**REVIEW ON THE AETIOLOGY OF COVID-19, IT’S PATHOGENESIS, HISTOPATHOLOGICAL FEATURES AND THE CURRENT POTENTIAL THERAPIES TO ADDRESS IT, ALSO THE FUTURE OF COVID-19 ON PUBLIC HEALTH.**

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**HISTOPATHOLOGY**

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**1.0 INTRODUCTION**

Coronavirus belongs to a family of viruses which may lead to different symptoms such as pneumonia, fever, breathing difficulty, and lung infection ([Committee, 2019](#_ENREF_7)). These viruses are common in animals worldwide, but very few cases are said to have an effect on humans. The World Health Organization (WHO) used the term 2019 novel coronavirus to refer to a coronavirus that had effect on the lower respiratory tract of patients with pneumonia in Wuhan, China on 29 December 2019 ([Control & Prevention, 2019](#_ENREF_8); [Li et al., 2020](#_ENREF_19); [Organization, 2020](#_ENREF_24)). The WHO announced that the official name of the 2019 novel coronavirus is coronavirus disease (COVID-19) ([Organization, 2020](#_ENREF_24)). The recent reference name for the virus is known as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). It was reported that a large number of patients with pneumonia of unknown cause was connected to a local Huanan South China Seafood Market in Wuhan, Hubei Province, China in December 2019 ([Zhu et al., 2020](#_ENREF_30)).

In response to the outbreak, the Chinese Center for Disease Control and Prevention (China CDC) dispatched a quick response team in order to accompany health authorities of Hubei province and Wuhan city to conduct epidemiological and etiological findings. The WHO confirmed that the outbreak of the coronavirus epidemic was linked with the Huanan South China Seafood Marketplace, but no specific animal association was identified ([Organization](#_ENREF_22)). Scientists quickly began to research the source of the new coronavirus, and the first genome of COVID-19 was published by the research team led by Prof. Yong-Zhen Zhang, on 10 January 2020 ([Gralinski & Menachery, 2020](#_ENREF_11)) . Within 1 month, this virus spread fast throughout China during the Chinese New Year – a period when a high level of human mobility among Chinese people has been recorded. Although it is still too early to foretell susceptible populations, early patterns have shown a trend similar to Severe Acute Respiratory Syndrome (SARS) and Middle East respiratory syndrome (MERS) coronaviruses. Susceptibility seems to be linked with age, biological sex, and other health conditions ([Fehr, Channappanavar, & Perlman, 2017](#_ENREF_9)). COVID-19 has been declared as a Public Health Emergency of International Concern by the WHO ([Organization, 2005](#_ENREF_23)).

**2.0 AETIOLOGY**

CoVs are positive-stranded RNA viruses with a crown-like appearance under an electron microscope (*coronam* is the Latin term for crown) due to the presence of spike glycoproteins on the envelope. The subfamily *Orthocoronavirinae* of the *Coronaviridae* family (order *Nidovirales*) classifies into four genera of CoVs: Alphacoronavirus (alphaCoV), Betacoronavirus (betaCoV), Deltacoronavirus (deltaCoV), and Gammacoronavirus (gammaCoV). Furthermore, the betaCoV genus divides into five sub-genera or lineages ([J. F.-W. Chan, To, Tse, Jin, & Yuen, 2013](#_ENREF_5)). Genomic characterization has shown that probably bats and rodents are the gene sources of alphaCoVs and betaCoVs. On the contrary, avian species seem to represent the gene sources of deltaCoVs and gammaCoVs.

Members of this large family of viruses can cause respiratory, enteric, hepatic, and neurological diseases in different animal species, including camels, cattle, cats, and bats. To date, seven human CoVs (HCoVs) — capable of infecting humans — have been identified. Some of HCoVs were identified in the mid-1960s, while others were only detected in the new millennium.

In general, estimates suggest that 2% of the population are healthy carriers of a CoV and that these viruses are responsible for about 5% to 10% of acute respiratory infections ([Chen, Liu, & Guo, 2020](#_ENREF_6)).

