International Journal of Science and Research Archive

eISSN: 2582-8185

Cross Ref DOI: 10.30574/ijsra

Journal homepage: https://ijsra.net/

(REVIEW ARTICLE)

Check for updates

A Comprehensive review on COVID-19: From clinical characterizations to treatment

Abbas Khan *, Misbah Ullah, Ubaid ur Rehman, Muhammad bin Riaz, Rizwan Khan and Muskan Saleem

Centre of Biotechnology and Microbiology, University of Peshawar, Pakistan.

International Journal of Science and Research Archive, 2024, 13(02), 583–589

Publication history: Received on 28 September 2024; revised on 06 November 2024; accepted on 09 November 2024

Article DOI: https://doi.org/10.30574/ijsra.2024.13.2.2158

Abstract

In December 2019, the outbreak of COVID-19 started which was originally believed to be pneumonia. Later on, after studies of vaccination and sign, symptoms revealed it to be a SAR-CoV (severe acute respiratory syndrome coronavirus 2), results in infection of the lower respiratory areas that centrals to risky breath shortness and even death. This pandemic not only brought massive human lives but also economic as well as societal loss, rising death numbers in millions, 21st century's deadliest viral disease till now. The world economic forum supported and appreciated each step for the treatment of COVID 19. Leading supporters to work immensely for the vaccine's formulation. Though, being an RNA virus, it deploys its genetics speedily and makes it hard almost impossible for the next mutated strain to be targeted by the same vaccine. Structurally it is like crown with spikes on it, that gets attached to the host cell. COVID-19 identified in the year 2019 but documented in February 2020, by the World Health Organization.

Keywords: COVID-19; Pandemic; China; SARS-CoV2; Virus

1. Introduction

COVID-19 is the sixth pandemic to affect humans worldwide after the influenza epidemic of 1918. The severe acute respiratory syndrome corona virus 2 (SARSCoV2) is the cause of the coronavirus illness, a highly contagious and pathogenic viral infection that has had a devastating effect on people and resulted in a sizable loss of life on a global scale. SARS-CoV2 and severe acute respiratory syndrome are phylogenetically related, according to genomic study [1].

It is believed that SAR-CoV-2 developed from an animal coronavirus through spillover and then acquired the ability to spread from person to person. These characteristics are mostly due to the coronavirus's high contagiousness, rapid transmission, and ongoing evolution within the human population [2]. Therefore, it's possible that the virus infected humans and then changed to acquire the characteristics that made it possible for it to spread so quickly as it infected more people [3].

Using phylogenetic research, the worldwide Council on Taxonomy of Viruses gave the corona virus the formal name severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The term "coronavirus" comes from the recognizable spikes with rounded tips that adorn their surface and give them a corona-like look. Positive-sense single-stranded RNA is the nucleic acid material found in coronaviruses, which are very small (65–125 nm in diameter). Between 26 to 32 kbs in length, enveloping spherical particles [4]. Alpha (a), beta (b), gamma (c), and delta (d) coronaviruses are the four subgroups of the coronavirus family [5].

2. Origin and spread

The capital city of Hubei province, Wuhan, China, was where the infectious illness that causes severe acute respiratory syndrome (SARS) was found and diagnosed [7]. In December 2019, the sickness begins to spread from China. Many

