

# World Journal of *Clinical Cases*

*World J Clin Cases* 2020 October 6; 8(19): 4280-4687



**OPINION REVIEW**

- 4280 Role of monoclonal antibody drugs in the treatment of COVID-19  
*Ucciferri C, Vecchiet J, Falasca K*

**MINIREVIEWS**

- 4286 Review of simulation model for education of point-of-care ultrasound using easy-to-make tools  
*Shin KC, Ha YR, Lee SJ, Ahn JH*
- 4303 Liver injury in COVID-19: A minireview  
*Zhao JN, Fan Y, Wu SD*

**ORIGINAL ARTICLE****Case Control Study**

- 4311 Transanal minimally invasive surgery *vs* endoscopic mucosal resection for rectal benign tumors and rectal carcinoids: A retrospective analysis  
*Shen JM, Zhao JY, Ye T, Gong LF, Wang HP, Chen WJ, Cai YK*
- 4320 Impact of *mTOR* gene polymorphisms and gene-tea interaction on susceptibility to tuberculosis  
*Wang M, Ma SJ, Wu XY, Zhang X, Abesig J, Xiao ZH, Huang X, Yan HP, Wang J, Chen MS, Tan HZ*

**Retrospective Cohort Study**

- 4331 Establishment and validation of a nomogram to predict the risk of ovarian metastasis in gastric cancer: Based on a large cohort  
*Li SQ, Zhang KC, Li JY, Liang WQ, Gao YH, Qiao Z, Xi HQ, Chen L*

**Retrospective Study**

- 4342 Predictive factors for early clinical response in community-onset *Escherichia coli* urinary tract infection and effects of initial antibiotic treatment on early clinical response  
*Kim YJ, Lee JM, Lee JH*
- 4349 Managing acute appendicitis during the COVID-19 pandemic in Jiaxing, China  
*Zhou Y, Cen LS*
- 4360 Clinical application of combined detection of SARS-CoV-2-specific antibody and nucleic acid  
*Meng QB, Peng JJ, Wei X, Yang JY, Li PC, Qu ZW, Xiong YF, Wu GJ, Hu ZM, Yu JC, Su W*
- 4370 Prolonged prothrombin time at admission predicts poor clinical outcome in COVID-19 patients  
*Wang L, He WB, Yu XM, Hu DL, Jiang H*

- 4380 Percutaneous radiofrequency ablation is superior to hepatic resection in patients with small hepatocellular carcinoma

*Zhang YH, Su B, Sun P, Li RM, Peng XC, Cai J*

- 4388 Clinical study on the surgical treatment of atypical Lisfranc joint complex injury

*Li X, Jia LS, Li A, Xie X, Cui J, Li GL*

- 4400 Application of medial column classification in treatment of intra-articular calcaneal fractures

*Zheng G, Xia F, Yang S, Cui J*

### Clinical Trials Study

- 4410 Optimal hang time of enteral formula at standard room temperature and high temperature

*Lakananurak N, Nalinthassanai N, Suansawang W, Panarat P*

### META-ANALYSIS

- 4416 Meta-analysis reveals an association between acute pancreatitis and the risk of pancreatic cancer

*Liu J, Wang Y, Yu Y*

### SCIENTOMETRICS

- 4431 Global analysis of daily new COVID-19 cases reveals many static-phase countries including the United States potentially with unstoppable epidemic

*Long C, Fu XM, Fu ZF*

### CASE REPORT

- 4443 Left atrial appendage aneurysm: A case report

*Belov DV, Moskalev VI, Garbuzenko DV, Arefyev NO*

- 4450 Twenty-year survival after iterative surgery for metastatic renal cell carcinoma: A case report and review of literature

*De Raffe E, Mirarchi M, Casadei R, Ricci C, Brunocilla E, Minni F*

- 4466 Primary rhabdomyosarcoma: An extremely rare and aggressive variant of male breast cancer

*Satală CB, Jung I, Bara TJ, Simu P, Simu I, Vlad M, Szodorai R, Gurzu S*

- 4475 Bladder stones in a closed diverticulum caused by *Schistosoma mansoni*: A case report

*Alkhamees MA*

- 4481 Cutaneous ciliated cyst on the anterior neck in young women: A case report

*Kim YH, Lee J*

- 4488 Extremely rare case of successful treatment of metastatic ovarian undifferentiated carcinoma with high-dose combination cytotoxic chemotherapy: A case report

*Kim HB, Lee HJ, Hong R, Park SG*

- 4494** Acute amnesia during pregnancy due to bilateral fornix infarction: A case report  
*Cho MJ, Shin DI, Han MK, Yum KS*
- 4499** Ascaris-mimicking common bile duct stone: A case report  
*Choi SY, Jo HE, Lee YN, Lee JE, Lee MH, Lim S, Yi BH*
- 4505** Eight-year follow-up of locally advanced lymphoepithelioma-like carcinoma at upper urinary tract: A case report  
*Yang CH, Weng WC, Lin YS, Huang LH, Lu CH, Hsu CY, Ou YC, Tung MC*
- 4512** Spontaneous resolution of idiopathic intestinal obstruction after pneumonia: A case report  
*Zhang BQ, Dai XY, Ye QY, Chang L, Wang ZW, Li XQ, Li YN*
- 4521** Successful pregnancy after protective hemodialysis for chronic kidney disease: A case report  
*Wang ML, He YD, Yang HX, Chen Q*
- 4527** Rapid remission of refractory synovitis, acne, pustulosis, hyperostosis, and osteitis syndrome in response to the Janus kinase inhibitor tofacitinib: A case report  
*Li B, Li GW, Xue L, Chen YY*
- 4535** Percutaneous fixation of neonatal humeral physal fracture: A case report and review of the literature  
*Tan W, Wang FH, Yao JH, Wu WP, Li YB, Ji YL, Qian YP*
- 4544** Severe fundus lesions induced by ocular jellyfish stings: A case report  
*Zheng XY, Cheng DJ, Lian LH, Zhang RT, Yu XY*
- 4550** Application of ozonated water for treatment of gastro-thoracic fistula after comprehensive esophageal squamous cell carcinoma therapy: A case report  
*Wu DD, Hao KN, Chen XJ, Li XM, He XF*
- 4558** Germinomas of the basal ganglia and thalamus: Four case reports  
*Huang ZC, Dong Q, Song EP, Chen ZJ, Zhang JH, Hou B, Lu ZQ, Qin F*
- 4565** Gastrointestinal bleeding caused by jejunal angiosarcoma: A case report  
*Hui YY, Zhu LP, Yang B, Zhang ZY, Zhang YJ, Chen X, Wang BM*
- 4572** High expression of squamous cell carcinoma antigen in poorly differentiated adenocarcinoma of the stomach: A case report  
*Wang L, Huang L, Xi L, Zhang SC, Zhang JX*
- 4579** Therapy-related acute promyelocytic leukemia with FMS-like tyrosine kinase 3-internal tandem duplication mutation in solitary bone plasmacytoma: A case report  
*Hong LL, Sheng XF, Zhuang HF*
- 4588** Metastasis of esophageal squamous cell carcinoma to the thyroid gland with widespread nodal involvement: A case report  
*Zhang X, Gu X, Li JG, Hu XJ*