* Common human CoVs: HCoV-OC43, and HCoV-HKU1 (betaCoVs of the A lineage); HCoV-229E, and HCoV-NL63 (alphaCoVs). They can cause common colds and self-limiting upper respiratory infections in immunocompetent individuals. In immunocompromised subjects and the elderly, lower respiratory tract infections can occur.
* Other human CoVs: SARS-CoV, SARS-CoV-2, and MERS-CoV (betaCoVs of the B and C lineage, respectively). These cause epidemics with variable clinical severity featuring respiratory and extra-respiratory manifestations. Concerning SARS-CoV, MERS-CoV, the mortality rates are up to 10% and 35%, respectively.

Thus, SARS-CoV-2 belongs to the betaCoVs category. It has round or elliptic and often pleomorphic form, and a diameter of approximately 60–140 nm. Like other CoVs, it is sensitive to ultraviolet rays and heat. Furthermore, these viruses can be effectively inactivated by lipid solvents including ether (75%), ethanol, chlorine-containing disinfectant, peroxyacetic acid and chloroform except for chlorhexidine.

In genetic terms, Chan et al. have proven that the genome of the new HCoV, isolated from a cluster-patient with atypical pneumonia after visiting Wuhan, had 89% nucleotide identity with bat SARS-like-CoVZXC21 and 82% with that of human SARS-CoV ([J. Chan et al.](#_ENREF_4)). For this reason, the new virus was called SARS-CoV-2. Its single-stranded RNA genome contains 29891 nucleotides, encoding for 9860 amino acids. Although its origins are not entirely understood, these genomic analyses suggest that SARS-CoV-2 probably evolved from a strain found in bats. The potential amplifying mammalian host, intermediate between bats and humans, is, however, not known. Since the mutation in the original strain could have directly triggered virulence towards humans, it is not certain that this intermediary exists.

**3.0 PATHOGENESIS**

The severe symptoms of COVID-19 are linked with an increasing numbers and rate of fatalities specially in the epidemic region of China. On January 22, 2020, the China National Health Commission reported the details of the first 17 deaths and on January 25, 2020 the death cases increased to 56 deaths. The percentage of death among the reported 2684 cases of COVID-19 was approximately 2.84% as of Jan 25, 2020 and the median age of the deaths was 75 (range 48–89) years ([Wang, Tang, & Wei, 2020](#_ENREF_27)).

Patients infected with COVID-19 displayed higher leukocyte numbers, abnormal respiratory findings, and increased levels of plasma pro-inflammatory cytokines. One of the COVID-19 case reports showed a patient at 5 days of fever presented with a cough, coarse breathing sounds of both lungs, and a body temperature of 39.0 °C. The patient's sputum showed positive real-time polymerase chain reaction results that confirmed COVID-19 infection. The laboratory studies showed leucopenia with leukocyte counts of 2.91 × 10^9 cells/L of which 70.0% were neutrophils. inclusively, a value of 16.16 mg/L of blood C-reactive protein was noted which is above the normal range (0–10 mg/L). High erythrocyte sedimentation rate and D-dimer were also observed ([Lei, Li, Li, & Qi, 2020](#_ENREF_18)).

The main pathogenesis of COVID-19 infection as a respiratory system targeting virus was severe pneumonia, RNAaemia, in addition with the incidence of ground-glass opacities, and acute cardiac injury. Significantly high blood levels of cytokines and chemokines were noted in patients with COVID-19 infection that included IL1-β, IL1RA, IL7, IL8, IL9, IL10, basic FGF2, GCSF, GMCSF, IFNγ, IP10, MCP1, MIP1α, MIP1β, PDGFB, TNFα, and VEGFA. Some of the severe cases that were admitted to the intensive care unit displayed high levels of pro-inflammatory cytokines including IL2, IL7, IL10, GCSF, IP10, MCP1, MIP1α, and TNFα that are reasoned to promote disease severity ([Huang et al., 2020](#_ENREF_12)) .