* Corresponding author: Abbas Khan

persons in Wuhan City suffered from acute pneumonia for unidentified reasons. WHO received a notification of the pandemic from China on December 31, 2019. The virus was identified as a coronavirus when its genome sequence was compared to that of the bat. Due to the positive COVID test results from seafood, Huanan Seafood businesses were forced to close on January 1st, 2020. Samples were taken from the items on the market and the animals that had COVID-19 good results. The first fatality instance was noted on January 11 due to the influx of people on New Year's Day. A pandemic is now more likely because of the crowded population and the contagious nature of the sickness. As soon as the epidemic started, lockdown and restriction measures were implemented. Nonetheless, the virus spread from Wuhan to neighboring cities in the province of Hubei. On January 23, the virus crossed the border, and cases were quickly found in Japan, South Korea, and Thailand. 96,000 instances were reported on March 3, 2020. 80,000 of which are Chinese. The number of instances sharply increased in other countries, such as South Korea, Italy, and Iran. In comparison to other countries, China now has the fewest cases. The epidemic is virtually under control as of right now [8]. On January 7, the culprit virus was identified, and on January 12, its genome was made public. As a result, the severe acute respiratory disease that eventually became known as COVID-19 was caused by a novel virus [6]. A beta-coronavirus is what it is. Currently, there are around six human-susceptible virus CoVs. Four of them often produce mild respiratory symptoms similar to the common cold and have minimal pathogenicity. The other two, MERS-CoV and SARS-CoV, cause respiratory illnesses that are exceedingly dangerous and can even be fatal. Interestingly, 96.2% of the genomic sequences of SARS-CoV-2 and bat CoVRsTG13 are similar. Although it resembles SARS-CoV by 79.5 According to the genome sequences, it is possible to conclude that the bat is serving as the founding host for the virus [7].

2.1. Clinical features and characteristics

COVID-19 an acute respiratory infectious disease spreads through respiratory tract, by droplets or respiratory secretions. SARS-CoV-2 was discovered from the fecal swabs of a critically ill patient with pneumonia at Sun Yat-sen University's Fifth Affiliated Hospital in Guangdong, China, on February 10, 2020. Similarly, the presence of SARS-CoV-2 in fecal swabs and blood, indicates the possibility of different route transmission [9]. 5 days are the median time from symptoms and signs to the well-developed phase of pneumonia [10]. According to the current epidemiological study, the incubation period is 1–14 days, with 3–7 days being the most common. The disease become lethal during their last period [10]. The clinical feature of 2019-nCoV is most likely to SARS-CoV and the symptoms of these include headache, dizziness, abdominal pain, diarrhea, nausea, and vomiting. Fever, dry cough, myalgia, and exhaustion were among the symptoms reported in the first 425 confirmed cases in Wuhan. In 75% of instances, both patients develop pneumonia. COVID-19, Nineteen people with upper respiratory tract symptoms—such as sore throats, sneezing, or rhinorrhea—are less common than those with lower respiratory tracts. Meaning that virus is happy in the lower respiratory tract. Both pregnant and non-pregnant have same characteristics. COVID-19 patients can start severe problems like hypoxemia, acute ARDS, Arrythmia, shock, acute cardiac injury, and acute kidney injury [9]. The severity rate varies from place to place. Like in Wuhan the cases were severe and fatal than those which are found in Hubei province [11].

The data released by Chinese National Reporting System showcasing COVID-19 patient age and sex, that the median age of verified cases were 51 years of which 77.8% were at the age of 30-69, in which the percentage of male patients were 51.1% [12].

3. Diagnosis of COVID-19

Governments imposed restrictions on social interaction after the COVID-19 outbreak in late 2019 in an effort to stop the infection's rapid spread. Also, scientists were driven to create extremely dependable and efficient diagnostic processes for the accurate identification of COVID-19 and to distinguish it from seasonal flu, which might impact the appropriate therapeutic approach to treat an infected patient [13]. To meet the aforementioned conditions, three different types of testing have been developed: molecular RT-PCR swab tests, rapid antigen or antibody tests, and serological tests. In the early stages of the pandemic, before serological and genetic methods for detection were available, clinical examinations and radiological imaging techniques were crucial [14].

3.1. Various diagnostic procedures

3.1.1. RT-PCR molecular test

The most effective and reliable method for diagnosing COVID-19. For the purpose of differentiating between COVID-19 and other disorders such as seasonal flu, etc., different primers and probes specific for various areas of the COVID-19 genome, such as RdRP coding genes, N- genes and S-genes, are utilized. Three primer pairs have also received CDC approval, two of which lie in the N gene area and one in the RdRP gene region [**15**]. COVID-19 is positive-stranded RNA virus with a 29,903 bp in length total genome.

