



Co-editors-in-chief:

Lester J. Layfield, MD, (University of Missouri, Columbia, MO, USA)
Vinod B. Shidham, MD, FIAC, FRCPath (WSU School of Medicine, Detroit, USA)

OPEN ACCESS
for HTML version

Editorial

Severe acute respiratory syndrome coronavirus 2 (the cause of COVID 19) in different types of clinical specimens and implications for cytopathology specimen: An editorial review with recommendations

Vinod B. Shidham¹, Nora K. Frisch², Lester J. Layfield³

¹Department of Pathology, Karmanos Cancer Center and Detroit Medical Center, Wayne State University School of Medicine, Detroit, Michigan, ²Department of Pathology, The University of Vermont Medical Center, Burlington, Vermont, United States, ³Department of Pathology, University of Missouri, Columbia, Missouri, United States.



***Corresponding author:**

Vinod B. Shidham, MD,
FRCPath, FIAC
Department of Pathology,
Karmanos Cancer Center and
Detroit Medical Center, Wayne
State University School of
Medicine, Detroit, Michigan,
United States.

vsidham@med.wayne.edu

Received : 08 April 2020

Accepted : 08 April 2020

Published : 10 April 2020

DOI

10.25259/Cytojournal_24_2020

Quick Response Code:



EDITOR'S LETTER

Coronavirus disease 2019 (COVID-19) caused by “Severe acute respiratory syndrome coronavirus 2” (SARS-CoV-2) was first reported in China.^[1] This is the third extremely pathogenic human coronavirus which has emerged recently after severe acute respiratory syndrome (SARS) coronavirus and Middle East respiratory syndrome (MERS) coronavirus. SARS-CoV-2 is mainly transmitted by person-to-person contact in community and health-care settings.^[2] This pattern of spread demands large-scale and proactive measures to avoid further widespread dissemination. SARS-CoV-2 survives on contaminated dry surfaces and fomites, which facilitate hand to mucous membranes (of the mouth, nose, and eyes) spread.^[3,4] This emphasizes the significance of in-depth knowledge about the perseverance of coronavirus on inanimate surfaces.^[5] Various fixatives and biocidal agents are widely used in health-care settings including cytopathology laboratories which may impact (and help negate) the spread of this virus.^[6,7]

The current review summarizes the available relevant data on this topic about cytopathology laboratory protocols and suggests precautions based on this data. These recommendations may change as new information comes to light. Each institution and laboratory has to adapt and adjust depending on local regulatory limitations. The recommendations suggested at the end of the review discussion should be considered with these things in mind.

At present, the diagnosis of COVID 19 is mostly being accomplished by performing real-time reverse transcriptase-polymerase chain reaction (rRT-PCR) for SARS-CoV-2 on respiratory specimens such as nasopharyngeal swabs.^[8] The primary mode of spread, which has led to the global pandemic, is the respiratory route. A report studying different types of clinical specimens from patients (most cases 1–3 days after hospital admission) detected a positive PCR test in about 1% ($n = 307$) of blood samples, suggesting the systemic nature of the disease in at least a portion of the cases.^[9] This study also reported positive results in 29% ($n = 153$) of fecal samples.^[9] Although tests based on PCR have been reported positive in non-respiratory specimens, it does equate with infectivity and so the non-respiratory route of viral transmission is possible but is not proven at this stage.

As mentioned previously, the molecular test to detect SARS-CoV-2 is based on rRT-PCR. This test amplifies viral RNA in a patient's specimen for the detection of SARS-CoV-2 genetic material.^[10] False negatives are possible due to multiple variables including simple technical errors, inadequate collection, improper handling, and shipping. Other possibilities for incorrect results include flawed key reagents in the kit.^[11] One study comparing rRT-PCR with computerized tomography (CT), reports that the sensitivity of the test is only 70%.^[12] Further compounding the issue, the sensitivity may be lower in some symptomatic cases due to a smaller viral load,^[13] but usually the viral load is higher in the early stages of the disease. However, newer tests suggest higher sensitivity with the potential of false positives due to very high sensitivity and possible cross contaminations during the pandemic with the widespread presence of virus (at the level of collection of sample and later during the technical procedure).

As a result, even if the specimen in the cytopathology laboratory is not expected to be positive or even if the molecular test is negative for SARS-CoV-2, all of the specimens should be considered potentially positive. It is therefore mandatory to practice all the universal/standard precautions with basic protective measures while handling any biological specimen irrespective of SARS-CoV-2 status [Tables 1-3].^[14-16] All cytology personnel should

follow the basic protective measures against SARS-CoV-2 recommended by the World Health Organization (WHO) [Table 2].^[16]

Although, appropriate disinfectants and precautions related to cytopathological/histological fixation and processing of samples during the current COVID 19 pandemic are not known, information can likely be extrapolated from other recent coronaviruses (e.g., SARS and MERS). Similar

Table 2: Summary of the WHO-recommended basic protective measures.^[16]

- a. Wash your hands frequently with soap and water counting up to 20 (approx. 20 s).
- b. Maintain social distancing and maintain at least 1 m (3 ft) distance between yourself and anyone to avoid droplet/microparticle infection due to coughing, sneezing, and even talking.^[36,37]
- c. Avoid touching face (eyes, nose, and mouth) is the most important component as final personal protection. Studies showed that rate of unknowingly touching the face is up to 15–23/h.^[38,39] The most probable mode of getting infection is from many inanimate surfaces [Table 4].
- d. If you are sick with fever, cough, or difficulty breathing, seek medical advice early and stay informed to follow updated advice by your health-care provider and official resources.

