positive at the initial coronavirus test. The tests results were nonetheless, communicated to our TE only few days after arrival of the hearts.

Morphological description of donated hearts

The first heart was a globally enlarged with severely dilated ventricles and decreased wall thickness: left ventricle 0.5 cm, interventricular septum 1.4 cm and right ventricle 0.3 cm. The anterior wall of left ventricle contained severe fibrotic alteration (ancient myocardial infarction). The mitral and tricuspid valve were slightly dilated, but without important alterations in the structure and morphology. The aortic valve presented severe atheromatous alterations and thickening and was therefore, discarded. The pulmonary valve was morphologically tricuspid with no structural

abnormalities and normal competence. This valve was provisory suitable for human application and it was cryopreserved in the dimethyl-sulfoxide 10% in RPMI (Roswell Park Memorial Institute, USA) and stored in liquid nitrogen vapours while awaiting the quality test results.

The second heart presented severely dilated ventricles with important decreased thickness of myocardium (left ventricle 0.7 cm, interventricular septum 0.8 cm and the right ventricle 0.4 cm). The aortic valve was tricuspid with smooth leaflets. Unfortunately, there were some large fenestrations in the commissural areas of all three leaflets. Therefore, it was not suitable for human application. Nonetheless, this valve was cryopreserved for further validation purposes. In contrast, the pulmonary valve was tricuspid with three equal leaflets, with one edge cluster-fenestration of 6 × 2 mm on the commissural area of the left leaflet but a normal competence test. This valve was provisory accepted for human application. As previous one, this pulmonary valve, was cryopreserved and stored in liquid nitrogen vapours, while awaiting the quality test results.

Tissue samples of myocardium, mitral valve and aortic and pulmonary wall from both hearts were sent, as per standard protocol, for histologic evaluation and bacteriology testing (Jashari 2010).

Histology evaluation

For histology evaluation, samples were collected from myocardium (left ventricle (LV), right ventricle (RV) and interventricular septum (IVS), posterior mitral leaflet, and from aortic and pulmonary wall). The collected tissues were fixed in 10% neutral formalin, embedded in paraffin and histological sections were analysed after haematoxylin and eosin (HE) staining. For detection of the presence of ACE2 (angiotensin converting enzyme), a complementary examination of myocardium was performed by immunostaining. For comparison with a normal heart tissue, the myocardium of a previous heart donor with normal function was similarly immunostained for analysis of the ACE2 presence. This donor was a 61 years old man who died in 2019 from a spontaneous brain haemorrhage. He was a multi-organ donor and his heart was donated for valves.

Evaluation of the cardiac tissues for presence of SARS-CoV-2 by RT-PCR

These tests were realised after confirmation of positive nasopharyngeal swab test for SARS-CoV-2 of the donors (from the donation centre). Routinely, after evaluation of the allografts, the heart residuals are preserved in a 0.9% saline solution and stored at -20 °C for approximately one month. For this test, tissue samples from each heart were collected from the residual myocardium (LV, RV, IVS), from the mitral and tricuspid valve and the aortic wall from the second donor heart. Testing of tissue samples was carried out according to the technique described by Corman et al. (Corman 2020).

Testing technique for SARS-CoV-2 PCR of the cardio-vascular tissues

RNA extraction

The QIAamp Viral RNA kit (QIAGEN, Hilden, Germany) was used for the RNA extraction procedure. Prior to extraction, part of each tissue sample was cut in small fragments of 25 mm^2 and stored at −80 °C for 10 min. After the freezing step, a volume of 180 µl buffer AVL (virus lysis buffer) and 20 µl proteinase K was added. Subsequently, the sample was vortexed for 10 min and stored overnight at + 2 °C to + 8 °C. After the overnight incubation, 5, 60 µL of buffer AVL and 5, 6 µL carrier RNA was added together with 10 µL internal extraction control (PDV, Phocine Distemper Virus). The sample was then vortexed for 15 s and briefly centrifuged. After incubation for 10 min at room temperature and a brief centrifugation step, the lysate (2 times 630 µL), was transferred into a QIAamp spin column. All next steps (washing/elution steps) were performed according to the manufacturers' instructions. RNA was eluted from the column with 60 µL elution buffer.