In order to make a diagnosis, a sample from the BALF is required, but it may also be obtained from other respiratory sources, such as nasopharyngeal and oropharyngeal swabs, which have a significant viral load to allow for viral RNA extraction and amplification [16]. The RNA is extracted using WHO-approved kits and lysing analytes following sample collection from nasopharyngeal swabs or BALF. RdRP is then cast-off to convert RNA to cDNA. Following cDNA synthesis, several targeted areas are amplified, and TaqMan probes are utilised to identify these amplified regions. While the TaqMan probes are primarily utilised for qualitative analysis, the fluorescent signals they produce are proportionate to the amplified product [17]. Even though the RT-PCR method has the highest level of accuracy, it has some drawbacks, including low sensitivity to improperly obtained samples, interference from inhibitors present in samples or added during handling, and sensitivity to pre-analytical and analytical bias during collection, storage, and handling [18]. These are the limitations which results in false-negative/positive diagnosis.

The test should be repeated with two distinct samples acquired from different sources or from the same source with a time delay in order to get over these limitations, according to the guidelines provided by the WHO. Also, the WHO has provided guidelines on the 2 to 3 viral genes, human control genes to be evaluated, and particular positive and negative controls that demonstrate how contaminations and handling inhibitors might alter the accuracy of test findings [19].

3.1.2. Rapid antigen and antibody test

It is used to deal with COVID-19 infection waves that repeat often and quickly diagnose in the most crowded areas like factoris and schools, etc. Salieva, blood samples, and respiratory track lining swabs are used in this test to look for viral antigens and anti-SARS-CoV-2 antibodies [20].

These both tests work on the principle of lateral flow immunoassay (LFIA). The sample and buffer are put into strip's sample well for fast antigen test. By means of capillary action, the sample carrying viral antigen (nucleocapsid or spike proteins) travels in the direction of conjugated pad. Anti-SARS-CoV-2 antigen conjugated antibodies as well as conjugated control rapid antibodies are included in conjugated pads. Anti-SARS-CoV-2 antibodies travel toward the test line after binding with viral antigen. The conjugated antibody and viral antigen combination attaches to immobilised antibodies specific for the viral antigen at the test line. This whole complex at the test line produces a colorimetric reaction which indicates the positivity of test. The conjugated control rapid antibodies moves further along with buffer and complex with anti-control rapid antibodies giving rise to colorimetric reaction shows that strip is correct [21].

In rapid antibody test, the sample well is used to load blood sample along with buffer. The sample containing human antibodies IgG, IgM and IgA moves towards the conjugated pad. Conjugated pad contains the gold tagged viral antigens and control rabbit antibodies. The human antibodies attaches with viral antigen and moves towards the test line where antigen-antibody complex bounds with the anti-human IgA,IgM and IgG antibodies giving rise to colorimetric reaction ,confirms the diagnosis of COVID-19 infection. The control rabbit antibodies moves further and complex with anti-control rabbit antibodies shows that the strip is working rightly [22].

Plus it gives evidence about the stages of infection if no infection control line is stained, in case resent infection, IgG and IgM bands gets stained, and in case of ongoing infection only IgG band get stained along with control line. Despite its advantages it has certain limitations, it has low sensitivity and specificity of 56.2% and 99.5% respectively [23]. It is not possible to predict about the ongoing infection or the infection has ended because the antibodies can persist for long time in body and It is also impossible to diagnose recent infection because IgM and IgG antibodies are generated in third week of infection [24].