**4.0 TRANSMISSION**

Based on the large number of infected people that were exposed to the wet animal market in Wuhan City where live animals are being sold, it is suggested that this is the likely zoonotic origin of the COVID-19. Efforts have been made to look for a reservoir host or intermediate carriers from which the infection may have spread to humans. Initial reports identified two species of snakes that could be a possible reservoir of the COVID-19. However, to date, there has been no consistent evidence of coronavirus reservoirs other than mammals and birds ([Bassetti, Vena, & Giacobbe, 2020](#_ENREF_2); [Ji, Wang, Zhao, Zai, & Li, 2020](#_ENREF_15)). Genomic sequence analysis of COVID-19 displayed 88% identity with two bat-derived severe acute respiratory syndrome (SARS)-like coronaviruses ([Lu et al., 2020](#_ENREF_20); [Wan, Shang, Graham, Baric, & Li, 2020](#_ENREF_25)), indicating that mammals are the most likely link between COVID-19 and humans. Several reports have suggested that person-to-person transmission is a likely route for spreading COVID-19 infection. This is supported by cases that occurred within families and among people who did not visit the wet animal market in Wuhan ([Carlos, Dela Cruz, Cao, Pasnick, & Jamil, 2020](#_ENREF_3); [Wu et al., 2020](#_ENREF_28)). Person-to-person transmission occurs primarily via direct contact or through droplets spread by coughing or sneezing from an infected individual. In a small study conducted on women in their third trimester who were confirmed to be infected with the coronavirus, there was no evidence that there is transmission from mother to child. However, all pregnant mothers underwent cesarean sections, so it remains unclear whether transmission can occur during vaginal birth. This is important because pregnant mothers are relatively more susceptible to infection by respiratory pathogens and severe pneumonia.

The binding of a receptor expressed by host cells is the first step of viral infection followed by fusion with the cell membrane. It is thought that the lung epithelial cells are the primary target of the virus. Thus, it has been reported that human-to-human transmissions of SARS-CoV occurs by the binding between the receptor-binding domain of virus spikes and the cellular receptor which has been spotted as angiotensin-converting enzyme 2 (ACE2) receptor ([Jaimes, Millet, Stout, André, & Whittaker, 2020](#_ENREF_14); [Wan et al., 2020](#_ENREF_25)). Importantly, the sequence of the receptor-binding domain of COVID-19 spikes is similar to that of SARS-CoV. This data strongly suggests that entry into the host cells is most likely via the ACE2 receptor ([Wan et al., 2020](#_ENREF_25)).

**5.0 HISTOPATHOLOGICAL FEATURES**

Since December 2019, the outbreak of a novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), infection (coronavirus disease 2019 [COVID-19]) that started in Wuhan, Hubei Province, People’s Republic of China, ([Huang et al., 2020](#_ENREF_12); [Zhu et al., 2020](#_ENREF_30)) has spread to all parts in the People’s Republic of China, other parts of Asia such as Japan and Thailand, Australia, Europe, and North America. The number of confirmed cases in the People’s Republic of China has reached 42,700, including 1017 deaths, as of February 11, 2020 (new reference, website). Although patients initially present with fever with or without respiratory symptoms, various degrees of pulmonary abnormalities develop later in all patients, and these can be seen on chest computed tomography (CT) imaging. ([Huang et al., 2020](#_ENREF_12); [D. Wang et al., 2020](#_ENREF_26)). Most patients only have a common, mild form of illness, but approximately 15% to 20% fall in the severe group, meaning they require assisted oxygenation as part of treatment. ([D. Wang et al., 2020](#_ENREF_26)). The severe group has a high mortality rate and is associated with older age, underlying diseases such as diabetes, and medical procedures (such as patients who were infected in a hospital setting while undergoing an operation for other indications).