Real-time PCR

All samples were subject to the SARS coronavirus (SARS-CoV) E-gene RT-PCR as well as a RT-PCR targeting PDV to check for PCR inhibition. In brief, SARS-CoV PCR was performed in a final reaction of 25 µL containing 1xiTaq universal probes reaction mix (Bio-Rad, Hercules, CA USA), 1xiScript

advanced reverse transcriptase (Bio-Rad), 400 nM E-Sarbeco -F primer, 400 nM E- Sarbeco -R primer, 200 nM E_Sarbeco_P1 probe and 5µL template. Primer and probe sequences of the group of Corman were used (Corman 2020). Thermal cycling was performed at + 50 °C for 10 min for reverse transcription, followed by + 95 °C for 5 min and then 50 cycles at + 95 °C for 10 s and + 58 °C for 30 s. The PCR reactions were performed on the QuantStudio 5 Real-Time PCR System (Thermo Fisher Scientific, Waltham, MA USA).

Results

SARS-CoV-2 PCR

The result of SARS-CoOV-2 PCR test performed on the nasopharyngeal swab of both donors was obtained few days after the hearts arrived in our TE. Both donors tested positive.

Histology

In the first case, a moderate eosinophilic inflammatory infiltrate was detected in the interstitium and around small vascular structures, suggesting a mild eosinophilic myocarditis. The aortic wall, the pulmonary arterial wall and the mitral leaflet were histologically normal (Fig. 1). Immunostaining showed present and diffuse ACE2 (Fig. 3A).

In the second case, some cardiomyocytes showed enlarged and irregular nucleus while other ones contained cytoplasmic vacuoles, and cardiomyocytes bundles varied in thickness and disposition, suggesting a hypertrophic cardiomyopathy. No signs of infection and no inflammatory infiltrate were found (Fig. 2). Immunostaining showed only a discreet presence of the ACE2 (Fig. 3B).

Furthermore, in the donor heart with a normal function (donated before COVID-19 era), we found only poor cytoplasmic and membrane staining for ACE2 (Fig. 4).

SARS-CoV-2 PCR test on tissues

In both cases, two tests on myocardium (LV, RV and IVS) as well as the transport solution used for shipment were negative with the SARS-CoV-RT-PCR. Similarly, two sample sets of mitral and tricuspid leaflets of both hearts and the aortic wall from the second donor heart were negative.

Discussion

In this paper, we present two recipients of heart transplantation who in turn donated their failed heart in a domino procedure to our Tissue Establishment for valve transplantation. Both patients tested positive for SARS-CoV-2 through the nasopharyngeal swabs immediately before transplantation. Nonetheless, due to the time constraint to limit ischemic time to 24 h after cardiac arrest (Jashari 2010), the hearts had to be processed in our TE immediately upon arrival despite the results of initial SARS-CoV-2 test were not yet available. Both tests resulted indeed positive 6 h after collection and we were notified of the result beyond 24 h after processing of the hearts.

Due to the lack of information about the behaviour of the virus within the SoHO, recommendations of the ECDC and the competent authorities regarding the donor selection in the beginning of the COVID-19 pandemic were not always clear and maybe too conservative. In addition, some preliminary reports showed the presence of the virus in the respiratory tract specimens, faeces, whole blood, serum, saliva and urine of some symptomatic patients (Chang 2020, To 2020, Xia 2020). Accordingly, a careful evaluation of the donors for the risk of viral transmission was necessary. Furthermore, the autopsy study of the subjects who died of SARS, performed by Ding et al. in 2003, had shown presence of SARS-CoV in the lung, trachea/bronchus, stomach, small intestine, kidney, liver, sweet gland, parathyroid, pituitary, pancreas and brain (Ding 2004). However, they did not detect any viral presence in the esophagus, spleen, lymph node, bone marrow, heart, aorta, cerebellum, thyroid, testis, ovary, uterus or muscle.

