Rapid Screening Diagnosis of SARS-COV-2 Infection With IgM-igG Combined Antibody Test Using Peripheral Blood

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Research article

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1 **Title page**

2 **Rapid screeningdiagnosisofSARS-CoV-2 infectionwith IgM-IgG combined**

3 **antibody test using peripheralblood**

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33 **Key points:**

34 1.There were higher sensitivity and specificity of the rapid IgM-IgG combined

35 antibody test for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)

36 using peripheral blood as a point-of-care testing (POCT) assay.

37 2. The POCT assay also can detect IgM and IgG antibodies of SARS-CoV-2 in

38 asymptomatic carriers.

39 3. The POCT assaycan be used for rapid screening of SARS-CoV-2 infection.

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Abstract

Background: Rapid and convenient screening for identification ofSARS-CoV-2 infected individuals are key to prevent and control this pandemic.

Methods: The peripheral blood samples werecollected fromcoronavirus disease 2019(COVID-19) patients and asymptomatic carriersto evaluate the test characteristics of the IgM-IgG combined assay for SARS-CoV-2 compared to that of serum samples and enzyme-linked immuno sorbent assay (ELISA). Close contacts,healthcare workers and workforces wererecruited and screened using this assay.

Results: The sensitivity of the rapid IgM-IgG combined antibody test for SARS-CoV-2 using peripheral blood (sued as a POCT) was 97.0% and the specificity was 99.2%,which was consistent with the result obtained using serum sample (consistency is about 100%). Furthermore, this POCT assay also can detect IgM and IgG antibodies of SARS-CoV-2 in asymptomatic carriers, with 19 of the 20 RT-PCR confirmed asymptomatic carriers testing positive. Therefore, this POCT assay was used for population screening of SARS-CoV-2 infection diagnosis. First, it found 4 positive close contacts among the 10 cases, and there were three IgM positive cases and one IgG positive case among them. It is worth noting that the IgM positive cases also tested positive for the nucleic acid of the SARS-CoV-2. Second, there was one IgM positive assay among the 63 healthcare workers, but RT-PCR of SARS CoV-2 was negative. Third, for workforces screening, there were no positive cases.

Conclusions: The IgM-IgG combined antibody test of SARS-CoV-2 can be used as a POCT for rapid screening of SARS-CoV-2 infection.

Keywords:COVID-19;IgM-IgG antibody; peripheral blood; rapid screening

Background

COVID-19 has spread rapidly around the world since its outbreak in December 2019, leading to more than 10 million cases in over 160 countries up to 29 June 2020,furthermore, the WHO reassessment of global risk was deemed to be very high.[1]And the biggest challenge for effective prevention and control of COVID-19 pandemic was how to quickly and accurately identify both symptomatic and symptomatic carriers of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) infection in the general population. Currently, viral nucleic acid real-time polymerase chain reaction (RT-PCR) has been the diagnostic standard for theSARS-CoV-2 infection.[2, 3] However, the currentRT-PCR assays have many limitations: 1). although RT-PCR is rapid and sensitive/specific, it has a long turnaround time andis operationally complicated, often taking upwards of 2-3 hours to produce results; 2)RT-PCR testing requires certified laboratories, expensive equipment and highly-trained technicians to perform the assay; 3) RT-PCR may produce false negative results,[4, 5] andthere are considerable differences in sensitivity of RT-PCR for different specimens.[6] As a result, RT-PCR is not suitable to be a POCT test for rapid screening of SARS-CoV-2 infection.

Blood specific antibodies, including IgM and IgG of SARS-CoV-2, have also been used for the diagnosis of SARS-CoV-2 infection.[2, 3] Specific antibody testing for SARS-CoV-2 has been as an ideal choice for the diagnosis of COVID-19 as it is simple to conduct and has both a quick turnaround time and high sensitivity. It is widely accepted that IgM provides the initial humoral immune response during viral infections, prior to the generation of the adaptive, high affinity IgG antibodies that are important for long term immunity and immunological memory.[7] The acute antibody response to SARS-CoV-2 infection is similar to many other acute viral infections.[8, 9] After the body has been infected with SARS-CoV-2, IgM antibodies are produced, such that increases in the level of IgM are markers of a recent infection. The production of IgG antibodies occurs later in the disease course and is an indicator of previous infections. The simultaneous detection of IgM antibody and IgG antibody can distinguish acute and previous infections[8]. Thus, the rapid detection of both IgM and IgG antibodies