Table 1: Standard precautions – Summary modified for cytopathology laboratory specimens based on the CDC guidelines.^[14,15]

1. Ensure that the technologist use personal protective equipment (PPE) such as medical mask, gloves, eye protection, and a long-sleeved gown.
2. If the specimen with potential of aerosol-generation, such as squirting of aspirates from fine-needle aspiration biopsy procedure is being processed, the personnel should wear at least the protective mask such as NIOSH certified N95, an EU standard FFP2, or the equivalent.
3. All personnel involved in handling and transporting the specimens should be trained for safely handling the process, including spill decontamination methods.
4. Transport the primary specimen container with the patient's label in a leak-proof secondary containers, such as sealable plastic biohazard specimen bag with properly filled laboratory requisition.
5. Adhere to all biosafety practices including transport precautions (6c) depending on the pathophysiology of the organism being considered.
6. Preferably transport fresh, unfixed specimens by hand, and DO NOT ship the specimen with pneumatic-tube systems.
7. Each specimen must be clearly labeled with at least two patient identifiers including full name and date of birth with other details with specific warnings as applicable (e.g., suspected or confirmed SARS-CoV-2 virus) on the form. Let the laboratory know immediately that such a specimen is on the way.

Table 3: Summary of the Interim Laboratory Biosafety Guidelines from the CDC for the specimens suspected for or positive for SARS-CoV-2.^[32]

1. Follow standard precautions when handling clinical specimens, all of which may contain potentially infectious materials mentioned in Table 1.
2. Any technique which may generate aerosols or droplets (e.g., squirting [instead of gently delivering as tiny drops] of the specimen through a needle, vertexing) should be avoided, but is required to be practiced then it should be executed in a certified Class II Biological Safety Cabinet (BSC). Similarly, for centrifugation suitable physical containment should be practiced with securely capped specimen tubes. Ideally, such procedures should also be performed in a Class II Biological Safety Cabinet.
3. Clean and disinfect the equipment(s) and work surfaces after specimens are processed using appropriate disinfectants which are used for disinfecting other respiratory pathogens, such as other human coronaviruses and seasonal influenza viruses.
4. Practice standard procedures applied for other respiratory pathogens, such as other human coronaviruses and seasonal influenza viruses.
5. If the diagnostic testing specimens are processed outside of a BSL-2 laboratory,^[33] such as preparation of cytology direct smears, rinsing of FNAB aspirates for cell block, the Standard Precautions (similar to those mentioned under Table 1) should be practiced as a barrier between the specimen and personnel.^[34]
6. Preparation and fixing of cytology smears should be performed under certified a Class II^[35] Biological Safety Cabinet.

protocols should be effective to disinfect and inactivate SARS-CoV-2.^[17] Thus, once the processing is complete as cytopathologic preparation and after formalin fixation and paraffin embedding for cell-blocks, SARS-CoV-2 if present in the specimen should be inactive.^[17]

A study reported that aerosol and fomite transmission of SARS-CoV-2 is possible because the pathogen continues to be infectious for hours in aerosols and for days on surfaces.^[18] The findings are comparable to those observed with SARS-CoV-1^[19] providing useful information for the current mitigation efforts during this pandemic. The study observed that SARS-CoV-2 survives for up to 24 h on cardboard and plastic/stainless-steel surfaces up to 2–3 days.^[18-20]

Many ostensibly clean surfaces and devices within a pathology department (including but not limited to doorknobs, tables and chairs, countertops, desks, keyboards, phones, microscopes, glass slides, slide trays/boards, on-site

adequacy carts, door handles, light switches, toilets, faucets, and sinks) may be contaminated with the virus and should be considered potential fomites.^[21] The duration for which SARS-CoV-2-like viruses have been reported to persist on various surfaces is listed in Table 4.^[22]

Virus infectivity is defined as the ability of the virus to enter and colonize the host to replicate and reproduce itself with the potential to establish itself as an infection resulting in disease.^[22] A previously suggested benchmark, a log₁₀ viral reduction factor of more than 3, is considered as virucidal effectivity against viruses including coronaviruses on surfaces.^[23] Formalin and ethanol used in low concentration (usually used as a preservative) decrease the viral infectivity to more than 3 log₁₀.^[22]

The effect of time and concentrations of various fixatives and biocidal agents on SARS and a few other viruses are summarized in Table 5. The table shows that for ethanol, 95%

Table 4: Persistence of coronaviruses and other viruses on different types of inanimate surfaces (modified from Ref #22).