- **Immunoenzymatic serological test:** Indirect enzyme-linked immunosorbent assay is often the basis of immunoenzymatic serological tests used to diagnose COVID-19 infection (ELISA). Sandwich and indirect ELISA testing can both be used to diagnose COVID-19. It is primarily based on a microwell plate-based chemiluminescent assay for the detection of human immunoglobulins, viral peptides, and antigens via their attachment to proteins and immunoglobulins that may be detected [25].
- **ELISA indirect test:** 96-well commercial tests for ELISA are available. The COVID-19 infection is diagnosed by indirect ELISA. The viral antigen in the micro-well is immobilised. To each well, the first blood sample is inserted. IgG, IgM, and IgA, anti-SARS-CoV-2 antibodies, hybridise with the viral antigen in the blood. To get rid of the blood and unattached antibodies, the well is now cleansed. Anti-IgG, anti-IgA, and anti-IgM radiolabeled/fluorescent tagged anti-human antibodies are added following a series of washes. These anti-human antibodies form complexes with SARC-CoV-2 and antigen hybrids. This complex generates observable signals that support a patient's infection. At present ELISA indirect test is used for the detection of IgM and IgG antibodies produced against COVID-19 [26]. The antigen is sandwiched between the antibodies in the ELISA sandwich technique. Initially, a 96-well tray containing immobilised antibodies specific for the antigen is filled

with the patient's serum, which contains viral antigens such spike proteins. Anti-SARC-CoV-2 antibodies and the viral antigen combine to form a hybrid. Conjugated antibodies that are likewise specific for viral antigen are now added after a number of washings. The hybrid viral antigen and anti-SARS-CoV-2 antibodies then form a compound with the conjugated antibodies, producing visible findings that confirm the presence or absence of infection in a sample. The primary use of ELISA sandwich is COVID-19 diagnostic [27]. The infectious status of the patient cannot be detected by ELISA. Even if a person is diagnosed positive with ELISA, RT-PCR based molecular test is necessary for confirmation.

- **Imaging methods utilised to diagnose COVID-19:** The only way to identify the illness at first, before molecular and serological lab techniques were created, was to use several imaging techniques that revealed alterations in the respiratory track. The identification of COVID-19 uses a variety of imaging modalities, including lung ultrasonography, CXR, and CT scanning.
- These imaging methods were also used to diagnose people without symptoms in cases when molecular and serological testing came up negative.
- **CT scan:** It can be used to check for GGO, consolidation, the quantity of lung lobes with GGO and consolidative opacities, and the severity of pleural alterations including pleural effusion and thickness, among other things [28]. SARC-CoV-2 pneumonia was distinguished from other viral and bacterial pneumonias using chest computed tomography (CT). Contrary to non-COVID-19 pneumonia, which exhibited patchy and density-increasing shadows, numerous mottling, multiple GGO, and sub-segmental regions of consolidation were frequently detected in COVID-19 patients [29].
- **A non-invasive, radiation-free imaging method:** It is lung ultrasonography. As it is portable, it may be used in emergency rooms at the bedside of suspected patients. Individuals with COVID-19 infection have thick, confluent, and atypical vertical artefacts as well as uneven pleural lines and tiny sub-pleural consolidations [30]. Also, because it is a non-invasive and radiation-free process, it is essential to utilise it for screening pregnant women because it lowers the risk of miscarriage.
- **Chest X-rays:** These are readily available at virtually all medical facilities; they were the cheapest and most popular diagnostic method during the early stages of COVID-19. Patients with moderate to severe symptoms and interstitial opacities, alveolar opacities, etc. were treated with it [31]. Despite its cheap cast, widespread accessibility, and ease of use, it has limited sensitivity, the radiological images it produces are blurry, and it exposes users to a lot of radiation. As a result, the CT scan was often employed for diagnosis.