Although there have been several studies describing clinical features and characteristic radiographic findings (mainly chest CT scans) ([Huang et al., 2020](#_ENREF_12)) ([D. Wang et al., 2020](#_ENREF_26)) no pathologic studies have been conducted on the basis of autopsies or biopsies. Some of the reasons for the lack of autopsies and biopsies include suddenness of the outbreak, vast patient volume in hospitals, shortage of health care personnel, and high rate of transmission, which makes invasive diagnostic procedures less of a clinical priority.

Fortunately and unfortunately, we encountered two patients who underwent an operation for malignancy and were later found to have been infected with SARS-CoV-2. The operation overlapped in time with the infection, which allowed us to obtain the necessary specimens to examine the histopathology of COVID-19 pneumonia.

**5.1 CASE PRESENTATION**

**5.1.1 CASE 1**

Case 1 was a female patient aged 84 years, who was admitted for treatment evaluation of a tumor measuring 1.5 cm in the right middle lobe of the lung. The tumor was discovered on a chest CT scan at an outside hospital. She had a medical history of hypertension for 30 years and type II diabetes. On day 6 of hospitalization, an enhanced chest CT scan was performed that confirmed an irregular solid nodule in the right middle lobe and bilateral ground-glass opacity (GGO). At that time, the significance of the latter findings was unknown. Her general condition was good, with no fever or respiratory symptoms, and with clear lung sounds on auscultation bilaterally. She underwent presurgical tests and preparations. On day 12, a thoracoscopic resection of the right middle lobe was performed without event. On day 13 (postoperative day 1), a repeat CT scan revealed postresection changes and bilateral GGO in the lower lobes of the lungs ([Fig. 1](https://www.sciencedirect.com/science/article/pii/S1556086420301325" \l "fig1)*A*). White blood cell (WBC) count was 12.49 × 1012/liter, whereas lymphocyte count decreased to 0.4 × 109/liter and the differential to 5%. There was a slight wheezing sound on auscultation on the right side. On day 16, the patient experienced some difficulty in breathing, chest tightness, wheezing, and dry cough. She received a diagnosis “suggestive of viral pneumonia,” with intermittent peripheral capillary oxygen saturation between 72% and 88%. On day 24, she was transferred to a special isolation ward owing to a pharyngeal swab test result that was positive for the 2019 novel coronavirus (2019-nCoV). Laboratory specimens drawn on the previous day (day 23) revealed the following: increased WBC count to 33.52 × 109/liter; increased neutrophils to 89.80%; decreased lymphocytes to 1.90%; decreased eosinophils to 0%; increased neutrophil count to 30.10 × 109/liter; decreased lymphocyte count to 0.65 × 109/liter; increased monocyte count to 2.50 × 109/liter; decreased eosinophil count to 0.01 × 109/liter; and increased basophil count to 0.26 × 109/liter.

**FIGURE 1**

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Figure 1. Representative images of chest computed tomography scan. (A) Case 1: image on postoperative day 1 revealing changes in the right lung and increased ground-glass opacities bilaterally (arrows); (B) case 2: foci of ground-glass opacity seen bilaterally (arrows).

Despite comprehensive treatment, including antibiotics, assisted oxygenation, and other supportive care, the patient’s condition deteriorated. Her peripheral capillary oxygen saturation (SpO2) decreased to 62.6% and heart rate to 40 bpm. A do-not-resuscitate order was given. She went into coma on day 27 and died on day 29. She did not manifest fever during the hospital stay.

Subsequent clinical information confirmed that she was exposed to another patient in the same room who was subsequently found to be infected with the 2019-nCoV.