Type of surface	Virus	Strain/isolate	Inoculum (viral titer)	Temperature	Persistence
Glass	SARS-CoV	P9	10 ⁵	RT	4 d
	HCoV	229E	10 ³	21°C	5 d
Plastic	SARS-CoV	HKU39849	10 ⁵	22–25°C	<5 d
	MERS-CoV	HCoV-EMC/2012	10 ⁵	20°C	48 h
				30°C	8–24 h
	SARS-CoV	P9	10 ⁵	RT	4 d
PVC plastic	SARS-CoV	FFM1	10 ⁷	RT	6–9 d
	HCoV	229E	10 ⁷	RT	2–6 d
	HCoV	229E	10 ³	21°C	5 d
	SARS-CoV	P9	10 ⁵	RT	4–5 d
Paper	SARS-CoV	GVU6109	10 ⁶	RT	24 h
			10 ⁵	RT	3 h
			10 ⁴	RT	<3 min
Surgical glove (latex)	HCoV	229E and OC43	5 × 10 ³	21°C	<8 h
	SARS-CoV	GVU6109	10 ⁶	RT	2 d
Disposable gown			10 ⁵	RT	24 h
			10 ⁴	RT	1 h
			5 × 10 ³	21°C	2–8 h
			10 ⁵	RT	5 d
Aluminum	HCoV	229E and OC43	5 × 10 ³	21°C	2–8 h
	SARS-CoV	P9	10 ⁵	RT	5 d
Metal	SARS-CoV	P9	10 ⁵	RT	5 d
Steel	MERS-CoV	HCoV-EMC/2012	10 ⁵	20°C	48 h
	TGEV	Unknown	10 ⁶	4°C	>28 d
				20°C	3–28 d
				40°C	4–96 h
				4°C	>28 d
				20°C	3–28 d
				40°C	4–96 h
Silicon rubber	HCoV	229E	10 ³	21°C	5 d
	HCoV	229E	10 ³	21°C	5 d
Wood	SARS-CoV	P9	10 ⁵	21°C	4 d
Ceramic	HCoV	229E	10 ³	21°C	5 d
Teflon	HCoV	229E	10 ³	21°C	5 d

CCV: Canine coronavirus, HCoV: Human coronavirus, MHV: Mouse hepatitis virus, MERS-Cov: Middle East respiratory syndrome coronavirus, RT: Room temperature, SARS-CoV: Severe Acute respiratory syndrome coronavirus, TGEV: Transmissible gastroenteritis virus, d: Day(s), h: Hours(s), min: Minute(s)

Table 5: Inactivation of coronaviruses by different types of fixative and biocidal agents in suspension tests (modified from Ref #22).

Fixative/Biocidal agent	Concentration (%)	Virus	Strain/Isolate	Exposure time	Reduction of viral infectivity (log ₁₀)
Ethanol	95	SARS-CoV	FFM-1	30 s	>5.5
	85	SARS-CoV	FFM-1	30 s	>5.5
	80	SARS-CoV	FFM-1	30 s	>4.3
	80	SARS-CoV	EMC	30 s	>4.0
	78	SARS-CoV	FFM-1	30 s	>5.0
	70	MHV	MHV-2 and MHV-N	10 min	>3.9
	70	CCV	I-71	10 min	>3.3
Formaldehyde	1%	SARS-CoV	FFM-1	2 min	> 3.0
	0.7%	SARS-CoV	FFM-1	2 min	> 3.0
	0.7%	MHV		10 min	> 3.5
	0.7%	CCV	I-71	10 min	> 3.7
	0.009%	CCV		24 h	> 4.0
Glutardialdehyde	2.5%	SARS-CoV	Hanoi strain	5 min	> 4.0
	2.5%	SARS-CoV	FFM-1	2 min	> 4.0
2-Propanol	100%	SARS-CoV	FFM-1	30 s	>3.3
	75%	SARS-CoV	FFM-1	30 s	>4.0
	75%	MERS-CoV	EMC	30 s	>4.0
	70%	SARS-CoV	FFM-1	30 s	>3.3
	50%	MHV	MHV-2 & MHV-N	10 min	>3.7
	50%	CCV	I-71	10 min	>3.7
	2-Propanol (a) and 1-propanol (b)	a-45% & b-30%	SARS-CoV	FFM-1	30 s
Sodium hypochlorite		SARS-CoV	FFM-1	30 s	>2.8
	0.21%	MHV	MHV-1	30 s	>4.0
	0.01%	MHV	MHV-2 & MHV-N	10 min	2.3-2.8
	0.01%	CCV	I-71	10 min	1.1
	0.001%	MHV	MHV-2 & MHV-N	10 min	0.3-0.6
Hydrogen peroxide	0.001%	CCV	I-71	10 min	0.9
	0.5%	HCoV	229E	1 min	> 4.0
	0.2%	HCoV	ATCC VR-759 (strain OC43)	10 min	0.0
	0.05%	MHV	MHV-2 & MHV-N	10 min	>3.7
	0.05%	CCV	I-71	10 min	>3.7
Benzalkonium chloride	0.00175%	CCV	S378	3 d	3.0
	7.5%	MERS-CoV	HCoV-EMC/2012	15 s	4.6
	4%	MERS-CoV	HCoV-EMC/2012	15 s	5.0
	1%	SARS-CoV	Hanoi strain	5 min	>4.0
	1%	SMES-CoV	HCoV-EMC/2012	15 s	4.3
	0.47%	SARS-CoV	Hanoi strain	1 min	3.8
	0.25%	SARS-CoV	Hanoi strain	1 min	>4.0
	0.23%	SARS-CoV	Hanoi strain	1 min	>4.0
	0.23%	SARS-CoV	FFM-1	15 s	>4.4
	0.23%	MERS-CoV	HCoV-EMC/2012	15 s	>4.4
	0.0025%	CCV	S378	3 d	> 4.0
Didecyldimethyl ammonium chloride					
	0.02%	MHV	MHV-2 & MHV-N	10 min	0.7-0.8
Chlorhexidine digluconate	0.02%	CCV	I-71	10 min	0.3