4. Treatment

There was little information available about COVID-19 and its therapies in the early stages of the epidemic. There is currently no permission for the use of antivirals or other drugs to treat COVID-19. Yet since the pandemic spread so quickly, it was possible to treat COVID-19 using already-approved medications that have been shown to be effective against HIV, MERS, and SARS. After then, the tireless work of clinical researchers has led to a greater knowledge of COVID-19 as well as the rapid development of treatments. Remdesivir, a broad-spectrum antiviral medication, has demonstrated antiviral activity against SARS-Cov-2. According to one research, it was FDA-approved for clinical usage in people who had just been hospitalised [32]. Molnupiravir, a broad-spectrum, instantly acting oral antiviral drug, was first developed as a possible treatment for influenza. Molnupiravir was administered early to at-risk adults who were unvaccinated and had mild-to-moderate laboratory-confirmed COVID-19 in order to reduce their risk of hospitalization or death. An FDA-approved combination medication for HIV therapy, lopinavir and ritonavir, was proposed as an antiviral treatment for COVID-19 in the early phases of the pandemic. One study claims that ritonavir is used as a booster for lopinavir, a protease inhibitor, which is used to treat HIV. In vitro experiments using the demonstrated anti-coronavirus activities [33]. For the treatment of COVID-19, the most often prescribed dosage of lopinavir/ritonavir was 400 mg/100 mg twice daily for up to 14 days. According to several research, lopinavir/ritonavir side effects might cause nausea, diarrhoea, and gastrointestinal discomfort [34]. Initially during the pandemic, chloroquine and hydroxychloroquine were suggested as antiviral therapies for covid-19 [32]. By preventing host receptor glycosylation, proteolytic processing, and endosomal acidification, they seem to prevent viral entrance into cells. With a half-maximal effective dose (EC50) in the low micromolar range, chloroquine suppresses SARS-CoV-2 in vitro. After 24 hours of development, hydroxychloroquine exhibits in vitro action with a lower EC50 for SARS-CoV-2 than chloroquine [34].

5. Prevention

Due to some nonspecific characters of disease I.e. infection occur before the appearance of symptoms in its incubation period, some people may have the disease and don’t show symptoms and therefore can transfer the disease to the Even after the afflicted individual has recovered clinically, the illness might still be mistakenly transferred to a healthy person

because they don't have any symptoms. These are some reasons which make the prevention a little difficult [35]. However, in order to avoid COVID-19, several preventative measures should be implemented.

- **Isolation:** The suspected and confirmed patients should be kept in isolation ward, isolation ward should be provided with all the basic facilities such as a private bathroom. It is important that all the necessities of the patient should be present in isolation area or isolation ward. The confirmed patients can be kept in same isolation room with 4 feet or 6 feet bed spacing [36]. The patients with mild illness can be isolated at home providing the proper ventilation and good sun light in order to destroy the virus [35]. Family should avoid visit to the patient's room and can do electronic communication with the patient as prevention.
- **Use of mask:** Masks should be worn by the patient, their family, and medical staff in order to avoid the illness. Two different kinds of masks are used as disease prevention gear.
- **MEDICAL /SURGICAL FACE MASK:** It is estimated that this mask reduces the risk of disease transmission about 80%.
- **FILTERING FACEPIECE RESPIRATORS:** This kind of mask achieves filtering by the use of polyethylene microfiber and the electrostatic charge phenomena. For instance, N95 or FFP2 are high-performance filtering masks.
- **Disinfection of isolation wards:** The isolation ward should be disinfected. The floor, walls, and other surfaces must be cleared of any visible or bigger contaminants first.They should then be sprayed or mopped with a disinfectant containing 1000g/l chlorine. Three times a day, for thirty minutes, the disinfection process should be performed.
- **Air disinfection:** Plasma air sterilisers should be used for air disinfection. If plasma air sterilisers are not present ultraviolet lamps can be used for one hour to achieve air disinfection in the areas with human activity. This process should be reformed at least three times a day.
- **HOSPITAL PRACTICE PROTOCOLS:** When working with COVID-19 patients, healthcare workers should adhere to the following protocol.

Put on specialized work attire and footwear, wash your hands thoroughly, and wear a disposable surgical hat. Put on protective mask I.e. N95; Wear inner disposable latex gloves; Put on Google and protective clothing; Wear outer disposal latex gloves; Donning completed to deal with covid-19 patients [36].