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118 will add value to the diagnosis and treatment of COVID-19. In our previous study, we

119 have designed a rapid IgM-IgG combined antibody test kit for diagnosis of

120 SARS-CoV-2 infection. It also has been that the test can be performed rapidly (<15 min)

121 and conveniently using peripheral blood samples to detectSARS-CoV-2 infection.[10]

122 However, there were some limitations in our previous study: 1) insufficient number of

123 COVID-19 cases using peripheral blood sampling 2) lack of data to confirm that it can

124 be used for asymptomatic carriers diagnosis, 3) and for as a POCT detection, and

125 screening for SARS-CoV-2 infection. Therefore, we designed and carried out this study

126 to address these limitations using IgM-IgG combined antibody test.

127

128 **Methods**

129 *Study oversight and design*

130 A flowchart outlining the milestones in the study is shown in Figure 1.

131 *Targeted testing*

132 COVID-19 patients, confirm by RT-PCRpositive of SARS-CoV-2 and whos' clinical

133 and virological characteristicswill be reported in other papers, were recruited in the

134 study to determinethe efficacy of IgM-IgG combined antibody test. The group included

135 both symptomatic individuals, who haveclinical symptoms of cough, fever, myalgias,

136 or shortness of breath, and the onset time more than seven days before antibody tested,

137 and asymptomatic carriers who confirmed by RT-PCRpositive of SARS-CoV-2.

138 *Population screening*

139 Population screening focused on the following three groups of individuals: 1)

140 closecontacts either symptom-free or had mild symptoms, but had contact withconfirm

141 COVID-19 patients. 2) Healthcare workers who took care COVID-19 patients for

142 extended periods of time. 3) Workforces who hadrecentexposure to high-risk areas and

143 needed to be ruled out SARS-CoV-2 infection before returning to work. Before

144 IgM/IgG test, all participants were required to self-quarantine for more than 14 days

145 either after last contact with confirmedCOVID-19 patients or come from high-risk

146 areas.

147   Participants positive for SARSCoV-2 were required to self-quarantine,then they

148 were retested by RT-PCR assay for SARS-CoV-2. If the RT-PCR results were positive,

149 they continued to be quarantined and treated until they were RT-PCR negative.

150 ***IgM and IgG antibody of SARS-CoV-2 was detected***

151 **Peripheralblood testing**

152 Just prior to testing, the pouched device was opened. and an alcohol disinfected finger

153 from the study subject was pricked with a disposable needle. Approximately one drop

154 of blood (about 15 μL) was squeezed out and pipetted into the sample port to which 2-3

155 drops (70-100 ul) of dilution buffer was added to drive capillary action along the strip.

156 Results were obtained 10-15 minutes later (Fig. 2).

157 **ELISA assay**

158 Anti-Human IgM (μ-chain specific) antibody or N protein of SARS-CoV-2 (IgG) was

159 used as the coating. The plasma obtained from patients was diluted at 1:100 for

160 testing. HRP labeled N protein of SARS-CoV-2 (IgM) or anti-human IgG (H + L)

161 antibody labeled with HRP was used as the secondary antibody. The colorimetric

162 reaction was induced by adding TMB and terminated by using H_2SO_4. Detection of

163 the substrate was carried out via spectrometry by measuring the OD450. The positive

164 and negative control were set at the same time.

165 ***Real-time reverse transcriptase polymerase chain reaction (RT-PCR) assay***

166 Clinical specimens were tested with RT-PCR assay kits certified by the Chinese

167 government (Kaijie biotechnology co., LTD, Shanghai, China). The detailed product

168 information, specifically the detection sequence ofSARS-CoV-2, could not be fully

169 obtained due to proprietary technology. However, it is known that the detection target

170 of RT-PCR for SARS-CoV-2 focuses on NP and ORF1ab genes, anda positive result

171 requires both gene tests to be positive. The detection operation was conducted in

172 accordance with the instructions of the products.