The right middle lobe resection specimen was delivered to the surgical pathology laboratory and processed according to the routine biosafety standards. Hematoxylin and eosin–stained sections were reviewed. A firm area of 1.5 cm in diameter was identified grossly, which in the histologic diagnosis was consistent with typical adenocarcinoma, with half exhibiting a lepidic and half an acinar pattern (not revealed). Sections away from the tumor, as found in [Figure 2](https://www.sciencedirect.com/science/article/pii/S1556086420301325" \l "fig2), revealed evident alveolar damage, including alveolar edema and proteinaceous exudates ([Fig. 2](https://www.sciencedirect.com/science/article/pii/S1556086420301325#fig2)*A*). Prominent inspissated spherical secretions or globules were also noted ([Fig. 2](https://www.sciencedirect.com/science/article/pii/S1556086420301325#fig2)*B*). There was vascular congestion but patchy and mild inflammatory infiltration. Focal fibrin clusters mixed with mononuclear inflammatory cells and multinucleated giant cells were noted in the airspaces ([Fig. 2](https://www.sciencedirect.com/science/article/pii/S1556086420301325#fig2)*C*). No significant neutrophil infiltration was present in the tissue. There was patchy and severe pneumocyte hyperplasia and interstitial thickening, indicating an ongoing reparative process. Suspected viral inclusions were also noted in some of these cells ([Fig. 2](https://www.sciencedirect.com/science/article/pii/S1556086420301325#fig2)*D*).

**FIGURE 2**

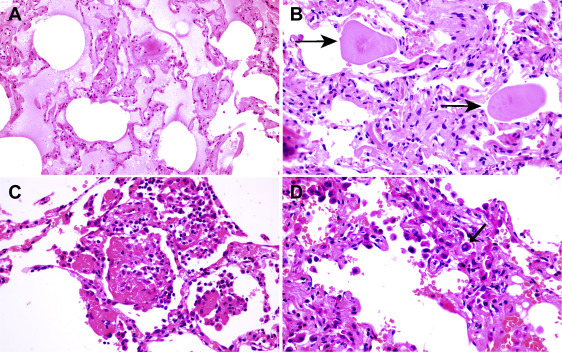


Figure 2. Histologic changes from case 1. (A) Proteinaceous exudates in alveolar spaces, with granules; (B) scattered large protein globules (arrows); (C) intra-alveolar fibrin with early organization, mononuclear inflammatory cells, and multinucleated giant cells; (D) hyperplastic pneumocytes, some with suspected viral inclusions (arrow)

**5.1.2 CASE 2**

Case 2 was a male patient aged 73 years, who presented for elective surgery for lung cancer. Nine months earlier, a nodule was discovered radiologically in the right lower lobe of the lung during a health examination. He had a medical history of hypertension for 20 years, which had been adequately managed. A diagnosis of adenocarcinoma was made in a subsequent needle biopsy. The patient was admitted 1 week after the biopsy to the thoracic tumor ward, where he underwent a right lower lobe lung resection with lymph node dissection 3 days after admission. He recovered well and was discharged on day 6 postoperationally. A chest CT scan was performed on postoperative day 2, which revealed postoperative changes and patchy GGO in the right upper lobe. On retrospective re-examination of the images, the patient was diagnosed as “suspect for atypical viral pneumonia.” A fever developed in the patient on postoperative day 9 (38.2°C), with dry cough, chest tightness, and muscle pain. A nucleic acid test for 2019-nCoV came back positive. Other laboratory specimens were significant for decreased lymphocyte count. He was readmitted to the infectious disease ward. A repeat chest CT scan revealed additional foci of GGO in the bilateral upper lobes, consistent with viral pneumonia ([Fig. 1](https://www.sciencedirect.com/science/article/pii/S1556086420301325#fig1)*B*, case 2). Tests for influenza virus and other infectious agents were negative. He underwent treatment for novel coronavirus pneumonia. He gradually recovered and was discharged after 20 days of treatment in the infectious disease ward.