CCV: Canine coronavirus; HCoV: Human coronavirus; MHV: Mouse hepatitis virus; MERS-Cov: Middle East respiratory syndrome coronavirus; SARS-CoV: Severe acute respiratory syndrome coronavirus; min: Minute(s); s: Second(s)

ethanol with SARS-CoV (Isolate FFM-1) for 30 s reduces the viral infectivity to more than 5.5 log₁₀; 85% ethanol with SARS-CoV (Isolate FFM-1) for 30 s reduces the viral infectivity to more than 5.5 log₁₀;^[24] 80% ethanol with SARS-CoV

(Isolate FFM-1) for 30 s reduces the viral infectivity to more than 4.3 log₁₀;^[24] 80% ethanol with MERS-CoV (Strain EMC) for 30 s reduces the viral infectivity to more than >4.0 log₁₀;^[25] 78% ethanol with SARS-CoV (Isolate FFM-1) for 30 s reduces

Table 6: Summary of measures recommended for routine cytopathology division (in addition to the *basic protective measures* summarized in Table 2) during SARS-CoV-2 pandemic.

Category/procedure	Measure(s) recommended***
General cytopathology division	Routine standard precautions [Table 1]. ^[14,15] In the case of SARS-CoV-2 suspected or known case-avoid exposure to older personnel over 60 years and personnel with compromised immunity.
Cytoprep laboratory	Routine standard precautions [Table 1]. ^[14,15] In cases suspected or positive for SARS-CoV-2 virus-perform the processing in certified Class II ^[35] Biological Safety Cabinet
FNAB procedure	To minimize the risk of exposure with rapid dissemination of the virus, the “on-site adequacy evaluation services” may be suspended during COVID 19 pandemic related suspension of elective procedures.** However, if FNAB has to be performed without on-site adequacy evaluation: <ul style="list-style-type: none"> • DO NOT squirt the specimen on the slide but drop gently on the slide without letting the specimen aerosolized. • Spread the specimen between two slides with two patient identifiers as routine to make direct smears* to be processed according to individual laboratory protocol(s). • If cell-block is indicated (discuss with associated pathologist), collect the needle rinses directly in 10% formalin (avoid any alcohol-based fixative to prevent potential compromise of immunohistochemistry results^[29] without contaminating the needle with formalin if that needle is to be re-used. • (Recommended to be performed under Class II^[35] Biological Safety Cabinet for cases suspected or positive for SARS-CoV-2 virus). • Send all the material (direct smears in slide container(s) and appropriately labeled 10% formalin container with needle rinses for cell-block) in a leak-proof sealed (Ziploc) specimen bag with properly filled requisition form.
EUS-FNA procedure	Same guidelines as for “#3 FNAB procedure” with extra precaution, because the endoscopes travel through anatomical sites with the highest proportion of viruses in potentially positive cases, especially asymptomatic ones.
Respiratory specimens such as bronchoalveolar lavage, bronchial lavage, bronchial brush, tracheal brush, sputum, and others such as rare percutaneous sampling of lung lesions	Routine Standard precautions [Table 1]. ^[14,15] In cases suspected or positive for SARS-CoV-2 virus-perform the processing in certified Class II ^[35] Biological Safety Cabinet.
Other body fluids such as peritoneal, pleural, pericardial, and other fluids (with potential positivity considered to be similar to blood positivity for SARS-CoV-2 virus) except urine	Routine Standard precautions [Table 1]. ^[14,15] In cases suspected or positive for SARS-CoV-2 virus-perform the processing in certified Class II ^[35] Biological Safety Cabinet.
Cell-block	Routine Standard precautions [Table 1]. ^[14,15] In cases suspected or positive for SARS-CoV-2 virus-perform the processing in certified Class II ^[35] Biological Safety Cabinet Fix the cell-block for at least 2 h (for 2–3 mm thick cell-block material, formalin diffuses at the rate of 1 mm/h and 10% formalin (3.7% formaldehyde) would inactivate the virus in the interior of the cell- block). Most of the lab protocols require more than 6 h (up to 72 h) fixation. ^[29]
All specimens received in 10% formalin and alcoholic fixatives	Routine Standard precautions [Table 1]. ^[14,15] Concerning the surfaces of transport containers and paperwork, etc. In cases suspected or positive for SARS-CoV-2 virus-perform the processing in certified Class II ^[35] Biological Safety Cabinet.
Splitting of specimens	Depending on individual institutional/laboratory protocols, some labs may split the specimen between various subspecialty labs. In such cases, the microbiology lab should split the specimen under microbiology precautions and send most of the specimen to the cytopathology lab for further processing.