- 4595** Severe hyperlipemia-induced pseudoerythrocytosis - Implication for misdiagnosis and blood transfusion: A case report and literature review  
*Zhao XC, Ju B, Wei N, Ding J, Meng FJ, Zhao HG*
- 4603** Novel brachytherapy drainage tube loaded with double 125I strands for hilar cholangiocarcinoma: A case report  
*Lei QY, Jiao DC, Han XW*
- 4609** Resorption of upwardly displaced lumbar disk herniation after nonsurgical treatment: A case report  
*Wang Y, Liao SC, Dai GG, Jiang L*
- 4615** Primary hepatic myelolipoma: A case report and review of the literature  
*Li KY, Wei AL, Li A*
- 4624** Endoscopic palliative resection of a giant 26-cm esophageal tumor: A case report  
*Li Y, Guo LJ, Ma YC, Ye LS, Hu B*
- 4633** Solitary hepatic lymphangioma mimicking liver malignancy: A case report and literature review  
*Long X, Zhang L, Cheng Q, Chen Q, Chen XP*
- 4644** Intraosseous venous malformation of the maxilla after enucleation of a hemophilic pseudotumor: A case report  
*Cai X, Yu JJ, Tian H, Shan ZF, Liu XY, Jia J*
- 4652** Intravesically instilled gemcitabine-induced lung injury in a patient with invasive urothelial carcinoma: A case report  
*Zhou XM, Wu C, Gu X*
- 4660** Bochdalek hernia masquerading as severe acute pancreatitis during the third trimester of pregnancy: A case report  
*Zou YZ, Yang JP, Zhou XJ, Li K, Li XM, Song CH*
- 4667** Localized primary gastric amyloidosis: Three case reports  
*Liu XM, Di LJ, Zhu JX, Wu XL, Li HP, Wu HC, Tuo BG*
- 4676** Displacement of peritoneal end of a shunt tube to pleural cavity: A case report  
*Liu J, Guo M*
- 4681** Parathyroid adenoma combined with a rib tumor as the primary disease: A case report  
*Han L, Zhu XF*

**ABOUT COVER**

Peer-reviewer of *World Journal of Clinical Cases*, Professor Adrián Ángel Inchauspe, obtained his MD in 1986 from La Plata National University (Argentina), where he remained as Professor of Surgery. Study abroad, at the Aachen and Tübingen Universities in Germany in 1991, led to his certification in laparoscopic surgery, and at the Louis Pasteur University in Strasbourg France, led to his being awarded the Argentine National Invention Award in 1998 for his graduate work in tele-surgery. He currently serves as teacher in the Argentine Acupuncture Society, as Invited Foreigner Professor at the China National Academy of Sciences and Hainan Medical University, and as editorial member and reviewer for many internationally renowned journals. (L-Editor: Filipodia)

**AIMS AND SCOPE**

The primary aim of *World Journal of Clinical Cases* (*WJCC*, *World J Clin Cases*) is to provide scholars and readers from various fields of clinical medicine with a platform to publish high-quality clinical research articles and communicate their research findings online.

*WJCC* mainly publishes articles reporting research results and findings obtained in the field of clinical medicine and covering a wide range of topics, including case control studies, retrospective cohort studies, retrospective studies, clinical trials studies, observational studies, prospective studies, randomized controlled trials, randomized clinical trials, systematic reviews, meta-analysis, and case reports.

**INDEXING/ABSTRACTING**

The *WJCC* is now indexed in Science Citation Index Expanded (also known as SciSearch®), Journal Citation Reports/Science Edition, PubMed, and PubMed Central. The 2020 Edition of Journal Citation Reports® cites the 2019 impact factor (IF) for *WJCC* as 1.013; IF without journal self cites: 0.991; Ranking: 120 among 165 journals in medicine, general and internal; and Quartile category: Q3.

**RESPONSIBLE EDITORS FOR THIS ISSUE**

Production Editor: Yan-Xia Xing; Production Department Director: Yun-Xiaojuan Wu; Editorial Office Director: Jin-Lai Wang.

**NAME OF JOURNAL**

*World Journal of Clinical Cases*

**ISSN**

ISSN 2307-8960 (online)

**LAUNCH DATE**

April 16, 2013

**FREQUENCY**

Semimonthly

**EDITORS-IN-CHIEF**

Dennis A Bloomfield, Sandro Vento, Bao-Gan Peng

**EDITORIAL BOARD MEMBERS**

<https://www.wjgnet.com/2307-8960/editorialboard.htm>

**PUBLICATION DATE**

October 6, 2020

**COPYRIGHT**

© 2020 Baishideng Publishing Group Inc

**INSTRUCTIONS TO AUTHORS**

<https://www.wjgnet.com/bpg/gerinfo/204>

**GUIDELINES FOR ETHICS DOCUMENTS**

<https://www.wjgnet.com/bpg/GerInfo/287>

**GUIDELINES FOR NON-NATIVE SPEAKERS OF ENGLISH**

<https://www.wjgnet.com/bpg/gerinfo/240>

**PUBLICATION ETHICS**

<https://www.wjgnet.com/bpg/GerInfo/288>

**PUBLICATION MISCONDUCT**

<https://www.wjgnet.com/bpg/gerinfo/208>

**ARTICLE PROCESSING CHARGE**

<https://www.wjgnet.com/bpg/gerinfo/242>

**STEPS FOR SUBMITTING MANUSCRIPTS**

<https://www.wjgnet.com/bpg/GerInfo/239>

**ONLINE SUBMISSION**

<https://www.f6publishing.com>

## Retrospective Study

## Clinical application of combined detection of SARS-CoV-2-specific antibody and nucleic acid

Qing-Bin Meng, Jing-Jing Peng, Xin Wei, Jia-Yao Yang, Peng-Cheng Li, Zi-Wei Qu, Yong-Fen Xiong, Guang-Jiang Wu, Zhi-Min Hu, Jian-Chun Yu, Wen Su

**ORCID number:** Qing-Bin Meng 0000-0001-7006-0920; Jing-Jing Peng 0000-0002-4596-4095; Xin Wei 0000-0002-5415-9354; Jia-Yao Yang 0000-0003-0926-9463; Peng-Cheng Li 0000-0001-5679-6149; Zi-Wei Qu 0000-0002-8941-1097; Yong-Fen Xiong 0000-0001-7299-3441; Guang-Jiang Wu 0000-0001-9922-8264; Zhi-Min Hu 0000-0002-9360-1686; Jian-Chun Yu 0000-0002-9342-8828; Wen Su 0000-0002-9654-8630.

**Author contributions:** Meng QB, Peng JJ, Wei X and Su W designed the research; Meng QB, Peng JJ, Wei X Yang JY, Qu ZW, Li PC, Xiong YY and Hu ZM collected the data; Wu GJ, Yang JY, Meng QB, Su W and Yu JC analyzed the data; Wu GJ did the statistical review of the study; Meng QB, Peng JJ and Wei X wrote the paper; all authors have read and approved the final manuscript.

**Supported by** Natural Science Foundation of Hubei Province, China, No. 2016CFB596; and Wuhan City Medical Research Project, China, No. WX17Q39 and No. WX15B14.