On pathologic examination of the resected lobectomy specimen, a 1.2-cm gray-white nodule adjacent to the pleura was identified, which was poorly demarcated from the adjacent nontumor lung parenchyma. Histopathologic diagnosis of the tumor was that of adenocarcinoma, pT1bN0 (28 lymph nodes all negative). The resection margins were negative as well. Histologically, the surrounding lung parenchyma was patchy but with evident proteinaceous and fibrin exudates ([Fig. 3](https://www.sciencedirect.com/science/article/pii/S1556086420301325" \l "fig3)*A*). There was diffuse thickening of alveolar walls ([Fig. 3](https://www.sciencedirect.com/science/article/pii/S1556086420301325#fig3)*B*), consisting of proliferating interstitial fibroblasts and type II pneumocyte hyperplasia. Focal fibroblast plug (arrow) and multinucleated giant cells (arrowheads) were seen in the airspaces ([Fig. 3](https://www.sciencedirect.com/science/article/pii/S1556086420301325#fig3)*C*), indicating varying degrees of proliferative phase of diffuse alveolar damage. Some areas had abundant alveolar macrophages along with type II pneumocyte hyperplasia ([Fig. 3](https://www.sciencedirect.com/science/article/pii/S1556086420301325#fig3)*D*).

**FIGURE 3**

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Figure 3. Histologic changes of coronavirus disease 2019 pneumonia in case 2. (A) Evident proteinaceous and fibrin exudate; (B) diffuse expansion of alveolar walls and septa owing to fibroblastic proliferations and type II pneumocyte hyperplasia, consistent with early diffuse alveolar damage pattern; (C) plugs of proliferating fibroblasts or “fibroblast balls” in the interstitium (arrow); (D) abundant macrophages infiltrating airspaces and type II pneumocyte hyperplasia.

**5.2 PATHOLOGICAL FINDINGS**

The pathologic findings reported here represent the first for SARS-CoV-2 pneumonia or COVID-19. At the time of manuscript preparation, no autopsies had been performed on patients with COVID-19. Data on lung biopsies performed for COVID-19 are similarly lacking.

Pathologic findings from these two patients were edema and prominent proteinaceous exudates, vascular congestion, and inflammatory clusters with fibrinoid material and multinucleated giant cells. Reactive alveolar epithelial hyperplasia was seen in case 1, and fibroblastic proliferation (fibroblast plugs) in case 2 is indicative of early organization. No prominent neutrophil infiltration was seen. The significance of the large protein globules is not entirely clear, as these were described in patients with SARS but could also represent a nonspecific change with aging. More cases with sufficient controls are necessary to further clarify this change.

The two cases reported here represent “accidental” sampling of COVID-19, in which surgeries were performed for tumors in the lungs at a time when the superimposed infections were not recognized. These provided the first opportunities for studying the pathology of COVID-19. For case 1, the operation was performed 6 days after the CT findings of early GGO signs, meaning the pathologic changes of the non–tumor lung parenchyma indeed represent at least the peripheral part of COVID-19 pneumonia, as the imaging changes were more prominent toward the lower lobes. For case 2, as recognized later, the patient was unknowingly placed in the same room with patients who were positive for SARS-CoV-2 infection; the status of infection was not known to anyone at the time. He developed early lung lesions on a chest CT scan performed to evaluate the result of the operation. However, owing to a lack of sufficient knowledge about the new infection, the lesions were recognized only retrospectively as representing COVID-19 pneumonia.

The differential diagnoses of COVID-19 pneumonia might include, but is not limited to, acute or chronic pneumonia resulting from other infections. Comprehensive clinical analyses of the epidemiologic status, CT scan, and nucleic acid test can easily exclude such possibilities. As for the original SARS, SARS-COV-19 shares high genetic homology with SARS-CoV. Therefore, the International Committee on Taxonomy of Viruses recently renamed the 2019-nCoV to SARS-CoV-2 and the disease as COVID-19. Compared with pathologic findings in a cohort of autopsy cases of SARS, the two cases presented here also exhibited exudative and proliferative phases of acute lung injury, such as edema, inflammatory infiltrate, type II pneumocyte hyperplasia, and organization, but without obvious hyaline membrane formation and other long-term processes, such as squamous metaplasia. ([Franks et al., 2003](#_ENREF_10); [Hwang et al., 2005](#_ENREF_13); [Nicholls et al., 2003](#_ENREF_21)). Of note, the pathologic changes seen in our two cases preceded the development of clinical symptoms and likely represent an earlier phase of the disease. Future studies of autopsies may add to the current findings.