*Air-drying both the direct smears spread between slides allows staining the smears with Diff-Quik and Pap stain (as saline-rehydrated alcohol-fixed air-dried smears).^[40] The saline used for rehydration should be discarded as biological waste similar to other biological specimens. The air-dried smears are easy to be transported to Cytoprep lab in slide containers, which should be sanitized/disinfected by rinsing in 95% for 2–5 min, if the slide containers are reused. **If on-site adequacy evaluation services are resumed, all personnel associated with performing the procedure and performing the onsite adequacy service should follow Routine Standard precautions [Table 1].^[14,15] ***Modify as per local regulatory issues and geopolitical limitations based on general information reviewed in this editorial.

the viral infectivity to more than $5.0 \log_{10}$;^[26] 70% ethanol with MHV (Strains MHV-2 and MHV-N) for 10 min reduces the viral infectivity to more than $>3.9 \log_{10}$;^[27] and 70% ethanol with CCV (Strain I-71) for 10 min reduces the viral infectivity to more than $>3.3 \log_{10}$.^[27]

Similarly for formalin, 1% formaldehyde with SARS-CoV (Isolate FFM-1) for 2 min reduces the viral infectivity to more than $>3.0 \log_{10}$;^[26] 0.7% formaldehyde with SARS-CoV (Isolate FFM-1) for 2 min reduces the viral infectivity to more than $>3.0 \log_{10}$;^[26] 0.7% formaldehyde with MHV for 10 min reduces the viral infectivity to more than $>3.5 \log_{10}$;^[27] 0.7% formaldehyde with CCV (Strain I-71) for 10 min reduces the viral infectivity to more than $>3.7 \log_{10}$;^[27] and 0.009% formaldehyde with CCV for 24 h reduces the viral infectivity to more than $>4.0 \log_{10}$.^[28] [Table 5].

About 95% ethanol reduces the viral infectivity to more than 5.5 in 30 s and formaldehyde even in the concentration of 1% decreased the viral infectivity to more than 3 in 2 min [Table 5].^[22] Various reagents such as ethanol and 10% formalin (3.7% formaldehyde) usually used in cytopathology processing at initial stages as fixative have virucidal activity.^[22] Based on the aforementioned, SARS-CoV-2 in any specimen processed with routine fixatives in cytopathology should be inactivated [Table 5].^[22,29]

The data presented thus far suggest that the susceptibility to infection follows the bell curve, with an increase in the severity of the disease with the higher mortality in members of the population over 50 years.^[30,31] This observation should be considered while organizing cytology laboratory services, namely, the potential effect on the personnel associated with various cytology services in regard to their potential for SARS-CoV-2 exposure.

A summary of recommendations for procedure specific protocols in routine cytopathology is enumerated in Table 6. These guidelines are recommended in addition to the WHO basic protective measures at a personal level [Table 2].^[16] The virus survives on various plastic/metal surfaces, cardboards, disposable gowns, and paper surfaces for a significant amount of time [Table 5].^[18,19,21,22,38] To avoid dissemination of the virus, it is recommended that on-site adequacy services should be canceled or postponed during the pandemic. In case a particular procedure is deemed necessary to be performed, the on-site personnel should follow the guidelines generated based on the information discussed in this review and summarized in Table 6.

Acknowledgments

The authors would like to thank Preeti N. Malani, MD, MSJ, (Chief Health Officer and a Professor of Medicine in the Division of Infectious Diseases, Associate Editor of the Journal of the American Medical Association [JAMA],

University of Michigan, Ann Arbor, MI, USA) and Hossein Salimnia, Ph.D., (Professor, Division of Microbiology, Department of Pathology, Detroit Medical Center, Detroit, MI, USA) for the scientific review of the draft of this editorial.

We also thank Amy Conners, MS, CT (ASCP); Anjani Shidham, BS; Inderpreet Dhillon, MS, CT (ASCP); Anushree Shidham, BS; Ahmed Noorsaeed, MD (Cytopathology fellow); Aditya Shidham, MS; and Kathy Rost, Administrative Assistant, for their critical input in scientific draft editing. Their participation in improving this article is greatly appreciated.