173 ***Statistical analysis***

174 The sensitivity, specificity, the overall coincidence rate and Kappa statistical test which

175 was used for the interobserver consistency are calculated according to the following

176 formulas

177 1)Sensitivity $= \dfrac{TP \text{ (Ture positive)}}{TP+FN \text{ (False negative)}} \times 100\%$

178 2) Specificity $= \dfrac{TN \text{ (Ture negative)}}{FP \text{ (False positive)} +TN} \times 100\%$.

179 3) The overall coincidence rate is expressed by the $\dfrac{TP+TN}{TP+FP+FN+TN} \times 100\%$ ratio

180 4) Kappa consistency was calculated by $\dfrac{PA-Pe}{1-Pe}$, in which PA$=\dfrac{TP+TN}{TP+FP+FN+TN}$, Pe $=$

181 $\dfrac{(TP+FP)(TP+FN)+(FN+TN)(FP+TN)}{(TP+FP+FN+TN)\times(TP+FP+FN+TN)}$. Results were accepted as either poor (kappa < 0.20),

182 fair (kappa = 0.21–0.40), moderate (kappa = 0.41–0.60), good(kappa = 0.61–0.80),

183 very good (kappa = 0.81–0.90), and excellent (kappa > 0.91)

184

185 **Results**

186 ***IgM-IgG combined antibody test showed a higher sensitivity and specificity for***

187 ***SARS-CoV-2 in confirmed COVID-19 patients using peripheralblood***

188 In order to evaluate whether the IgM-IgG combined antibody test can detect specific

189 antibodies ofSARS-CoV-2 using peripheralblood,samples from confirm COVID-19

190 (RT-PCR positive of SARS-CoV-2), non-COVID-19 patients (RT-PCR negative of

191 SARS-CoV-2) and healthy were recruited.

192 A totalof 85 cases were tested: 33 confirmed COVID-19 patients, 23 non-COVID-19

193 patients and 29 healthy subjects. The IgM/IgG tested time of confirm COVID-19

194 patients was average 35±8.5 days postsymptom onset (Supplementary Table 1), and it

195 was average 2.1±0.9 days post symptom onset for non-COVID-19 patients.

196 Furthermore, 19 of 33 confirm COVID-19 patients were IgM positive (sensitivity

197 57.6%), and the test was most negative in both non-COVID-19 and healthy individuals

198 (specificity 98.5%). TheIgG antibody test results showed a sensitivity of 97.0% and a

199 specificity of 99.2%, with 32 of the 33 COVID-19 patientstested positive(Table

200 1).These operations usedperipheral blood.

201 We also evaluated the differences in test characteristics of the IgM-IgG combined

202 antibody assay between peripheralblood and serum samples, as well as between the

203 combined antibody assay and ELISA. As shown in Table 2, the overall coincidence rate

between peripheralblood and serum samples was 100% for IgM and IgG antibody testing. Furthermore, compared to ELISAassay, the overall coincidence rate was 80% (16 out of 20) for the IgM-IgG combined antibody test. Among the 16 patients, 4 patients were both IgM and IgG positive, 5 were IgM positive and IgG negative,7 were IgM negative and IgG positive (Fig. 3).

IgM-IgG combined antibody test of SARS-CoV-2 also showed a positive diagnosis for asymptomatic carriers using peripheral blood

This study recruited 20 asymptomatic carriers who had no clinical symptoms or travel history of high-risk area. They were permanent residents in Sichuan province, China. However, they had closecontact with confirmed COVID-19 patients in their community within 14 days and werepositive for SARS-CoV-2 by RT-PCR. Subsequently, they got the IgM and IgG antibodies tested at 5.8±2.87 days (4-14 days) after the initial positive PCR assay using peripheralblood samples. The total positive rate was 95% as compared to RT-PCR. The positive rate of single IgM and IgM-IgG combinedwere higher than that of single IgG, 95% v.s95% v.s 30%, respectively (Table 3). The results verified that the IgM-IgG combined antibody test can be used to diagnose asymptomatic SARS-CoV-2 carriers.