In our study, the examination of myocardium of the patient with ischemic cardiomyopathy showed a moderate eosinophilic inflammatory infiltrate in the interstitium and around small vascular structures, suggesting a mild eosinophilic myocarditis. In the donor with hypertrophic obstructive cardiomyopathy, examination showed no inflammatory reaction, but only some enlarged, irregular and vacuolated nuclei, and cardiomyocytes bundles that varied in thickness

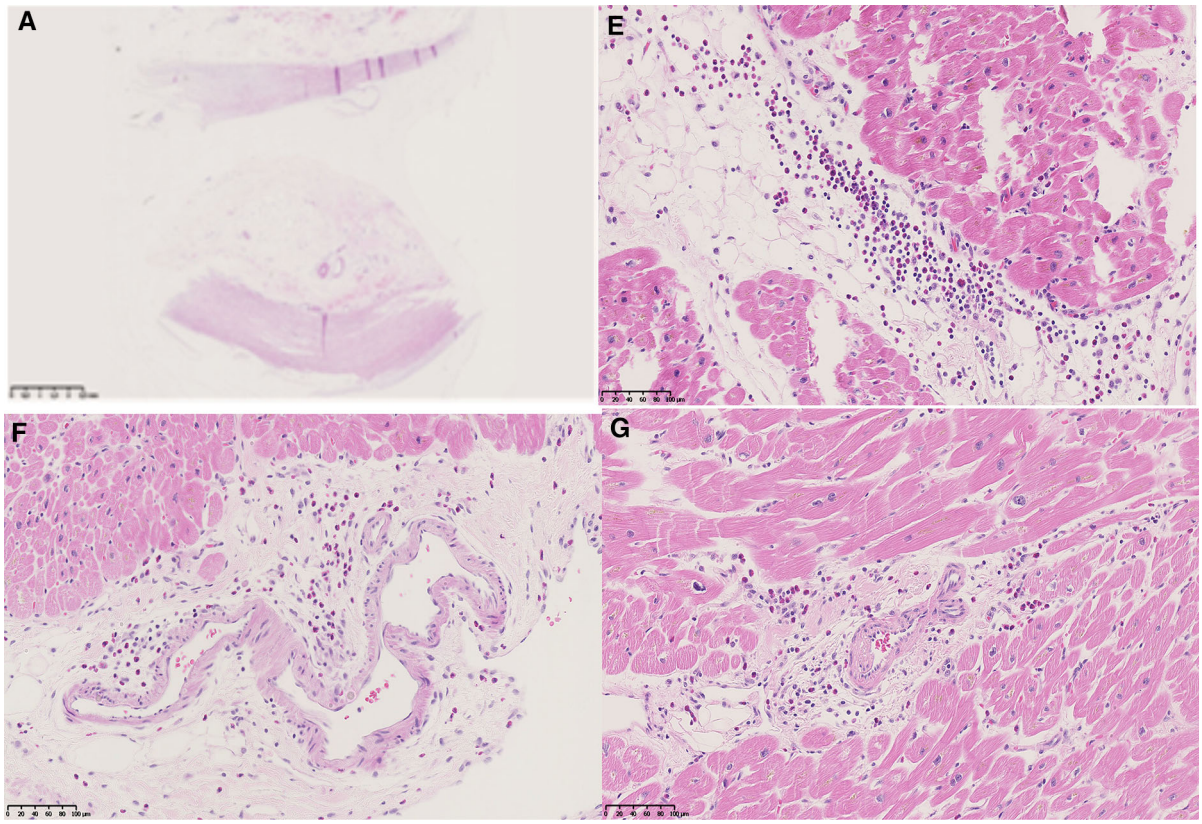

Fig. 1 Light microscopy of cardiac tissue examination, HE staining (ischemic cardiomyopathy heart): **a**: Low magnification of aorta and pulmonary artery, (× 8.5); **e**: Diffuse interstitial infiltration by eosinophils (× 200); **f**: Perivascular infiltration by eosinophils (× 200); **g**: Perivascular infiltration by eosinophils (× 200)

and disposition, confirming the dilated cardiomyopathy. The RT-PCR for SARS-CoV-2 did not reveal any presence of virus in the heart tissues (myocardium, mitral and tricuspid valve, aortic wall) of these two donors. Furthermore, the histology evaluation was not able to reveal any presence of viral particles.

Interestingly, the immunostaining of the myocardium of the heart with eosinophilic myocarditis showed a diffuse presence of ACE2 in the area with inflammatory infiltration (Fig. 3a). In contrast, this was not the case with the heart with hypertrophic cardiomyopathy, where the immunostaining showed only a discreet presence of the ACE2 (Fig. 3b). For comparison, the immunostained myocardial tissue of a donor with normal myocardial function (donation before the COVID-19 era) showed a poor cytoplasmic and membrane staining for ACE2 (Fig. 4). These findings in the ischemic heart are in accordance with findings of Chen et al. who have demonstrated high expression of the ACE2 in pericytes of the adult human hearts, indicating an intrinsic susceptibility of hearts to SARS-CoV-2 infection (Chen 2020).