The authors also thank “Webpage capture – Archive-today” <https://archive.is/> to archive some of the web references for permanent archival so that their original links may be inactive in the future.

The icon used for this article in HTML format is reproduced from:

Markie M. New collection ensures immediate access to the latest welcome-funded research in the global fight against COVID-19.

Original URL: <https://blog.wellcomeopenresearch.org/2020/04/02/new-collection-ensures-immediate-access-to-the-latest-welcome-funded-research-in-the-global-fight-against-covid-19/>

Long term URL: <https://archive.is/wip/VTSpH>

COMPETING INTERESTS STATEMENT BY ALL AUTHORS

The authors declare that they have no competing interests.

AUTHORSHIP STATEMENT BY ALL AUTHORS

All authors of this article declare that we qualify for authorship as defined by ICMJE <http://www.icmje.org/#author>. Each author has participated sufficiently in the work and takes public responsibility for appropriate portions of the content of this article. VS conceived the idea, conducted literature review, and wrote the manuscript. All (VS, NF, and LL) critically reviewed the article. All authors read and approved the final manuscript.

LIST OF ABBREVIATIONS (IN ALPHABETIC ORDER)

BSC: Biological safety cabinet
BSL-2: Biosafety level 2
CCV: Canine coronavirus
CDC: Centers for Disease Control and Prevention
COVID-19: Coronavirus Disease 2019
CT: Computerized tomography
D: day(s)
FNAB: Fine needle aspiration biopsy
H: hours(s)
HCoV: Human coronavirus

MERS-CoV: Middle East Respiratory Syndrome Coronavirus
 MHV: Mouse hepatitis virus
 min: minute(s)
 PCR: polymerase chain reaction
 PPE: Personal protective equipment
 rRT-PCR: Real-time reverse transcriptase-PCR
 s: second(s)
 SARS-CoV: Severe Acute Respiratory Syndrome Coronavirus
 SARS-CoV-2: Severe acute respiratory syndrome coronavirus 2
 TGEV: transmissible gastroenteritis virus
 WHO: World Health Organization