**Institutional review board statement:** The study was reviewed and approved by the Ethics Committee of Wuhan Integrated TCM and Western

**Qing-Bin Meng**, Department of Pulmonary and Critical Care Medicine and Department of Gastrointestinal Surgery, Wuhan Integrated TCM and Western Medicine Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan 430022, Hubei Province, China

**Jing-Jing Peng**, Department of Respiratory Medicine, General Hospital of the Yangtze River Shipping, Wuhan 430015, Hubei Province, China

**Xin Wei**, Department of Gastrointestinal Surgery, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan 430000, Hubei Province, China

**Jia-Yao Yang**, Department of Gastroenterology, Wuhan Integrated TCM and Western Medicine Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan 430022, Hubei Province, China

**Peng-Cheng Li, Yong-Fen Xiong**, Department of Transfusion Medicine, Wuhan Integrated TCM and Western Medicine Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan 430022, Hubei Province, China

**Zi-Wei Qu**, Department of Gastrointestinal Surgery, Wuhan Integrated TCM and Western Medicine Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan 430022, Hubei Province, China

**Guang-Jiang Wu**, Department of Infection Management and Disease Control, Beijing Shijitan Hospital, Capital Medical University, Beijing 100038, China

**Zhi-Min Hu**, Department of Clinical Microbiology and Molecular Biology, Wuhan Integrated TCM and Western Medicine Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan 430022, Hubei Province, China

**Jian-Chun Yu**, Department of General Surgery, Peking Union Medicine College Hospital, Chinese Academy of Medical Sciences, Beijing 100730, China

**Wen Su**, Department of Science and Education, Wuhan Integrated TCM and Western Medicine Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan 430022, Hubei Province, China

**Corresponding author:** Wen Su, MD, PhD, Dean, Professor, Department of Science and

Medicine Hospital, Huazhong University of Science and Technology (Approval No. [2020]8).

**Informed consent statement:** The requirement for written informed consent was waived given the context of emerging infectious diseases.

**Conflict-of-interest statement:** All the authors have no potential conflicts of interest related to the manuscript.

**Data sharing statement:** No additional data are available.

**Open-Access:** This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

**Manuscript source:** Invited manuscript

**Received:** April 19, 2020

**Peer-review started:** April 19, 2020

**First decision:** July 25, 2020

**Revised:** August 8, 2020

**Accepted:** September 2, 2020

**Article in press:** September 2, 2020

**Published online:** October 6, 2020

**P-Reviewer:** Sukocheva O

**S-Editor:** Ma YJ

**L-Editor:** Webster JR

**P-Editor:** Li JH



Education, Wuhan Integrated TCM and Western Medicine Hospital, Tongji Medical College, Huazhong University of Science and Technology, No. 215 Zhongshan Avenue, Wuhan 430022, Hubei Province, China. [501820747@qq.com](mailto:501820747@qq.com)

## Abstract

### BACKGROUND

The global outbreak of human severe acute respiratory syndrome coronavirus (SARS-CoV)-2 infection represents an urgent need for readily available, accurate and rapid diagnostic tests. Nucleic acid testing of respiratory tract specimens for SARS-CoV-2 is the current gold standard for diagnosis of coronavirus disease 2019 (COVID-19). However, the diagnostic accuracy of reverse transcription polymerase chain reaction (RT-PCR) tests for detecting SARS-CoV-2 nucleic acid may be lower than optimal. The detection of SARS-CoV-2-specific antibodies should be used as a serological non-invasive tool for the diagnosis and management of SARS-CoV-2 infection.

### AIM

To investigate the diagnostic value of SARS-CoV-2 IgM/IgG and nucleic acid detection in COVID-19.

### METHODS

We retrospectively analyzed 652 suspected COVID-19 patients, and 206 non-COVID-19 patients in Wuhan Integrated TCM and Western Medicine Hospital. Data on SARS-CoV-2 nucleic acid tests and serum antibody tests were collected to investigate the diagnostic value of nucleic acid RT-PCR test kits and immunoglobulin (Ig)M/IgG antibody test kits. The  $\chi^2$  test was used to compare differences between categorical variables. A 95% confidence interval (CI) was provided by the Wilson score method. All analyses were performed with IBM SPSS Statistics version 22.0 (IBM Corp., Armonk, NY, United States).

### RESULTS

Of the 652 suspected COVID-19 patients, 237 (36.3%) had positive nucleic acid tests, 311 (47.7%) were positive for IgM, and 592 (90.8%) were positive for IgG. There was a significant difference in the positive detection rate between the IgM and IgG test groups ( $P < 0.001$ ). Using the RT-PCR results as a reference, the specificity, sensitivity, and accuracy of IgM/IgG combined tests for SARS-CoV-2 infection were 98.5%, 95.8%, and 97.1%, respectively. Of the 415 suspected COVID-19 patients with negative nucleic acid test results, 366 had positive IgM/IgG tests with a positive detection rate of 88.2%.

### CONCLUSION

Our data indicate that serological IgM/IgG antibody combined test had high sensitivity and specificity for the diagnosis of SARS-CoV-2 infection, and can be used in combination with RT-PCR for the diagnosis of SARS-CoV-2 infection.

**Key Words:** SARS-CoV-2; COVID-19; Nucleic acid detection; Immunoglobulin M; Immunoglobulin G; Diagnosis

©The Author(s) 2020. Published by Baishideng Publishing Group Inc. All rights reserved.

**Core Tip:** We retrospectively analyzed 652 suspected coronavirus disease 2019 (COVID-19) patients, and 206 non-COVID-19 patients to investigate the diagnostic value of severe acute respiratory syndrome coronavirus (SARS-CoV)-2 IgM/IgG and nucleic acid detection. We found that 237/652 (36.3%) suspected COVID-19 patients had positive nucleic acid tests, 311 (47.7%) were positive for IgM, and 592 (90.8%) were positive for IgG. Using reverse transcription polymerase chain reaction (RT-PCR) results as a reference, the specificity, sensitivity, and accuracy of IgM/IgG combined tests for SARS-CoV-2 infection were 98.5%, 95.8%, and 97.1%, respectively. Our data indicate that the serological IgM/IgG combined test can be used in combination with RT-PCR for the diagnosis of SARS-CoV-2 infection.

**Citation:** Meng QB, Peng JJ, Wei X, Yang JY, Li PC, Qu ZW, Xiong YF, Wu GJ, Hu ZM, Yu JC, Su W. Clinical application of combined detection of SARS-CoV-2-specific antibody and nucleic acid. *World J Clin Cases* 2020; 8(19): 4360-4369

**URL:** <https://www.wjgnet.com/2307-8960/full/v8/i19/4360.htm>

**DOI:** <https://dx.doi.org/10.12998/wjcc.v8.i19.4360>

## INTRODUCTION

Coronavirus disease 2019 (COVID-19) was first reported in Wuhan, Hubei Province, China and has spread worldwide<sup>[1,2]</sup>. COVID-19 is a highly transmissible disease caused by severe acute respiratory syndrome coronavirus (SARS-CoV)-2, which was also named 2019 novel coronavirus (2019-nCoV)<sup>[2,3]</sup>. As of April 19, 2020, 2160207 confirmed COVID-19 cases were reported worldwide, causing 146088 deaths<sup>[4]</sup>. The World Health Organization (WHO) declared COVID-19 a global pandemic on March 11, 2020<sup>[5,6]</sup>. The global outbreak of human SARS-CoV-2 infection has highlighted the necessity for readily available, accurate and rapid diagnostic tests.