Many authors have evaluated the risk of donor-derived transmission of SARS-CoV-2 in recent months. Although the SARS-CoV-2 can be transmitted from person-to-person via droplets, uncertainties about the presence of the virus in blood and bodily fluids of an asymptomatic SoHO donor, may be considered a potential threat to the safety of SoHO (ECDC 2020(2)).

Other authors have reported that between 6 and 41% of patients with positive SARS-CoV-2 test were asymptomatic at the moment of testing (Lee 2020, Byambasuren 2020).

Kates et al. (Kates 2020) reported controversial results from the autopsy of some patients who died of COVID-19, showing degeneration, necrosis and microvascular injury. However, they did not find any evidence of SARS-CoV-2 infection in non-lung organs. In addition, they reported a case of progressing

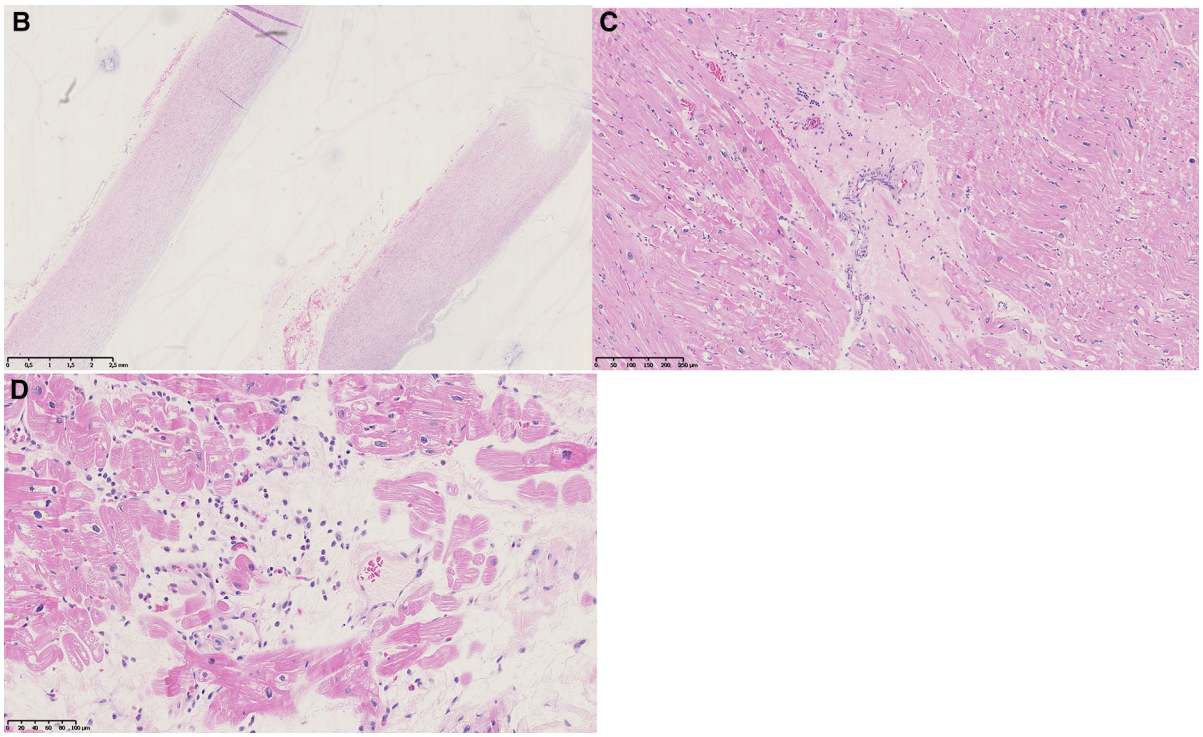

Fig. 2 Light microscopy of cardiac tissue examination, H&E staining (hypertrophic cardiomyopathy): **b**: Low magnification of aorta and pulmonary artery (× 12.5); **c**: Mild perivascular fibrosis, few irregular nuclei in large cardiomyocytes, with several cytoplasmic vacuoles, coherent with hypertrophic cardiomyopathy (× 100); **d**: Aspecific mixed inflammatory infiltrate in the interstitium with neutrophils and monocytes (× 200)