REFERENCES

1. Tan W, Zhao X, Ma X, Wang W, Niu P, Xu W, *et al.* Notes from the field: A novel coronavirus genome identified in a cluster of pneumonia cases Wuhan, China 2019-2020. *China CDC Wkly* 2020;2:61-62.
2. Chan JF, Yuan S, Kok KH, To KK, Chu H, Yang J, *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;6736:30154-9.
3. Otter JA, Donskey C, Yezli S, Douthwaite S, Goldenberg SD, Weber DJ. Transmission of SARS and MERS coronaviruses and influenza virus in healthcare settings: The possible role of dry surface contamination. *J Hosp Infect* 2016;92:235e50.
4. Dowell SF, Simmerman JM, Erdman DD, Wu JS, Chaovavanich A, Javadi M, *et al.* Severe acute respiratory syndrome coronavirus on hospital surfaces. *Clin Infect Dis* 2004;39:652e7.
5. Geller C, Varbanov M, Duval RE. Human coronaviruses: Insights into environmental resistance and its influence on the development of new antiseptic strategies. *Viruses* 2012;4:3044e68.
6. Kampf G. Antiseptic Stewardship: Biocide Resistance and Clinical Implications. Cham, Switzerland: Springer International Publishing; 2018.
7. Li Q, Guan X, Wu P, Wang X, Zhou L, Tong Y, *et al.* Early transmission dynamics in Wuhan, China, of novel coronavirus infected pneumonia. *N Engl J Med* 2020;382:1199-207.
8. Zhang W, Du RH, Li B, Zheng XS, Yang XL, Hu B, *et al.* Molecular and serological investigation of 2019-nCoV infected patients: Implication of multiple shedding routes. *Emerg Microbes Infect* 2020;9:386-9.
9. Wenling W, Yanli X, Ruqin G, Roujian L, Kai H, Guizhen W, *et al.* Detection of SARS-CoV-2 in different types of clinical specimens. *JAMA*. 2020;11:3786.
10. Centers for Disease Control and Prevention. Fact Sheet for Healthcare Providers. 2019-nCoV Real-Time RT-PCR Diagnostic Panel. Atlanta, Georgia: Centers for Disease Control and Prevention; 2020. Available from: <https://www.cdc.gov/coronavirus/2019-ncov/downloads/Factsheet-for-Healthcare-Providers-2019-nCoV.pdf>. [Last accessed on 2020 April 09].
11. Krieger LM. Coronavirus False Test Results: With the Push to Screen Come Questions of Accuracy Reports of "False Negatives" Could Complicate Efforts to Control the Spread of COVID-19. *The Mercury News*; 2020. Available from: Original URL: <https://www.mercurynews.com/2020/03/19/coronavirus-false-test-results-with-the-push-to-screen-come-questions-of-accuracy>. Long Term URL: <https://www.archive.is/aclxp>. [Last accessed on 2020 April 09].
12. Ai T, Yang Z, Hou H, Zhan C, Chen C, Lv W, *et al.* Correlation of chest CT and RT-PCR testing in coronavirus disease 2019 (COVID-19) in China: A report of 1014 cases. *Radiology* 2020;2020:200642.
13. Jha S. False negative: COVID-19 Testing's Catch-22; 2020. Available from: Original URL: <https://www.kevinmd.com/blog/2020/03/false-negative-covid-19-testings-catch-22>. Long Term URL: <https://www.archive.is/LFin8>. [Last accessed on 2020 April 09].
14. Centers for Disease Control and Prevention. Standard Precautions for All Patient Care. Atlanta, Georgia: Centers for Disease Control and Prevention; 2016. Available from: Original URL: <https://www.cdc.gov/infectioncontrol/basics/standard-precautions>. Long Term URL: <https://www.archive.is/wip/7uT69>. [Last accessed on 2020 April 09].
15. Centers for Disease Control and Prevention. Transmission-Based Precautions; Atlanta, Georgia: Centers for Disease Control and Prevention; 2016. Available from: Original URL: <https://www.cdc.gov/infectioncontrol/basics/transmission-based-precautions>. Long Term URL: <https://www.archive.is/wip/qSgsl>. [Last accessed on 2020 April 09].
16. World Health Organization. Coronavirus Disease (COVID-19) advice for the Public. Basic Protective Measures against the New Coronavirus; 2020. Available from: Original URL: <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public>; Long Term URL: <https://www.archive.is/DZuYq>. [Last accessed on 2020 Mar 18].
17. Henwood AF. Coronavirus disinfection in histopathology. *J Histotechnol* 2020;2020-1-3.
18. Doremalen N, Bushmaker T, Morris DH, Holbrook MG, Gamble A, Williamson BN, *et al.* Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1. Available from: Original URL: <https://www.nejm.org/doi/full/10.1056/NEJMc2004973.pdf>. Long Term URL: <https://www.nejm.org/doi/pdf/10.1056/NEJMc2004973?articleTools=true>. [Last accessed on 2020 Mar 17].
19. Chen YC, Huang LM, Chan CC, Su CP, Chang SC, Chang YY, *et al.* SARS in Hospital Emergency Room. *Emerg Infect Dis* 2004;10:782-8.
20. Gray R. We can Pick up the Covid-19 by Touching Surfaces Contaminated with the New Coronavirus, but it is only just becoming Clear how Long the Virus can Survive Outside the Human Body. *BBC Future*; 2020. Available from: Original URL: <https://www.bbc.com/future/article/20200317-covid-19-how-long-does-the-coronavirus-last-on-surfaces>; Long Term URL: <https://www.archive.is/nB8oM>. [Last accessed on 2020 Mar 17].
21. Volkin V. How long can the virus that causes COVID-19 live on surfaces? 2020. Available from: <https://www.archive.is/wip/LFin8>. [Last accessed on 2020 April 09].
22. Kampf G, Todt D, Pfaender S, Steinmann E. Persistence of