6. Prevention measures at community level

- **Avoid crowded areas:** People should avoid crowded area such as parks, shopping mall wedding halls and other social gatherings.
- **Six feet:** In marketplaces, shops, and other places, people should keep a maximum of six feet between one another. They should practice cough hygiene, which is to cough in tissue or sleeves rather than in their hands. **Hand hygiene:** Individuals should wash their hands every 15 to 20 minutes. Additionally, hand sanitizer use must to be promoted.
- **Travel restrictions:** China was subject to travel restrictions at the beginning of the epidemic.

People who were returning from China were first checked for the symptoms and tested of Covid-19. They were quarantined for 2 weeks even if they don't show any symptoms. Due to the rapid spread of Covid-19 the travel restrictions have been extended to many other countries where ratio of disease is high [37].

7. Conclusion

The coronavirus epidemic is the deadliest in recent history. The extensive and strong measures taken for the identification of the SAR-CoV 2 mutation that caused the COVID-19 pandemic were a significant development. The signs and symptoms of shortness of breath and low oxygen made it easy to identify an illness other than pneumonia. The scientific and research community's diagnostic stages were exhausting and difficult, resulting in therapy and vaccine, as well as boosters that are still used to improve immunity. After all of the safety procedures and precautions of utilizing sanitizers, distance speaking, masks, and a few others, the most important of all is that there is nearly little risk of becoming infected. Keep safe and stay healthy.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Jevšnik, M., Uršič, T., Žigon, N., Lusa, L., Krivec, U., & Petrovec, M. (2012). Coronavirus infections in hospitalized pediatric patients with acute respiratory tract disease. BMC Infectious Diseases, 12(1). https://doi.org/10.1186/1471-2334-12-365

[2] Huang, C., Wang, Y., Li, X., Ren, L., Zhao, J., Hu, Y., Zhang, L., Fan, G., Xu, J., Gu, X., Cheng, Z., Yu, T., Xia, J., Wei, Y., Wu, W., Xie, X., Yin, W., Li, H., Liu, M., . . . Cao, B. (2020). Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. The Lancet, 395(10223), 497–506. https://doi.org/10.1016/s0140-6736(20)30183-5

[3] Coronavirus disease (COVID-19) epidemiological updates and monthly operational updates. (2020). World Health Organization. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports

[4] Wu, F., Zhao, S., Yu, B., Chen, Y., Wang, W., Song, Z., Hu, Y., Tao, Z., Tian, J., Pei, Y., Yuan, M., Zhang, Y., Dai, F., Liu, Y., Wang, Q., Zheng, J., Xu, L., Holmes, E. C., & Zhang, Y. (2020). A new coronavirus associated with human respiratory disease in China. Nature, 579(7798), 265–269. https://doi.org/10.1038/s41586-020-2008-3

[5] Zhu, N., Zhang, D., Wang, W., Li, X., Yang, B., Song, J., Zhao, X., Huang, B., Shi, W., Lu, R., Niu, P., Zhan, F., Ma, X., Wang, D., Xu, W., Wu, G., Gao, G. F., & Tan, W. (2020). A Novel Coronavirus from Patients with Pneumonia in China, 2019. New England Journal of Medicine, 382(8), 727–733. https://doi.org/10.1056/nejmoa2001017

[6] Chan, J. F., Yuan, S., Kok, K., To, K. K., Chu, H., Yang, J., Xing, F., Liu, J., Yip, C. C., Poon, R. W., Tsoi, H., Lo, S. K., Chan, K., Poon, V. K., Chan, W., Ip, J. D., Cai, J., Cheng, V. C., Chen, H., . . . Yuen, K. (2020). A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. The Lancet, 395(10223), 514–523. https://doi.org/10.1016/s0140-6736(20)30154-9

[7] Chauhan, S. (2020). Comprehensive review of coronavirus disease 2019 (COVID-19). Biomedical Journal, 43(4), 334–340.