IgM-IgG combined antibody test can be used as a screening test for SARS-CoV-2 infection

The above results proved that the IgM-IgG combined antibody test can test the IgM and IgG antibody of SARS-CoV-2 in 10-15 minutesusing peripheral blood as a POCT. Furthermore, this POCT assay can test the antibody in symptomatic and asymptomatic individuals confirmed by RT-PCR. Therefore, we suggest that this POCT assay can be sued for screening diagnosis of SARS-CoV-2 infection in publication. In order to illustrate its screening characteristics, three distinct groups of individualswere included in this study (Fig. 4A). The first group were 10subjects who have an explicit contact history with confirmed COVID-19 patients without proper protective gear, among whom, 3 cases (30%) were IgM positive but asymptomatic, as well as the RT-PCR retesting of SARS-CoV-2also was positive., And 1 case (33.3%)

233   was reported IgG positive but RT-PCR negative. Those RT-PCR positive patients

234   received standard treatment afterwards(Fig. 4B). The second group were 63healthcare

235   workers who were in closecontact with COVID-19 patients but wore standard

236   personal protective gear, among whom one showed positive (2.12%). Re-testing using

237   RT-PCRassayfor SARS-CoV-2 showed negative for this individual although, she was

238   advised to quarantinefor her previous close contact with confirmed COVID-19

239   patients (Fig. 4B). The third group were 298workforcesfrom high-risk areas. All

240   subjects tested negative and were considered noninfectious and cleared to return to

241   work (Fig. 4B).

242

243   **Discussion**

244   We evaluated the rapid screening diagnosis of SARS-CoV-2 infection with IgM-IgG

245   combined antibody test using peripheralblood based on previous validated study [10].

246   We affirmed that therapid IgM-IgG combined antibody test for SARS-CoV-2using

247   peripheralblood(used as a POCT) presented high sensitivity and specificity compared

248   with serum samples and ELISA. Furthermore, the POCTassay can be used to test the

249   IgM and IgGantibody of SARS-CoV-2 in both symptomatic and asymptomatic

250   individuals. Therefore, we recommend this POCT assay as a screening tool for those

251   potentially exposed to SARS-CoV-2 in a hope to actmore efficiently in the prevention

252   and control of this pandemic.

253   The current techniques to detect SARS-CoV-2 can be classified into four types

254   based on methodology: pathogen culture, antigen testing, nucleic acid testing and

255   antibody testing. Pathogen culture has traditionally been considered as the

256   goldstandard for viral detection for more than 70years.[11] However, it has limited

257   use because of its slow turnaround time when rapid pathogen detection is

258   required.[12]Although nucleicacid amplification tests including RT-PCR are rapid,

259   highly sensitive and specific,[13, 14]PCR testing requires certified laboratories,

260   expensive equipment, and well-trained technicians, taking 2-3 hours to obtain results.

261   Furthermore, RT-PCR may yield false negative results.[4, 5]Metagenomic

262 next-generation sequencing (NGS)has been widely usedas an emerging detection

263 technology, butit requires the sequencing process to be completed before analysis

264 canbegin.[15]Metagenomic NGS also requires cumbersome instruments and a

265 dedicated laboratory. Antigen testing may be able to fit screening, however there are

266 no commercially available products yet. In this occasion, the IgM-IgG combined

267 antibody test of SARS-CoV-2 can be used to address current needs.[10] We were able

268 to verify the utility of this bedside antibody test indetecting the IgM and IgG

269 antibodies of SARS-CoV-2 using peripheral blood(Fig. 2). The results can be obtained

270 within 15 minutes with high sensitivity and specificity (Table 1), which is consistent

271 with the previous study.[16]The results obtained from peripheral blood were highly

272 consistent with those from serum samples, which implies that the sampling process can

273 be optimized. The above findings suggest that the rapid IgM-IgG combine antibody test

274 can be employed as a POCT for screening COVID-19 patients. [17]

275 It has been well established that the initial production of IgM after a viral infection is

276 followed by IgG, which confers along term immunity and immunological

277 memory.[7]According to other coronavirus infections such as SARS-CoV-1, IgM

278 antibodies can be detected in blood samples 3-6 days after the initial infection and IgG

279 after 8 days.[18, 19] In COVID-19 patients, IgM are typically produced within 7 days

280 after the onset of illness, but IgG single positive and IgM-IgG double positive can

281 appear in the acute and convalescence periods (1-35d).[16]Zhao et al found that less

282 than 40% of patients had detectable antibodies within 7 days of disease onset, and this

283 portion increased to 100% after 15 days from initial onset, of which 94.3% was

284 detected for IgM and 79.8% for IgG.[8]Herein, we found that the detection sensibility

285 was lower in individual IgM antibody test than individual IgG or IgG-IgM combined

286 antibody test when the testing time was later from onset (Table 1; average 35±8.5 days).