Nucleic acid testing or genetic sequencing of respiratory tract specimens for SARS-CoV-2 is the current gold standard for the diagnosis of COVID-19<sup>[7-9]</sup>. However, according to recent evidence, the diagnostic accuracy of reverse transcription polymerase chain reaction (RT-PCR) tests for detecting SARS-CoV-2 nucleic acid may be lower than optimal. Liu *et al*<sup>[10]</sup> analyzed the RT-PCR results of throat swab samples from 4880 cases of suspected SARS-CoV-2 infection, and found that only 38.42% were positive. Another important concern is the number of false-negative RT-PCR results for COVID-19<sup>[11]</sup>. RT-PCR has some other limitations, including potential biological safety hazards due to handling of patient samples and long waiting time for results.

Given the limitations of the currently used nucleic acid detection for diagnosis of COVID-19, clinical laboratories should apply sensitive and accurate assays such as immunological detection kits that target viral antigens or antibodies for diagnosing SARS-CoV-2 infection as quickly as possible<sup>[12]</sup>. Therefore, SARS-CoV-2 serum IgM and IgG antibody positivity was added to the diagnostic criteria in the Novel Coronavirus Pneumonia Diagnosis and Treatment Guidelines (Trial Version 7)<sup>[13]</sup>. Dong *et al*<sup>[14]</sup> reported a COVID-19 case without detectable virus in oropharyngeal specimens and suggested testing for serum IgM and IgG antibodies to SARS-CoV-2 as an alternative for diagnosis. Li *et al*<sup>[15]</sup> demonstrated a rapid and simple point-of-care lateral flow immunoassay that can detect SARS-CoV-2 IgM and IgG antibodies in the blood of patients at different stages of infection. The overall testing sensitivity was 88.66% and specificity was 90.63%. However, there is limited clinical information on the SARS-CoV-2 antibody test (colloidal gold).

In the present study, we collected clinical data from 652 suspected COVID-19 patients and 206 non-COVID-19 patients to investigate the diagnostic value of SARS-CoV-2 IgM/IgG antibody test kits with colloidal gold immunoassays and nucleic acid RT-PCR test kits.

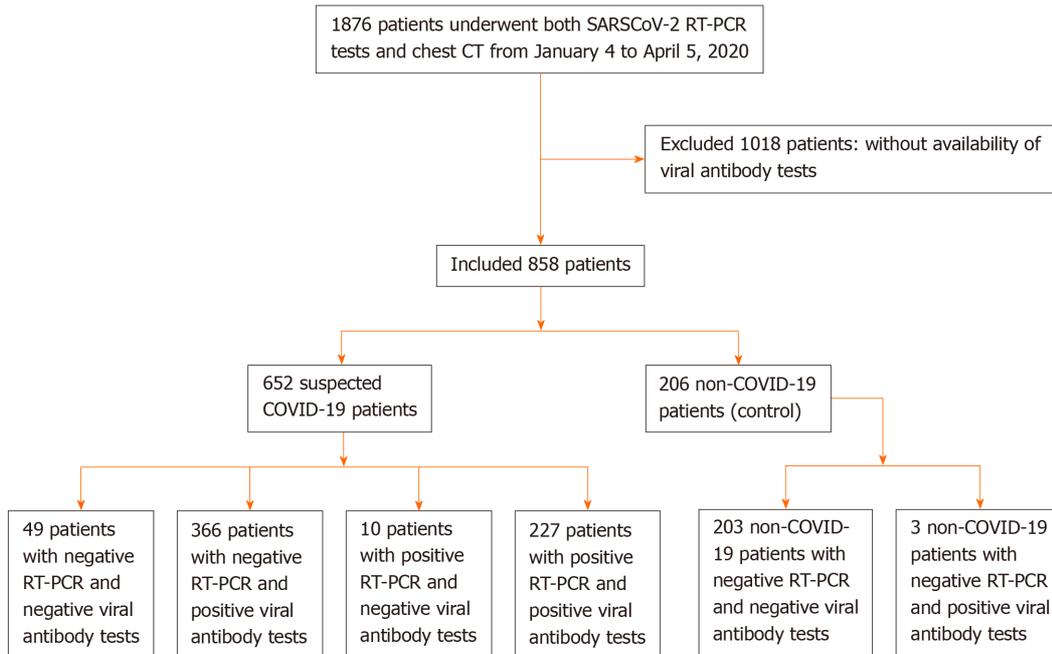
## MATERIALS AND METHODS

### **Ethics statement**

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of Wuhan Integrated TCM and Western Medicine Hospital, Huazhong University of Science and Technology (No. [2020]8). The requirement for written informed consent was waived given the context of emerging infectious diseases.

### **Patients**

From January 4 to April 5, 2020, data on 1876 consecutive patients who underwent SARS-CoV-2 nucleic acid tests and chest computed tomography were retrospectively collected in Wuhan Integrated TCM and Western Medicine Hospital. A total of 1018 patients were excluded because they did not have SARS-CoV-2 IgM/IgG antibody tests. We included 652 suspected COVID-19 patients and 206 non-COVID-19 patients (Figure 1). RT-PCR, SARS-CoV-2 IgM/IgG antibody tests, and pulmonary imaging features were extracted from patients' electronic medical records in our hospital information system. The patients were clinically diagnosed with COVID-19 according



**Figure 1 Flowchart of this study.** SARS-CoV: Severe acute respiratory syndrome coronavirus; RT-PCR: Reverse transcription polymerase chain reaction; CT: computed tomography; COVID-19: Coronavirus disease 2019.

to the Diagnosis and Treatment Protocol for Novel Coronavirus Pneumonia (Trial Version 7)<sup>[13]</sup>. Suspected COVID-19 patients met the following criteria: Clear history of epidemiological contact, typical clinical symptoms and pulmonary imaging features.

### Laboratory reagents and methods

The SARS-CoV-2 Antibody Test Kit (catalog No. 20203400177, colloidal gold) was obtained from Innovita (Tangshan) Biotechnology Co., Ltd. (Tangshan, China), with the recombinant SARS-CoV-2 antigen coated on the surface of the colloid gold particles. The SARS-CoV-2 nucleic acid detection kit (catalog No. 20203400057, fluorescent PCR) was purchased from Shanghai Zhijiang Biotechnology Co., Ltd. (Shanghai, China)<sup>[16]</sup>.

**SARS-CoV-2 antibody test:** Peripheral blood (4 mL) was collected from each patient with a yellow top collection tube and sent to the laboratory for serum SARS-CoV-2 IgM/IgG antibody test. Detection of serum IgM/IgG antibody was performed using the SARS-CoV-2 Antibody Test Kit (colloidal gold). The presence of two purple bands (M and C) indicated the presence of SARS-CoV-2 IgM antibodies. The presence of two purple bands (G and C) indicated the presence of SARS-CoV-2 IgG antibodies. For negative results, only one purple band appeared at the control line (C). If the control line (C) failed to appear, regardless of whether the G/M line was visible, the test was invalid.