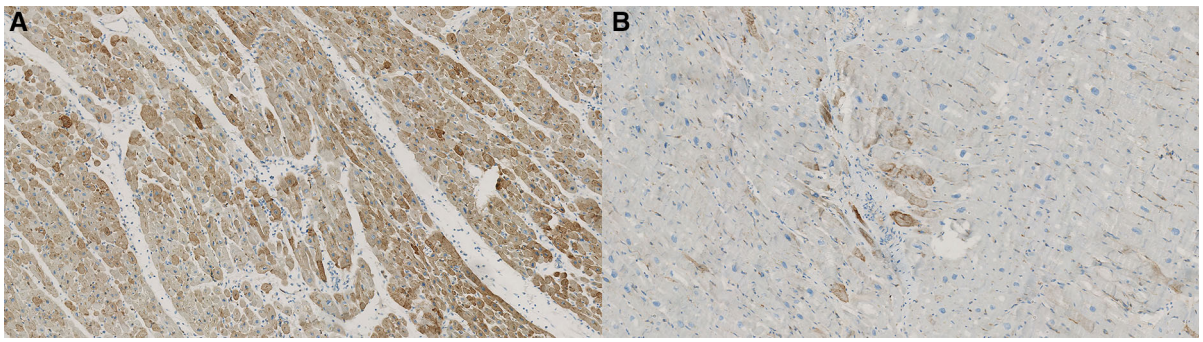

Fig. 3 ACE2 Immunostaining of both specimens (× 100). **a**: diffuse cytoplasmic ACE2 immunostaining in the ischemic cardiomyopathy heart; **b**: discrete ACE2 immunostaining, marking some scattered cardiomyocytes in the hypertrophic cardiomyopathy heart

cardiogenic shock, attributed to SARS-CoV-2 viral myocarditis. In contrast, the endo-myocardial biopsy of this case showed low-grade myocardial inflammatory infiltration. They conclude that the cause of cardiogenic shock might have not been in direct relation to the viral infiltration.

Bradley has detected a small amount of viral RNA of SARS-CoV-2 in the heart samples of one patient out of 12 (8.3%) who died of COVID-19 (Bradley 2020). Consequently, detection of the viral presence in the myocardium means that the use of the heart tissue for transplantation might lead to viral transmission to the recipients of these tissues. However, at present time,

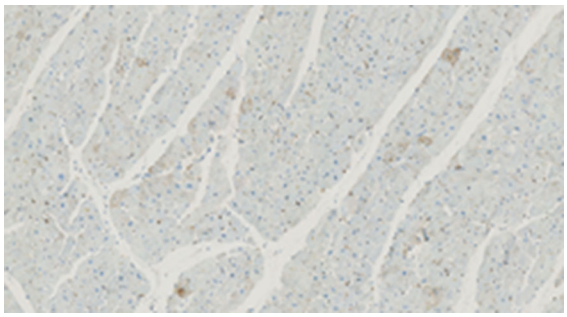

Fig. 4 Poor cytoplasmic and membrane staining for ACE2 in a donor heart with a normal function (donated before COVID-19 era). (× 100)

no more data from the literature are available to support this hypothesis.

Hong et al. showed no transmission of virus in case of living-donor liver transplantation (daughter to mother) from a COVID-19 positive donor. In this case, the living donor (daughter) tested positive to COVID-19 only after donation of the liver to her mother. Nonetheless, the transplant recipient (mother) did not present any signs of COVID-19 infection in the postoperative period and the liver function remained normal after transplantation (Hong 2020).

Human plasma for manufacturing of the medical products and some tissues for life-saving transplantation (e.g. heart valves) are considered to be "essential SoHO", as they can be stored (ECDC 2020(2)). Therefore, maintaining a safe, sufficient and accessible supply of critical and essential SoHO during a pandemic is of a vital interest for public health. It is therefore essential that tissue establishments recognise the potential impact of the pandemic on safe and sufficient supply of SoHO and adequately respond to ensure the maintenance of core services (ECDC 2020(2)).