287 However, the detection sensibility of individual IgMand IgG-IgM combined antibody

288 testwill be higher than individual IgG when the testing time was early from onset (Table

289 3; average 5.8±2.87 days). Additionally, we found that the detection sensibility was

290 higher in IgG-IgM combined antibody test than in individual IgG or IgM antibody

291 test.[10] Therefore, combined with the production of IgM and IgG antibody, we

292 recommend theIgM-IgG combined antibody testwill be better used.

293   The IgMand IgGantibodies of COVID-19 serve as an indicator of infection. Based

294 on the current understanding of the disease process in China, the Chinese clinical

295 guideline considers the detection of antibodies a diagnostic option for

296 COVID-19.[2]Besides, we believe the rapid IgM-IgG combined antibody test of

297 SARS-CoV-2may play an important role in screening individualswith potential

298 exposure to the virus, particularly the asymptomatic carriers.Relevant reports indicate

299 asymptomatic carriers can still transmit the virus to others individuals.[20, 21]

300 Therefore,large scale screening for asymptomatic carriers combined with early

301 detection, quarantine, prevention, and treatment will be crucial to control this

302 epidemic.[22] Fortunately, we found that the rapid IgM-IgG combined antibody test of

303 SARS-CoV-2 could serve as a better testing tool for asymptomatic carriers (Table 3).

304 It is showed that asymptomatic carriers of COVID-19 are highly contagious, and

305 people in close contact with them are susceptible to infection. Therefore, it is important

306 to identify and isolate of asymptomatic carriers of COVID-19, more testing and more

307 follow-up, which is benefit to the prevention and control of the epidemic.[23-25]

308 Interestingly, the rapid IgM-IgG combined antibody test of SARS-CoV-2 has better

309 practical application for the screening of asymptomatic patients, and guided isolation

310 therapy in advance (Fig. 4).

311   There are limitations to userapid IgM-IgG combined antibody test of

312 SARS-CoV-2as a screening tool.Firstly, there will be false negative results as its lower

313 sensitivity compared to that of ELISA (Table 2). Secondly, since IgM and IgG are

314 produced later(usually 3-5 days after onset) in the disease course, early negative results

315 do not rule out an infection. Third, false positive of IgM and IgG antibody testing

316 should not be ignored. Therefore, multiple detection methods can be used to improve

317 the diagnostic accuracy when necessary.

318

319 **Conclusion**

320 The rapid IgM-IgG combined antibody test for SARS-CoV-2 provides high sensitivity

321 and specificity using peripheralbloodsamples as a POCT, which can also be used to

322 detect the antibodies in asymptomatic carriers of the SARS-CoV-2 virus, Therefore, it

323 can be used as a POCT tool to screen the high-risk populations.

324

325 **Abbreviations**

326 SARS-CoV-2: severe acute respiratory syndrome coronavirus 2; POCT: point-of-care

327 testing assay; COVID-19):coronavirus disease 2019;ELISA: enzyme-linked immuno

328 sorbent assay; RT-PCR: real-time polymerase chain reaction; NGS: next-generation

329 sequencing.

330

331 **Declaration**

332 *Consent for publication:*

333 Not applicable.

334

335 *Ethics approval and consent for participate:*

336 This observational study was obtained ethical approvalfrom the Ethics Committee of

337 the First Affiliated Hospital of Guangzhou Medical University (Ethical number:

338 2020-36),and the informed consent was obtainedfromeach participant.

339

340 *Availability of data and material:*

341 The data that support the findings of this study are available from the corresponding

342 author on reasonable request. Participant data without names and identifiers will be

343 made available after approval from the corresponding author. After publication of

344 study findings, the data will be available for others on request. The research team will

345 provide an email address for communication once the data are approved for sharing

346 with others. A proposal containing a detailed description of study objectives and

347 statistical analysis plan will be needed for evaluating the reasonability of request for

348 our data. The corresponding author will make a decision based on these materials.

349 Additional materials may also be required during the process.

350

Competing interests:

The authors report no conflicts of interest.