- coronaviruses on inanimate surfaces and their inactivation with biocidal agents. *J Hosp Infect* 2020;104:246e251.
23. Rachel L, Hulkower RL, Casanova LM, Rutala WA, Weber DJ, Sobsey MD. Inactivation of surrogate coronaviruses on hard surfaces by health care germicides. *Am J Infect Control* 2011;39:401-7.
 24. Rabenau HF, Kampf G, Cinatl J, Doerr HW. Efficacy of various disinfectants against SARS coronavirus. *J Hosp Infect* 2005;61:107e11.
 25. Siddharta A, Pfaender S, Vielle NJ, Dijkman R, Friesland M, Becker B, *et al.* Virucidal activity of world health organization recommended formulations against enveloped viruses, including Zika, Ebola, and emerging coronaviruses. *J Infect Dis* 2017;215:902e6.
 26. Rabenau HF, Cinatl J, Morgenstern B, Bauer G, Preiser W, Doerr HW. Stability and inactivation of SARS coronavirus. *Med Microbiol Immunol* 2005;194:1e6.
 27. Saknimit M, Inatsuki I, Sugiyama Y, Yagami K. Virucidal efficacy of physico-chemical treatments against coronaviruses and parvoviruses of laboratory animals. *Jikken Dobutsu Exp Anim* 1988;37:341e5.
 28. Pratelli A. Canine coronavirus inactivation with physical and chemical agents. *Vet J (London, England: 1997)* 2008;177:71e9.
 29. Shidham VB. CellBlockistry: Chemistry and art of cell-block making a detailed review of various historical options with recent advances (review). *CytoJournal* 2019;16:12.
 30. Chodosh S. These Charts Show who is most Vulnerable to COVID-19. *Popular Science*. 2020. Available from: Original URL: <https://www.popsci.com/story/health/covid-19-coronavirus-death-rate-by-age>. Long Term URL: <https://www.archive.is/LTNe8>. [Last accessed on 2020 April 09].
 31. Matthews D. 11 Charts that Explain the Coronavirus Pandemic; 2020. Available from: Original URL: <https://www.vox.com/future-perfect/2020/3/12/21172040/coronavirus-covid-19-virus-charts>. Long Term URL: <https://www.archive.is/9Qmxe>. [Last accessed on 2020 Mar 17].
 32. Centers for Disease Control and Prevention. Interim Laboratory Biosafety Guidelines for Handling and Processing Specimens Associated with Coronavirus Disease 2019 (COVID-19). Atlanta, Georgia: Centers for Disease Control and Prevention; 2019. Available from: Original URL: <https://www.cdc.gov/coronavirus/2019-nCoV/lab/lab-biosafety-guidelines>. Long Term URL: <https://www.archive.is/wip/5Ii97>. [Last accessed on 2020 Mar 31].
 33. Centers for Disease Control and Prevention. Recognizing the Biosafety Level. Atlanta, Georgia: Centers for Disease Control and Prevention; 2019. Available from: <https://www.cdc.gov/training/quicklearns/biosafety>. [Last accessed on 2020 April 09].
 34. Centers for Disease Control and Prevention. Interim Infection Prevention and Control Recommendations for Patients with Suspected or Confirmed Coronavirus Disease 2019 (COVID-19) in Healthcare Settings. Atlanta, Georgia: Centers for Disease Control and Prevention; 2020. Available from: Original URL: <https://www.cdc.gov/coronavirus/2019-ncov/infection-control/control-recommendations>. Long Term URL: <https://www.archive.is/0A5Ne>. [Last accessed on 2020 Mar 19].
 35. Rijal N. Biological Safety Cabinet (BSC): Types and Working Mechanism. *Microbe Online*; 2019. Available from: Original URL: <https://www.microbeonline.com/biological-safety-cabinet-bsc-types-working-mechanism>. Long Term URL: <https://www.archive.is/G5u0G>. [Last accessed on 2019 Dec 05].
 36. NHK World Japan (video). An NHK Experiment Found that Microdroplets Emitted while Sneezing and Coughing and During Conversations Stay in the Air for Longer than Normal Droplets, Potentially Posing a Uniquely Dangerous Risk for Coronavirus Infection. Shot in Cooperation with Shin Nippon Air Technologies; 2020. Available from: Original URL: <https://www3.nhk.or.jp/nhkworld/en/news/atagance/844>. Long Term URL: <https://www.archive.is/XoI31>. [Last accessed on 2020 Mar 31].
 37. Canelli R, Connor CW, Gonzalez M, Nozari A, Ortega R. Barrier Enclosure during Endotracheal Intubation; 2020. Available from: Original URL: <https://www.nejm.org/doi/full/10.1056/NEJMc2007589>. Long Term URL: <https://www.archive.is/wip/427et>. [Last accessed on 2020 Apr 03].
 38. Nicas M, Best D. A study quantifying the hand-to-face contact rate and its potential application to predicting respiratory tract infection. *J Occup Environ Hyg* 2008;5:347-52.
 39. Kwok YL, Gralton J, McLaws ML. Face touching: A frequent habit that has implications for hand hygiene. *Am J Infect Control* 2015;43:112-4.
 40. Shidham V, Kampalath B, England J. Routine air drying of all the smears prepared during fine needle aspiration and intraoperative cytology studies: An opportunity to practice a unified protocol, offering the flexibility of choosing variety of staining methods. *Acta Cytologica* 2001;45:60-8.

How to cite this article: Shidham VB, Frisch NK, Layfield LJ. Severe acute respiratory syndrome coronavirus 2 (the cause of COVID 19) in different types of clinical specimens and implications for cytopathology specimen: An editorial review with recommendations. *CytoJournal* 2020;17:7.

The FIRST **Open Access** cytopathology journal

Publish in *CytoJournal* and **RETAIN** your *copyright* for your intellectual property

Become Cytopathology Foundation Member to get all the benefits

Annual membership fee is nominal US \$ 50 (US \$ 1000 for life)

In case of economic hardship it is free

For details visit <https://cytojournal.com/cf-member>

PubMed indexed

FREE world wide open access

Online processing with rapid turnaround time.

Real time dissemination of time-sensitive technology.

Publishes as many **colored high-resolution images**

Read it, cite it, bookmark it, use RSS feed, & many----



CYTOJOURNAL

www.cytojournal.com

Peer-reviewed academic cytopathology journal





NextGen CelBloking™ Kits

**Frustrated with your cell blocks?
We have a better solution!**

Nano

Nano NextGen CelBloking™

Cell block kit to process single scattered cell specimens and tissue fragments of **any** cellularity.



PATENT PENDING



Pack #1



Pack #2

Micro

Micro NextGen CelBloking™

For cellular specimens (more than 1 ml concentrated specimen with Tissuecrit more than 50%)



PATENT PENDING



Pack #2