**Fluorescent PCR for SARS-CoV-2 nucleic acid detection:** Pharyngeal swabs were used to collect secretions from the lateral and posterior pharyngeal walls and placed in sterile tubes (containing 1 mL sterile normal saline). Fluorescence PCR was performed using the SARS-CoV-2 Nucleic Acid Detection Kit. The results were divided into positive and negative according to the manufacturer's protocol.

### Statistical analysis

The statistical methods used in this study were reviewed by Guang-Jiang Wu from Beijing Shijitan Hospital, Capital Medical University. Categorical variables were displayed as counts and percentages. Continuous variables were presented as median (interquartile range; IQR). The  $\chi^2$  test was used to compare differences between categorical variables. The specificity, sensitivity, positive predictive value (PPV) and negative predictive value (NPV) of the SARS-CoV-2 Antibody Test Kit (colloidal gold) were calculated according to the following formulas. Specificity (%) =  $100 \times [\text{true negative}/(\text{true negative} + \text{false positive})]$ ; Sensitivity (%) =  $100 \times [\text{true positive}/(\text{true positive} + \text{false negative})]$ ; PPV (%) =  $100 \times [\text{true positive}/(\text{true positive} + \text{false$

positive); NPV (%) =  $100 \times [\text{true negative}/(\text{true negative} + \text{false negative})]$ ; and Accuracy (%) =  $100 \times (\text{true positive} + \text{true negative})/(\text{true positive} + \text{false positive} + \text{true negative} + \text{false negative})$ . A 95% confidence interval (CI) was provided by the Wilson score method. All *P* values were two-sided, and *P* < 0.05 was considered statistically significant. All analyses were performed with IBM SPSS Statistics version 22.0 (IBM Corp., Armonk, NY, United States).

## RESULTS

### Results of SARS-CoV-2 nucleic acid RT-PCR tests

Of the 652 suspected COVID-19 patients, 237 had positive and 415 had negative SARS-CoV-2 nucleic acid tests with a positive detection rate of 36.3% (95% CI: 32.6%–40.1%); therefore, 237 patients were confirmed to have COVID-19 by the SARS-CoV-2 nucleic acid RT-PCR test.

### Results of SARS-CoV-2 IgM and IgG antibody tests

The median time from illness onset to IgM/IgG antibody tests was 34 d (IQR 28–39 d). A representative photograph of SARS-CoV-2 IgM and IgG antibody tests is shown in [Figure 2](#). [Figure 2A](#) shows detection of IgM in low concentration (Score 1) and IgG in high concentration (Score 2); [Figure 2B](#) shows IgG only in high concentration (Score 2); [Figure 2C](#) shows both IgM and IgG in high concentration (Score 2); and [Figure 2D](#) shows no IgM and IgG (Score 0). Score  $\geq 1$  was defined as positive.

Of 206 non-COVID-19 patients, one was positive for IgM antibody against SARS-CoV-2, and two were positive for IgG antibody against SARS-CoV-2. Of the 652 suspected COVID-19 patients, 311 were positive for SARS-CoV-2-specific IgM antibody with a positive detection rate of 47.7% (95% CI: 43.9%–51.5%); 592 patients were positive for SARS-CoV-2-specific IgG antibody with a positive detection rate of 90.8% (95% CI: 88.6%–93.0%); and 593 patients were positive for SARS-CoV-2-specific IgM and/or IgG antibody combined tests with a positive detection rate of 91.0% (95% CI: 88.7%–93.2%). There was a significant difference regarding the positive detection rate between the IgM and IgG test groups (*P* < 0.001) ([Table 1](#)).

### Performance of SARS-CoV-2-specific IgM and IgG antibody kit

Of the 237 patients who were positive for SARS-CoV-2 nucleic acid tests, 109 were positive for IgM, 227 patients were positive for IgG, and 227 patients were positive for IgM and/or IgG. Using the RT-PCR results as a reference, the specificity, sensitivity, and accuracy of SARS-CoV-2-specific IgM, IgG and IgM/IgG combined tests for detecting SARS-CoV-2 infection are shown in [Table 2](#).

Receiver operating characteristic curve analysis showed that the area under the curve of IgM tests, IgG tests and IgM/IgG combined tests for diagnosing COVID-19 were 0.728 (95% CI: 0.681–0.775), 0.978 (95% CI: 0.963–0.993) and 0.978 (95% CI: 0.963–0.993) ([Figure 3](#)).

Of the 415 suspected COVID-19 patients who were negative for SARS-CoV-2 nucleic acid tests, 366 patients were positive for SARS-CoV-2-specific IgM and/or IgG antibody tests with a positive detection rate of 88.2% (95% CI: 85.1–91.3%).

## DISCUSSION

In the current retrospective study, we included 652 suspected COVID-19 patients with a clear history of epidemiological contact, typical clinical symptoms and pulmonary imaging features, to investigate the positive detection rate of nucleic acid and antibody tests. The results showed that of 652 patients, 237 (36.3%) were confirmed to have COVID-19 by the SARS-CoV-2 nucleic acid test, 311 (47.7%) were positive for SARS-CoV-2-specific IgM antibodies, 592 (90.8%) were positive for SARS-CoV-2-specific IgG antibodies, and 593 (91.0%) were positive for SARS-CoV-2 specific IgM and/or IgG antibodies. We included 237 confirmed COVID-19 patients with positive SARS-CoV-2 nucleic acid tests and 206 confirmed non-COVID-19 patients to evaluate the performance of the SARS-CoV-2-specific IgM and IgG antibody test kit.

Liu *et al*<sup>[10]</sup> reported that the positive rate of RT-PCR detection of SARS-CoV-2 infection was 38.4% (1875/4880) and an increased positive percentage was found in male and older patients. Ai *et al*<sup>[17]</sup> reported that 59% (601/1014) of patients had positive SARS-CoV-2 RT-PCR results. In the current study, the positive percentage of

**Table 1 Severe acute respiratory syndrome coronavirus immunoglobulin M and immunoglobulin G antibody detection result, *n* (%)**

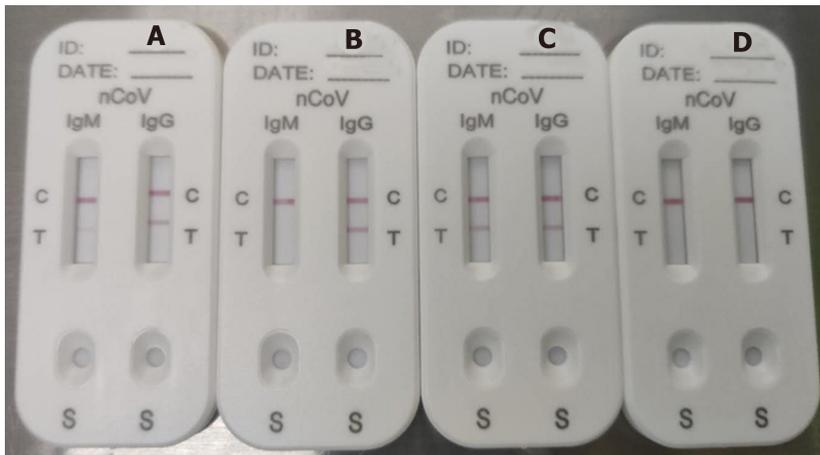
SARS-CoV-2; IgM antibody detection	SARS-CoV-2; IgG antibody detection		P value
	Positive	Negative	
Positive	310 (99.7)	1 (0.3)	< 0.001 <sup>1</sup>
Negative	282 (82.7)	59 (17.3)	

<sup>1</sup>Pearson's  $\chi^2$  test,  $\chi^2 = 56.46$ ,  $P < 0.001$ . SARS-CoV-2: Severe acute respiratory syndrome coronavirus 2.