The Netherlands Transplant Foundation (NTS) has distributed its guidelines regarding the donor selection during the COVID-19 pandemic, with very strict recommendations for the potential donors with active infection, those who recovered from the disease and those who were in close contact with infected persons. They recommend no deferral of donors who were symptom free for the previous 28 days and those who had no contact with infected individuals in the last 28 days (NTS 2020). Regarding the heart donation for valves, this document states that some COVID-19 patients develop fulminant myocarditis or other cardiac problems (as mentioned by some authors above). Consequently, due to the presence of ACE2 receptors in the heart, they do not rule out the presence of the coronavirus in the heart tissues of the donor during the COVID-19 pandemic. Furthermore, some autopsy reports from the SARS cases (from the Toronto group of 2003) have demonstrated viral RNA in up to 35% of the heart samples of persons who died of SARS (Oudit 2009). Therefore, they recommend very careful evaluation before accepting the potential heart donors.

The ASTS (The American Society of Transplant Surgeons) strike Force Guidance to Members on the Evolving Pandemic from the 19th of March 2020 recommends deferral of organ, tissue and cell donation that might present risk for disease transmission, as there was an evidence of a spread of virus in the USA through live and deceased donation events (ASTS 2020).

With the current methods of testing, it is not possible to exclude completely the risk of viral transmission from person-to-person with tissue transplantation. Nonetheless, some tissues may have an estimated low risk of virus contamination and for some critically ill patients this risk may be worth taking (Kates 2020).

Due to the mandatory pre-donation test for SARS-CoV-2 with subsequent deferral of many potential donors, at the time of writing of this paper, the number of human heart tissues from COVID-19 positive donors is extremely limited. So far, only these two heart donors in our TE tested positive for SARS-CoV-2. To the best of our knowledge, this is the first report about COVID-19 positive donors for heart valves.

For decades, the CVTE have been permanently confronted with the scarcity of some specific tissues such as pulmonary valves, small size aortic valves and vascular allografts, due to insufficient sources of the donors, particularly those of very young age. Additionally, the pandemic has aggravated this situation between February and May 2020 (personal, unpublished data). Hence, suitability of some critical SoHO (heart valves, vascular grafts) remains largely a responsibility of the TE manager.

One potential source of the heart valve allografts for human application are the living donors (recipients of heart transplantation). Despite severely damaged myocardium, the pulmonary valves retrieved from these hearts usually are very well preserved

morphologically and functionally. Gaudino et al. reported excellent function of the pulmonary valves from the RHT donors with pulmonary hypertension (Gaudino 1997). In our TE, approximately 15–20% of all donated hearts belong to this donor category (Jashari 2004). However, these patients usually undergo a life-saving procedure after a long waiting-time and oftentimes the procedure can not be delayed until all test results are obtained, such in this case, SARS-CoV-2 testing of these two patients/donors.

Conclusion

The myocardium and heart valves of both living donors that were SARS-CoV-2 positive were free of any trace of the novel coronavirus. However, presence of the ACE2 was demonstrated in the ischemic cardiomyopathy case, in contrast with the hypertrophic obstructive cardiomyopathy case, where presence of ACE2 was only discrete.

Although the RT-PCR did not reveal any viral presence in the myocardium and valve/vascular tissues, on basis of only two donor hearts evaluated in this study, we are not able to suggest with security the clinical application of these allograft valves. In our opinion, clinical application of the valves from these donors presents a negligible risk for novel coronavirus transmission. Nonetheless, considering the uncertainty regarding the risk of viral transmission with cryopreserved allografts, we would not release in any case the pulmonary valve recovered from the heart with eosinophilic myocarditis. In contrast, we may consider the release of the pulmonary valve from the heart with dilated obstructive cardiomyopathy only for a life-threatening situation when no other similar allograft were available.

Strengths of this paper

In the best of our knowledge, this is the first report of two living heart donors for valves that were SARS-CoV-2 positive, showing no presence of the virus in the myocardium, cardiac valves and vascular tissues.

Weakness of this paper

The number of cases is very limited. However, due to the obligatory testing of the potential donors prior to donation, all positive or doubtful SARS-CoV-2 cases have been systematically deferred for organ/tissue donation.

Funding There was no external funding used for this study. All costs of the tests were covered by the TE.This work was carried out in compliance with the tissue banking Ethical Standards.

Declarations

Conflict of interest The authors declare not having a conflict of interest. Doctor Jashari is a Director of the TE.

Ethical approval Our tissue establishment is an authorized Cardiovascular Tissue Establishment in compliance with the EU and Belgian National Tissue Banking regulation. The aims of our TE were approved by the Ethical Committee of the University Hospital Saint Luc in Brussels. The donor consent was obtained in accordance with the current tissue banking regulation.

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