Although case 1 patient was never febrile, her complete blood count profile, especially from postoperative day 1, revealed high WBC counts and lymphocytopenia, which is consistent with COVID-19. This may be a good clue for early diagnosis in the future. Case 2 developed a fever a few days after the CT findings, suggesting a delay in symptom development in these patients. During the earlier days of the outbreak, there had been limitations in both capacity and turnaround time for the nucleic acid test, which had further caused delay in confirming the diagnosis of COVID-19 ([Xiao, Wu, & Liu, 2020](#_ENREF_29)) in many patients. It seems that the time for the early lung lesions or COVID-19 to become severe enough to cause clinical symptoms is rather long. Even among patients with fever, the typically used pharyngeal swab polymerase chain reaction test may be negative, owing to the absence of viruses in the upper respiratory tract despite the presence of pneumonia. However, radiographic changes can occur early (chest CT scan is mostly employed in the People’s Republic of China during the current outbreak). Therefore, during an epidemic season, it is prudent to carefully evaluate any lung infiltration for GGO, and an appropriate serology test must be performed to rule out potential infection ([Xiao et al., 2020](#_ENREF_29)).

These two incidents also typify a common scenario during the earlier phase of the SARS-CoV-2 outbreak, during which a significant number of health care providers became infected in hospitals in Wuhan, and patients in a same room were cross-infected, as they were exposed to unknown transmission sources. Because of this, it is important to practice “universal precaution” in surgical pathology laboratories and regard all fresh specimens as potentially infectious. In the People’s Republic of China, most surgical specimens are received already fixed in formalin. However, for larger specimens, the center of a specimen may not be sufficiently fixed and still pose potential risk for infection. Therefore, proper personal protective equipment with surgical masks or N95 respirators is worn all the time in the gross room. Fortunately, thus far, to our knowledge, no cases of pathologists being infected by COVID-19 had occurred.

It would be beneficial if reverse-transcriptase polymerase chain reaction or immunohistochemical stains, or both could be performed on these two cases to further confirm the presence of the viruses that may be associated with pneumonia. Unfortunately, these tests are currently under development, and adaptation to tissue specimens is not yet available. Nevertheless, we believe that it is imperative to report the findings of routine histopathology for better understanding of the mechanism by which the SARS-CoV-2 causes lung injury in the unfortunate tens of thousands of patients in Wuhan and worldwide.

**6.0 CURRENT AND POTENTIAL THERAPIES TO COMBAT COVID19**

Vaccines and treatment options for COVID-19 are currently being investigated around the world. There’s some evidence that certain medications may have the potential to be effective with regard to preventing illness or treating the symptoms of COVID-19.

However, researchers need to perform [randomized controlled trialsTrusted Source](https://www.cdc.gov/coronavirus/2019-ncov/hcp/clinical-guidance-management-patients.html) in humans before potential vaccines and other treatments become available. This may take several months or longer.

Here are some treatment options that are currently being investigated for protection against SARS-CoV-2 and treatment of COVID-19 symptoms.

* **REMDESIVIR**

Remdesivir is an experimental broad-spectrum antiviral drug originally designed to target Ebola.

Researchers have found that remdesivir is highly effective at fighting the novel coronavirus in [isolated cellsTrusted Source](https://www.nature.com/articles/s41422-020-0282-0).

This treatment is not yet approved in humans, but two clinical trials for this drug have been implemented in China. One clinical trial was recently also approved by the FDA in the United States.

* **CHLOROQUINE**

Chloroquine is a drug that’s used to fight malaria and autoimmune diseases. It’s been in use for more than [70 yearsTrusted Source](https://www.nature.com/articles/s41422-020-0282-0) and is considered safe.