**Table 2 Performance of the immunoglobulin M/immunoglobulin G antibody test kit for the diagnosis of severe acute respiratory syndrome coronavirus 2 infection with the reverse transcription-polymerase chain reaction result as a reference**

	Results of IgM/IgG test ( <i>n</i> )				IgM/IgG antibody test performance (%)				
	TP	TN	FP	FN	Specificity (95%CI)	Sensitivity (95%CI)	PPV (95%CI)	NPV (95%CI)	Accuracy (95%CI)
IgM	109	205	1	128	99.5 (98.6-100.0)	46.0 (39.6-52.4)	99.1 (97.3-100.0)	61.6 (56.3-66.8)	70.9 (66.6-75.1)
IgG	227	204	2	10	99.0 (97.7-100.0)	95.8 (93.2-98.4)	99.1 (97.9-100.0)	95.3 (92.5-98.2)	97.3 (95.8-98.8)
M/G	227	203	3	10	98.5 (96.9-100.0)	95.8 (93.2-98.4)	98.7 (97.2-100.0)	95.3 (92.4-98.2)	97.1 (95.5-98.6)

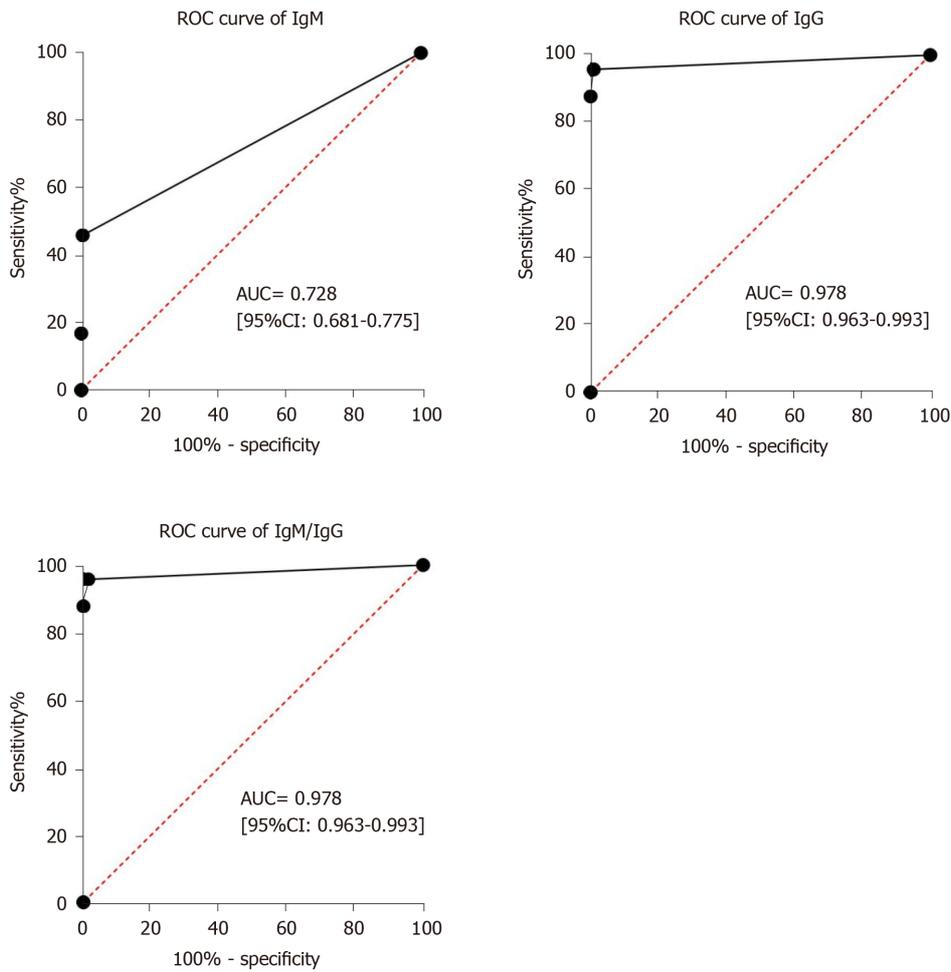
SARS-CoV-2: Severe acute respiratory syndrome coronavirus 2; COVID-19: Coronavirus disease 2019; RT-PCR: Reverse transcription-polymerase chain reaction; IgM: Immunoglobulin M; IgG: Immunoglobulin G; M/G: IgM and/or IgG; TP: True positive; TN: True negative; FP: False positive; FN: False negative; PPV: Positive predictive value; NPV: Negative predictive value.



**Figure 2 Representative picture of severe acute respiratory syndrome coronavirus-2 IgM and IgG antibody test results.** A: IgM in low concentration (Score 1) and IgG in high concentration (Score 2); B: Only IgG in high concentration (Score 2); C: Both IgM and IgG in high concentration (Score 2); D: No IgM or IgG (Score 0).

SARS-CoV-2 RT-PCR tests was lower than that of previous studies. According to the Novel Coronavirus Pneumonia Diagnosis and Treatment Guidelines, SARS-CoV-2 nucleic acid test by RT-PCR assay on respiratory tract specimens plays an important role in the etiological diagnosis of SARS-CoV-2 infection and discharge evaluation<sup>[13]</sup>. However, the accuracy of the laboratory diagnosis of COVID-19 using RT-PCR is affected by many potential factors, including preanalytical problems such as improper collection, storage and transport of swabs; sample contamination and testing patients receiving antiretroviral therapy; as well as analytical problems such as active viral recombination, use of inadequately validated assays, instrument malfunctioning, along with other specific technical issues<sup>[9]</sup>. Therefore, it is necessary to develop a more sensitive, accurate and simple detection method for the diagnosis of SARS-CoV-2 infection.

Dong *et al*<sup>[14]</sup> reported that COVID-19 was confirmed with positive IgM and positive IgG antibodies tests against SARS-CoV-2. As recently reported, a rapid IgM/IgG



**Figure 3 Results of the receiver operating characteristic curve analysis.** Receiver operating characteristic curve analysis showed that the area under the curve of IgM tests, IgG tests and IgM/IgG combined tests for the diagnosis of coronavirus disease 2019 were 0.728 (95%CI: 0.681–0.775), 0.978 (95%CI: 0.963–0.993) and 0.978 (95%CI: 0.963–0.993). ROC: Receiver operating characteristic curve; AUC: Area under the curve; IgM: Immunoglobulin M; IgG: Immunoglobulin G.

combined antibody test was used for the diagnosis of SARS-CoV-2 infection, showing 88.66% sensitivity and 90.63% specificity<sup>[15]</sup>. In the current study, we found that the specificity, sensitivity, and accuracy of IgM and/or IgG antibody combined detection for the diagnosis of SARS-CoV-2 infection were 98.5% (203/206), 95.8% (227/237), and 97.1% (430/443), respectively. Of the 415 suspected COVID-19 patients who were negative for SARS-CoV-2 nucleic acid tests, 88.2% (366) of patients were positive for SARS-CoV-2 specific IgM and/or IgG antibody tests. Therefore, 366 patients were considered to have COVID-19 with SARS-CoV-2 IgM and/or IgG antibody tests. All the results confirmed that IgM and/or IgG antibody tests can be used as an effective method for serological diagnosis of SARS-CoV-2 infection.