[8] Harapan, H., Itoh, N., Yufika, A., Winardi, W., Keam, S., Te, H., Megawati, D., Hayati, Z., Wagner, A. L., & Mudatsir, M. (2020). Coronavirus disease 2019 (COVID-19): A literature review. Journal of Infection and Public Health, 13(5), 667–673.

[9] Guo, Y., Cao, Q., Hong, Z., Tan, Y., Wang, S., Jin, H., Tan, K., Wang, D. Y., & Yan, Y. (2020). The origin, transmission and clinical therapies on coronavirus disease 2019 (COVID-19) outbreak – an update on the status. Military Medical Research, 7(1).

[10] Singhal, T. (2020). A Review of Coronavirus Disease-2019 (COVID-19). Indian Journal of Pediatrics, 87(4), 281–286.

[11] O'Dowd, A. (2020). Covid-19: Avoid indoor mixing over Christmas or risk third wave, warns iSAGE. BMJ, m4832. https://doi.org/10.1136/bmj.m4832

[12] Sanyaolu A, Okorie C, Marinkovic A, Ayodele O, Abbasi AF, Prakash S, Ahmed M, Kayode D, Jaferi U and Haider N: Navigating the diagnostics of COVID-19. SN Compr Clin Med. Jul 25–2020.Epub ahead of print.

[13] European Commission (EC): Current performance of COVID-19 test methods and devices and proposed performance criteria. EC; Brussels: 2020, https://ec.europa.eu/docsroom/documents/40805. Accessed January 2, 2021.

[14] da Silva SJR, Silva CTAD, Guarines KM, Mendes RPG, Pardee K, Kohl A and Pena L: Clinical and Laboratory Diagnosis of SARS-CoV-2, the Virus Causing COVID-19. ACS Infect Dis. 6:2319–2336. 2020.

[15] US Food & Drug: Infographic on COVID-19 tests and collection kits approved by the FDA in 2020. https://www.fda.gov/medical-devices/coronavirus-covid-19-and-medical-devices/covid-19-tests-and-collection-kits-authorized-fda-2020-infographic. January 8, 2021, accessed.

[16] Fomsgaard AS and Rosenstierne MW: A different approach for the molecular detection of SARS-CoV-2 - avoiding the lack of NA extraction kits, Copenhagen, Denmark, March 2020. 25:20003982020 Euro Surveill.

[17] Diagnosing COVID-19: The Disease and Techniques for Detection by Udugama B, Kadhiresan P, Kozlowski HN, Malekjahani A, Osborne M, Li VYC, Chen H, Mubareka S, Gubbay JB, and Chan WCW. 2020. ACS Nano. 14:3822–

[18] Afzal A: Molecular diagnostic technologies for COVID-19: Limitations and challenges. J Adv Res. 26:149–159. 2020.

[19] Stability concerns of RT-PCR testing of SARS-CoV-2 for hospitalised patients clinically diagnosed with COVID-19 by Li Y, Yao L, Li J, Chen L, Song Y, Cai Z, and Yang C. 2020. J Med Virol 92:903-908.

[20] Human angiotensin converting enzyme 2 is used in a new quick detection method for SARS-CoV-2 spike 1 antigens by Lee JH, Choi M, Jung Y, Lee SK, Lee CS, Kim J, Kim J, Kim NH, Kim BT, and Kim HG (ACE2). 171:1127152021.

[21] Accuracy of a nucleocapsid protein antigen fast test in the diagnosis of SARS-CoV-2 infection. Diao B, Wen K, Zhang J, Chen J, Han C, Chen Y, Wang S, Deng G, Zhou H, and Wu Y. 2021. Clin Microbiol Infect. 27:289-e1-289-e4.