Researchers have discovered that this drug is effective at fighting the SARS-CoV-2 virus in studies done in test tubes.

At least [10 clinical trialsTrusted Source](https://www.nature.com/articles/d41587-020-00003-1) are currently looking at the potential use of chloroquine as an option for combating the novel coronavirus.

* **LOPINAVIR AND RITONAVIR**

Lopinavir and ritonavir are sold under the name Kaletra and are designed to treat HIV.

In South Korea, a 54-year-old man was given a combination of these two drugs and had a [significant reductionTrusted Source](https://www.ncbi.nlm.nih.gov/pubmed/32056407) in his levels of the coronavirus.

According to the World Health Organization (WHO), there could be benefits to using Kaletra in combination with other drugs.

* **APN01**

A clinical trial is set to start soon in China to examine the potential of a drug called [APN01](https://pipelinereview.com/index.php/2020022673884/Proteins-and-Peptides/APEIRONs-respiratory-drug-product-to-start-pilot-clinical-trial-to-treat-coronavirus-disease-COVID-19-in-China.html) to fight the novel coronavirus.

The scientists who first developed APN01 in the early 2000s discovered that a certain protein called ACE2 is involved in [SARS](https://www.healthline.com/health/severe-acute-respiratory-syndrome-sars) infections. This protein also helped protect the lungs from injury due to respiratory distress.

From recent research, it turns out that the 2019 coronavirus, like SARS, also uses the ACE2 protein to infect cells in humans.

The randomized, dual-arm trial will look at the effect of the medication on 24 patients for 1 week. Half of the participants in the trial will receive the APN01 drug, and the other half will be given a placebo. If results are encouraging, larger clinical trials will be done.

* **FAVILAVIR**

China has approved the use of the antiviral drug [favilavir](https://www.upi.com/Health_News/2020/02/17/China-approves-antiviral-favilavir-to-treat-coronavirus/5291581953892/) to treat symptoms of COVID-19. The drug was initially developed to treat inflammation in the nose and throat.

Although the results of the study haven’t been released yet, the drug has supposedly shown to be effective in treating COVID-19 symptoms in a clinical trial of 70 people.

**7.0 FUTURE OF COVID-19 ON PUBLIC HEALTH**

Extensive measures to reduce person-to-person transmission of COVID-19 are needed to limit the current outbreak. Special attention and efforts to guide or reduce transmission should be applied in susceptible populations including children, health care providers, and elderly people. ([Jin et al., 2020](#_ENREF_16)). The early death cases of COVID-19 outbreak occurred primarily in elderly people, possibly due to a weak immune system that permits faster progression of viral infection ([W. Wang et al., 2020](#_ENREF_27)) ([Li et al., 2020](#_ENREF_19)). The public services and facilities should provide decontaminating reagents for cleaning hands on a routine basis. Physical contact with wet and infected objects should be considered in dealing with the virus, especially agents such as faecal and urine samples that can potentially serve as an alternative route of transmission ([Assiri et al., 2013](#_ENREF_1); [Lee et al., 2003](#_ENREF_17)). China and other countries including the US have implemented major prevention and control measures including travel screenings to control further spread of the virus ([Carlos et al., 2020](#_ENREF_3)). Epidemiological changes in COVID-19 infection should be monitored taking into account potential routes of transmission and subclinical infections, in addition to the adaptation, evolution, and virus spread among humans and possible intermediate animals and reservoirs. There remains a considerable number of questions that need to be addressed. These include, but are not limited to, details about who and how many have been tested, what proportion of these turned positive and whether this rate remains constant or variable. Very few paediatric cases have so far been reported; is this due to lack of testing or a true lack of infection/susceptibility? Of the ones that have so far been tested, how many have developed severe disease and how many were tested positive but showed no clinical sign of disease? There are some basic questions that would provide a framework for which more specific and detailed public health measures can be implemented.

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