According to the Diagnosis and Treatment Protocol for Novel Coronavirus Pneumonia (Trial Version 7), double positive results of IgM and IgG antibody tests can be used as serological evidence for the diagnosis of SARS-CoV-2 infection<sup>[13]</sup>. However, the fact that IgM testing may be negative in convalescent patients with COVID-19 is not surprising considering the probable kinetics of SARS-CoV-2-specific IgM antibody<sup>[18-20]</sup>. Therefore, IgM and/or IgG positivity should be used as serological evidence for the diagnosis of SARS-CoV-2 infection.

There were several notable limitations in the present study. Firstly, the main weaknesses were its single center retrospective nature and small sample size. Secondly, due to the retrospective nature of the study, most patients did not complete the dynamic monitoring of SARS-CoV-2-specific IgM and IgG by the end of the study. Thirdly, the median time from symptom onset to the IgM and IgG test was long due to late availability of the SARS-CoV-2-specific IgM and IgG test kits.

## CONCLUSION

In summary, this retrospective study indicated that serum specific IgM and IgG antibody combined test has high sensitivity, specificity and accuracy for the diagnosis of SARS-CoV-2 infection. Our data indicate that the antibody-based test can be used as a detection tool in combination with RT-PCR in the diagnosis of SARS-CoV-2 infection in epidemic areas.

## ARTICLE HIGHLIGHTS

### **Research background**

Coronavirus disease 2019 (COVID-19) is a highly transmissible disease caused by severe acute respiratory syndrome coronavirus (SARS-CoV)-2. The global outbreak of human SARS-CoV-2 infection has highlighted the necessity for readily available, accurate and rapid diagnostic tests. SARS-CoV-2 serum IgM and IgG antibody positivity was added to the diagnostic criteria in the Novel Coronavirus Pneumonia Diagnosis and Treatment Guidelines (Trial Version 7). However, there is limited clinical information on the SARS-CoV-2 antibody test (colloidal gold).

### **Research motivation**

According to recent evidence, the diagnostic accuracy of reverse transcription polymerase chain reaction (RT-PCR) tests for detecting SARS-CoV-2 nucleic acid may be lower than optimal. Given the limitations of RT-PCR tests for the diagnosis of COVID-19, clinical laboratories should apply sensitive and accurate assays such as immunological detection kits that target viral antigens or antibodies for diagnosing SARS-CoV-2 infection as quickly as possible. We are very interested in this issue and hope that we can present a new antibody test adopted in our hospital.

### **Research objectives**

The objectives were to report the diagnostic value of SARS-CoV-2 IgM/IgG and nucleic acid detection in COVID-19.

### **Research methods**

We retrospectively analyzed data on 652 suspected COVID-19 patients, and 206 non-COVID-19 patients in Wuhan Integrated TCM and Western Medicine Hospital. RT-PCR, SARS-CoV-2 IgM/IgG antibody tests, and pulmonary imaging features were extracted from patients' electronic medical records in our hospital information system. The specificity, sensitivity, PPV and NPV of the SARS-CoV-2 Antibody Test Kit were calculated. A 95% confidence interval (CI) was provided by the Wilson score method. All analyses were performed with IBM SPSS Statistics version 22.0 (IBM Corp., Armonk, NY, United States), and two-tailed *P* values less than 0.05 were considered to be statistically significant.

### **Research results**

Of the 652 suspected COVID-19 patients, 237 (36.3%) patients were confirmed to have COVID-19 by the SARS-CoV-2 nucleic acid RT-PCR test. Using RT-PCR results as a reference, the specificity, sensitivity, and accuracy of the SARS-CoV-2-specific IgM/IgG combined tests for detecting SARS-CoV-2 infection were 98.5%, 95.8%, and 97.1%, respectively. Of the 415 suspected COVID-19 patients who were negative for the SARS-CoV-2 nucleic acid tests, 366 patients were positive for the SARS-CoV-2-specific IgM and/or IgG antibody tests with a positive detection rate of 88.2%.

### **Research conclusions**

Our data indicate that the serological IgM/IgG antibody combined test had high specificity, sensitivity, and accuracy for the diagnosis of SARS-CoV-2 infection, and can be used in combination with RT-PCR for the diagnosis of SARS-CoV-2 infection.

### **Research perspectives**

For COVID-19 patients, it is worth further completing the dynamic monitoring of SARS-CoV-2-specific IgM and IgG.

## ACKNOWLEDGEMENTS

The authors thank Professor Ling-Qian Chang (Beijing Advanced Innovation Center for Biomedical Engineering, School of Biological Science and Medical Engineering, Beihang University), Associate Professor Feng Chen (College of Materials Science and Engineering, Zhejiang University of Technology) and Jie Qiao (Hubei College of Traditional Chinese Medicine, Wuhan, Hubei Province, China) for their guidance in study design and interpretation of results, and review of the manuscript.