Authors' contributions:

FY, SQL, YWW and ZTL conceived and designed the study, had full access to all data, and took responsibility for the data accuracy and integrity.CJ, YL, ZMC, MZ, KJS, WSC and MDW contributed to the population screening. YWW and ZMC contributed to the RT-PCR test. FY and ZTL contributed to the statistical analysis. The remaining authors contributed to the management and treatment of patients.All authors contributed to data acquisition, data analysis, or data interpretation, and reviewed and approved the final version of the manuscript.

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453   **characteristics of 24 asymptomatic infections with COVID‑19 screened among close**
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460 **Figure legends**

461 **Figure 1. Study Design for Targeted Testing and Population Screening.** In this

462 study, targeted testing for coronavirus disease 2019 (COVID-19) was applied to those

463 with symptoms as well as asymptomatic carriers, as well as for screening for the contact

464 tracing, medical workers, and company staff, who were high-risk populations.

Figure 2. Operating procedure of detecting antibody in peripheral blood. The

procedure was simple and convenient, and results can be obtained within 15 minutes.

Figure 3. Comparing the detection characteristics between ELISA and the rapid

antibody test. The quadrate (earthy yellow) represents the ELISA assay and the circle

represents the rapid antibody test. IgM antibody testing is depicted in red and IgG

antibody testing is depicted in orange-yellow.

Figure 4.Population screening with rapid IgM-IgG combined antibody test for

SARS-CoV-2 in peripheral blood. A was a picture showed the screening site. B

shows the screening results, including Close contacts, healthcare workers and

workforces.

Tables

Table 1. The detection sensibility and specificity of SARS-CoV-2 IgM-IgG
combined antibody test using peripheral blood

Variable			PCR			Sensibility	Specificity
			Positive	Negative	Total		
IgM	**COVID-19**	Positive	19	0	19		
		Negative	14	0	14		
	Non-COVID-19	Positive	0	2	2	57.6%	98.5%
		Negative	0	99	99		
	Healthy person	Positive	0	0	0		
		Negative	0	29	29		
		Total	33	130	163		
IgG	**COVID-19**	Positive	32	0	32		
		Negative	1	0	1		
	Non-COVID-19	Positive	0	1	1	97.0%	99.2%
		Negative	0	100	100		

			Positive	Negative	Total			
	Healthy person	Positive	0	0	0			
		Negative	0	29	29			
		Total	33	130	163			
IgM /IgG	**COVID-19**	Positive	32	0	32			
		Negative	1	0	1			
	Non-COVID-19	Positive	0	3	3	97.0%	97.7%	9
		Negative	0	98	98			
	Healthy person	Positive	0	0	0			
		Negative	0	29	29			
		Total	33	130	163			

483 Noting:1) The IgM and IgG tested time was average 35 ± 8.5 days post symptom onset.

484   2) IgM/IgG means IgM positive or/and IgG positive.

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498 **Table 2. The comparing between peripheral blood and serum of venous blood of**
499 **SARS-CoV-2 IgM-IgG combined antibody test**

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Variable			Serum of venous blood			The overall coincidence
			Positive	**Negative**	**Total**	
peripheral blood	**IgM**	Positive	13	0	13	
		Negative	0	29	29	100%
		Total	13	29	42	
	IgG	Positive	30	0	30	
		Negative	0	12	12	100%
		Total	0	12	42	

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Table 3. IgM-IgG combined antibody detection of SARS-CoV-2 in