[22] Performance characteristics of a quick SARS-CoV-2 antigen detection assay at a public plaza testing location in San Francisco. Pilarowski G, Lebel P, Sunshine S, Liu J, Crawford E, Marquez C, Rubio L, Chamie G, Martinez J, Peng J, et al. Jan. 4, 2021, J Infect Dis. e-pub before print.

[23] Quick, point-of-care antigen and molecular-based tests for diagnosis of SARS-CoV-2 infection: Cochrane COVID-19 Diagnostic Test Accuracy Group. Dinnes J, Deeks JJ, Adriano A, Berhane S, Davenport C, Dittrich S, Emperador D, Takwoingi Y, Cunningham J, Beese S, et al. CD0137052020, Cochrane Database Syst Rev. 8.

[24] Anti-SARS-Cov-2 IgA in Present Situation of IgM and IgG Quick Test: A Novel Option for the Diagnosis of COVID-19. SN Compr Clin Med. 26:1-3. 2020. La Rosa Fabián C and Urquizo Briceo L.

[25] Enzyme Linked Immunosorbent Assay by Alhajj M and Farhana A, number 25. StatPearls. Treasure Island, FL: 2020 StatPearls.

[26] Analytical and clinical validation of an ELISA for specific SARS-CoV-2 IgG, IgA, and IgM antibodies by Tré-Hardy M, Wilmet A, Beukinga I, Favresse J, Dogné JM, Douxfils J, and Blairon L. 2021. J Med Virol 93:803-811.

[27] Tanaka Y, Kamimura K, Nakamura R, Ohkoshi-Yamada M, Koseki Y, Mizusawa T, Ikarashi S, Hayashi K, Sato H, Sakamaki A, et al: Utility of ultrasonography to evaluate the response to steroidal therapy for the uncommon case of type 2b immunoglobulin G4-related sclerosing cholangitis without pancreatitis. World J Clin Cases, 2020, 8, 5821–5830.

[28] J. Liu, H. Yu and S. Zhang, "The indispensable role of chest CT in the detection of coronavirus disease 2019 (COVID-19)", Eur. J. Nucl. Med. Mol. Imaging, pp. 1-2, 2020.

[29] D. Zhao et al., "A comparative study on the clinical features of COVID-19 pneumonia to other pneumonias", Clin. Infect. Dis., 2020.

[30] D. Buonsenso, A. Piano, F. Raffaelli, N. Bonadia, K. de Gaetano Donati and F. Franceschi, "Point-of-Care lung ultrasound findings in novel coronavirus disease-19 pnemoniae: A case report and potential applications during COVID-19 outbreak", Eur. Rev. Med. Pharmacol. Sci., vol. 24, no. 5, pp. 2776-2780, 2020.

[31] Ippolito D, Maino C, Pecorelli A, Allegranza P, Cangiotti C, Capodaglio C, Mariani I, Giandola T, Gandola D, Bianco I, et al: Chest X-ray features of SARS-CoV-2 in the emergency department: A multicenter experience from northern Italian hospitals. Respir Med. 170:1060362020.

[32] Cascella, M. (2022, October 13). Features, Evaluation, and Treatment of Coronavirus (COVID-19). StatPearls - NCBI Bookshelf.

[33] Jamshaid, H., Zahid, F., Din, I. U., Zeb, A., Choi, H. Y., Khan, G. M., & Din, F. U. (2020). Diagnostic and Treatment Strategies for COVID-19. Aaps Pharmscitech, 21(6).

[34] EXPERIMENTAL BIOMEDICAL RESEARCH. (n.d.-b).

[35] Biointerface Research in Applied Chemistry. (n.d.)

[36] Singhal, T. (2020b). A Review of Coronavirus Disease-2019 (COVID-19). Indian Journal of Pediatrics, 87(4), 281–286

[37] Ağalar, C., & EngiN, D. Ö. (2020). Protective measures for COVID-19 for healthcare providers and laboratory personnel. TURKISH JOURNAL OF MEDICAL SCIENCES, 50(SI-1), 578–584. https://doi.org/10.3906/sag-2004-132.