## REFERENCES

- 1 **Wang D**, Hu B, Hu C, Zhu F, Liu X, Zhang J, Wang B, Xiang H, Cheng Z, Xiong Y, Zhao Y, Li Y, Wang X, Peng Z. Clinical Characteristics of 138 Hospitalized Patients With 2019 Novel Coronavirus-Infected Pneumonia in Wuhan, China. *JAMA* 2020; **323**: 1061-1069 [PMID: [32031570](#) DOI: [10.1001/jama.2020.1585](#)]
- 2 **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 GF, Tan W; China Novel Coronavirus Investigating and Research Team. A Novel Coronavirus from Patients with Pneumonia in China, 2019. *N Engl J Med* 2020; **382**: 727-733 [PMID: [31978945](#) DOI: [10.1056/NEJMoa2001017](#)]
- 3 **Coronaviridae Study Group of the International Committee on Taxonomy of Viruses**. The species Severe acute respiratory syndrome-related coronavirus: classifying 2019-nCoV and naming it SARS-CoV-2. *Nat Microbiol* 2020; **5**: 536-544 [PMID: [32123347](#) DOI: [10.1038/s41564-020-0695-z](#)]
- 4 **World Health Organization**. Coronavirus disease 2019 (COVID-19) Situation Report-89. 2020. [18 April 2020]. Available from: [https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200418-sitrep-89-covid-19.pdf?sfvrsn=3643dd38\\_2](https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200418-sitrep-89-covid-19.pdf?sfvrsn=3643dd38_2)
- 5 **Cucinotta D**, Vanelli M. WHO Declares COVID-19 a Pandemic. *Acta Biomed* 2020; **91**: 157-160 [PMID: [32191675](#) DOI: [10.23750/abm.v91i1.9397](#)]
- 6 **Mahase E**. Covid-19: WHO declares pandemic because of "alarming levels" of spread, severity, and inaction. *BMJ* 2020; **368**: m1036 [PMID: [32165426](#) DOI: [10.1136/bmj.m1036](#)]
- 7 **Pang J**, Wang MX, Ang IYH, Tan SHX, Lewis RF, Chen JI, Gutierrez RA, Gwee SXW, Chua PEY, Yang Q, Ng XY, Yap RK, Tan HY, Teo YY, Tan CC, Cook AR, Yap JC, Hsu LY. Potential Rapid Diagnostics, Vaccine and Therapeutics for 2019 Novel Coronavirus (2019-nCoV): A Systematic Review. *J Clin Med* 2020; **9** [PMID: [32110875](#) DOI: [10.3390/jcm9030623](#)]
- 8 **Jin YH**, Cai L, Cheng ZS, Cheng H, Deng T, Fan YP, Fang C, Huang D, Huang LQ, Huang Q, Han Y, Hu B, Hu F, Li BH, Li YR, Liang K, Lin LK, Luo LS, Ma J, Ma LL, Peng ZY, Pan YB, Pan ZY, Ren XQ, Sun HM, Wang Y, Wang YY, Weng H, Wei CJ, Wu DF, Xia J, Xiong Y, Xu HB, Yao XM, Yuan YF, Ye TS, Zhang XC, Zhang YW, Zhang YG, Zhang HM, Zhao Y, Zhao MJ, Zi H, Zeng XT, Wang YY, Wang XH; for the Zhongnan Hospital of Wuhan University Novel Coronavirus Management and Research Team, Evidence-Based Medicine Chapter of China International Exchange and Promotive Association for Medical and Health Care (CPAM). A rapid advice guideline for the diagnosis and treatment of 2019 novel coronavirus (2019-nCoV) infected pneumonia (standard version). *Mil Med Res* 2020; **7**: 4 [PMID: [32029004](#) DOI: [10.1186/s40779-020-0233-6](#)]
- 9 **Lippi G**, Simundic AM, Plebani M. Potential preanalytical and analytical vulnerabilities in the laboratory diagnosis of coronavirus disease 2019 (COVID-19). *Clin Chem Lab Med* 2020; **58**: 1070-1076 [PMID: [32172228](#) DOI: [10.1515/ccclm-2020-0285](#)]
- 10 **Liu R**, Han H, Liu F, Lv Z, Wu K, Liu Y, Feng Y, Zhu C. Positive rate of RT-PCR detection of SARS-CoV-2 infection in 4880 cases from one hospital in Wuhan, China, from Jan to Feb 2020. *Clin Chim Acta* 2020; **505**: 172-175 [PMID: [32156607](#) DOI: [10.1016/j.cca.2020.03.009](#)]
- 11 **Li D**, Wang D, Dong J, Wang N, Huang H, Xu H, Xia C. False-Negative Results of Real-Time Reverse-Transcriptase Polymerase Chain Reaction for Severe Acute Respiratory Syndrome Coronavirus 2: Role of Deep-Learning-Based CT Diagnosis and Insights from Two Cases. *Korean J Radiol* 2020; **21**: 505-508 [PMID: [32174053](#) DOI: [10.3348/kjr.2020.0146](#)]
- 12 **Li X**, Geng M, Peng Y, Meng L, Lu S. Molecular immune pathogenesis and diagnosis of COVID-19. *J Pharm Anal* 2020; **10**: 102-108 [PMID: [32282863](#) DOI: [10.1016/j.jpaha.2020.03.001](#)]
- 13 **National Health Commission of the people's Republic of China**. Novel coronavirus pneumonia diagnosis and treatment guideline (trial version 7). 2020. Available from: <http://www.nhc.gov.cn/xcs/zhengcwj/202003/2020046c209294a202007dfe202004cef2020080dc202007f205912eb201989.shtml>
- 14 **Dong X**, Cao YY, Lu XX, Zhang JJ, Du H, Yan YQ, Akdis CA, Gao YD. Eleven faces of coronavirus disease 2019. *Allergy* 2020; **75**: 1699-1709 [PMID: [32196678](#) DOI: [10.1111/all.14289](#)]
- 15 **Li Z**, Yi Y, Luo X, Xiong N, Liu Y, Li S, Sun R, Wang Y, Hu B, Chen W, Zhang Y, Wang J, Huang B, Lin Y, Yang J, Cai W, Wang X, Cheng J, Chen Z, Sun K, Pan W, Zhan Z, Chen L, Ye F. Development and clinical application of a rapid IgM-IgG combined antibody test for SARS-CoV-2 infection diagnosis. *J Med Virol* 2020 [PMID: [32104917](#) DOI: [10.1002/jmv.25727](#)]
- 16 **Loeffelholz MJ**, Tang YW. Laboratory diagnosis of emerging human coronavirus infections - the state of the art. *Emerg Microbes Infect* 2020; **9**: 747-756 [PMID: [32196430](#) DOI: [10.1080/22221751.2020.1745095](#)]
- 17 **Ai T**, Yang Z, Hou H, Zhan C, Chen C, Lv W, Tao Q, Sun Z, Xia L. Correlation of Chest CT and RT-PCR Testing for Coronavirus Disease 2019 (COVID-19) in China: A Report of 1014 Cases. *Radiology* 2020; **296**: E32-E40 [PMID: [32101510](#) DOI: [10.1148/radiol.2020200642](#)]
- 18 **Zhou P**, Yang XL, Wang XG, Hu B, Zhang L, Zhang W, Si HR, Zhu Y, Li B, Huang CL, Chen HD, Chen J, Luo Y, Guo H, Jiang RD, Liu MQ, Chen Y, Shen XR, Wang X, Zheng XS, Zhao K, Chen QJ, Deng F, Liu LL, Yan B, Zhan FX, Wang YY, Xiao GF, Shi ZL. A pneumonia outbreak associated with a new coronavirus

- of probable bat origin. *Nature* 2020; **579**: 270-273 [PMID: 32015507 DOI: 10.1038/s41586-020-2012-7]
- 19 **Zhang W**, Du RH, Li B, Zheng XS, Yang XL, Hu B, Wang YY, Xiao GF, Yan B, Shi ZL, Zhou P. Molecular and serological investigation of 2019-nCoV infected patients: implication of multiple shedding routes. *Emerg Microbes Infect* 2020; **9**: 386-389 [PMID: 32065057 DOI: 10.1080/22221751.2020.1729071]
- 20 **Jin Y**, Wang M, Zuo Z, Fan C, Ye F, Cai Z, Wang Y, Cui H, Pan K, Xu A. Diagnostic value and dynamic variance of serum antibody in coronavirus disease 2019. *Int J Infect Dis* 2020; **94**: 49-52 [PMID: 32251798 DOI: 10.1016/j.ijid.2020.03.065]



Published by **Baishideng Publishing Group Inc**  
7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA  
**Telephone:** +1-925-3991568  
**E-mail:** [bpgoffice@wjgnet.com](mailto:bpgoffice@wjgnet.com)  
**Help Desk:** <https://www.f6publishing.com/helpdesk>  
<https://www.wjgnet.com>