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asymptomaticcarriers

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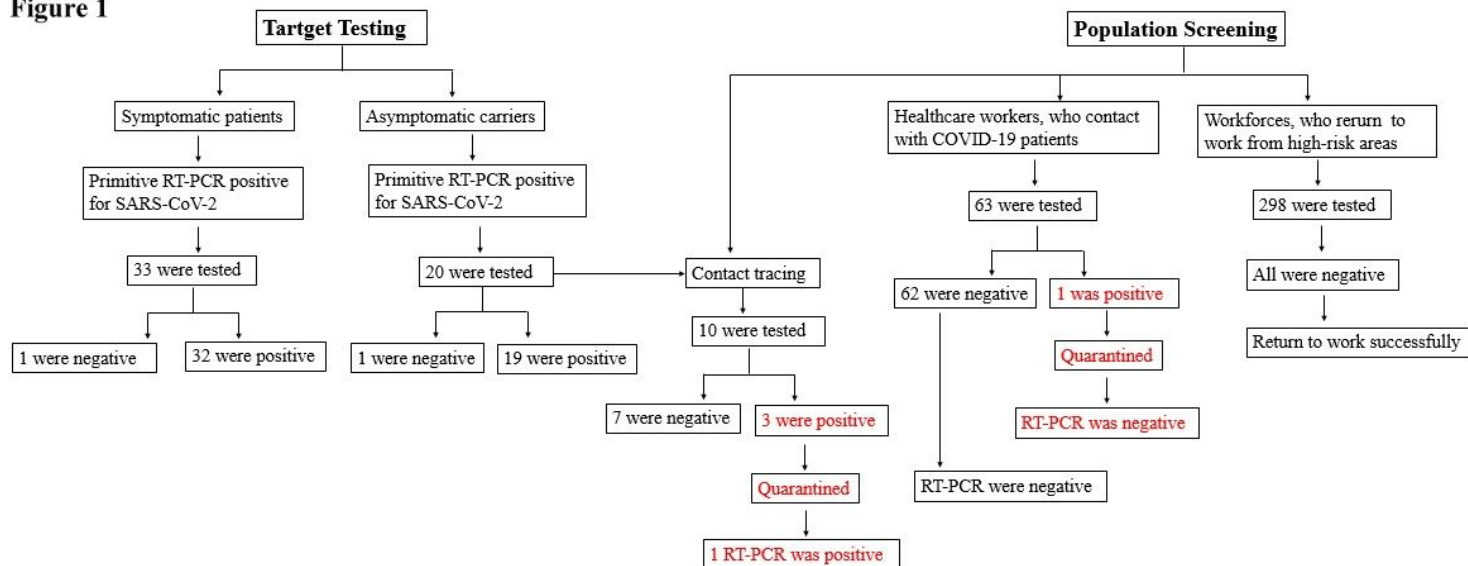| Variable	Asymptomatic carriers		
Male sex, no. (%)	8/20 (40)		
Mean age (years)	25.2±12.79		
Nationality	China		
Place of residence	Sichuan province		
Anyepidemic area travel, no. (%)	0/20 (0)		
Known contact with infected person, no. (%)	20/20 (100), cluster cases		
The time contacting	No clear		
Symptoms reported, no. (%)	0/20 (0)		
RT-PCR positive, no. (%)	20/20 (100)		
Antibody testing, no. (%);	IgM (+)	IgG (+)	IgM or IgG (+)
using peripheral blood	19/20 (95)	6/20 (30)	19/20 (95)
The time to take results	10-15 min		
Time distance from RT-PCR positive (days)	5.8±2.87		

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Figures

Figure 1

Study Design for Targeted Testing and Population Screening. In this study, targeted testing for coronavirus disease 2019 (COVID-19) was applied to those with symptoms as well as asymptomatic carriers, as well as for screening for the contact tracing, medical workers, and company staff, who were high-risk populations.
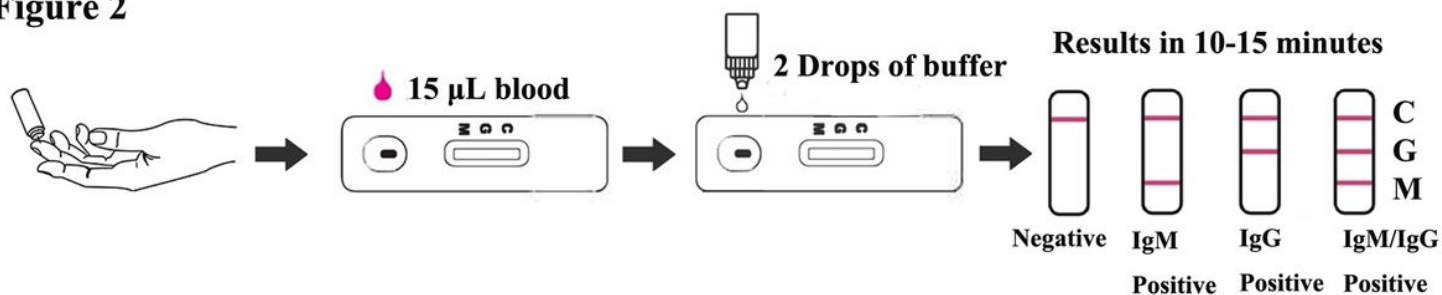

Figure 2

Operating procedure of detecting antibody in peripheral blood. The procedure was simple and convenient, and results can be obtained within 15 minutes.
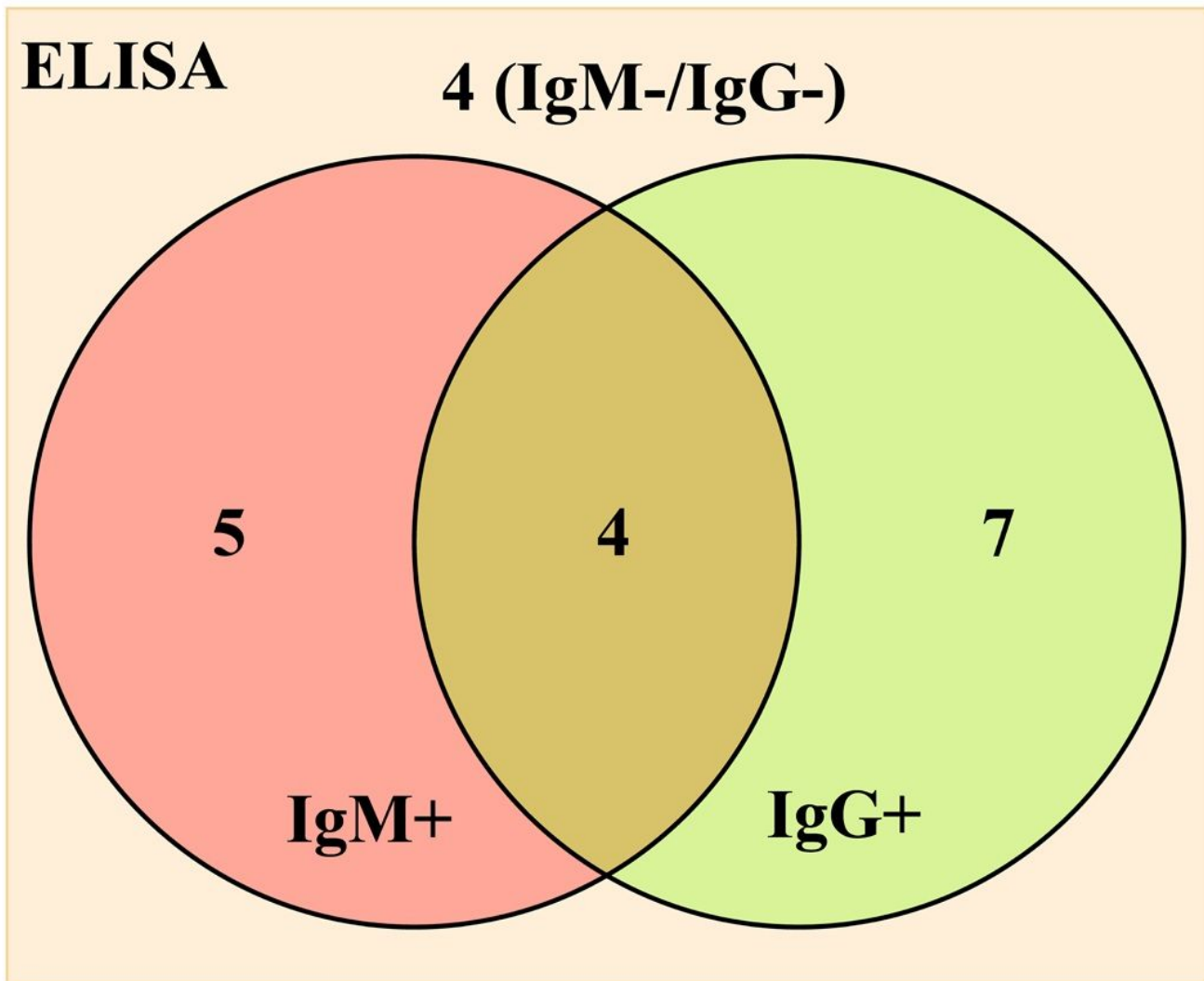
Figure 3

Total: 20

Figure 3

Comparing the detection characteristics between ELISA and the rapid antibody test. The quadrate (earthy yellow) represents the ELISA assay and the circle represents the rapid antibody test. IgM antibody testing is depicted in red and IgG antibody testing is depicted in orange-yellow.
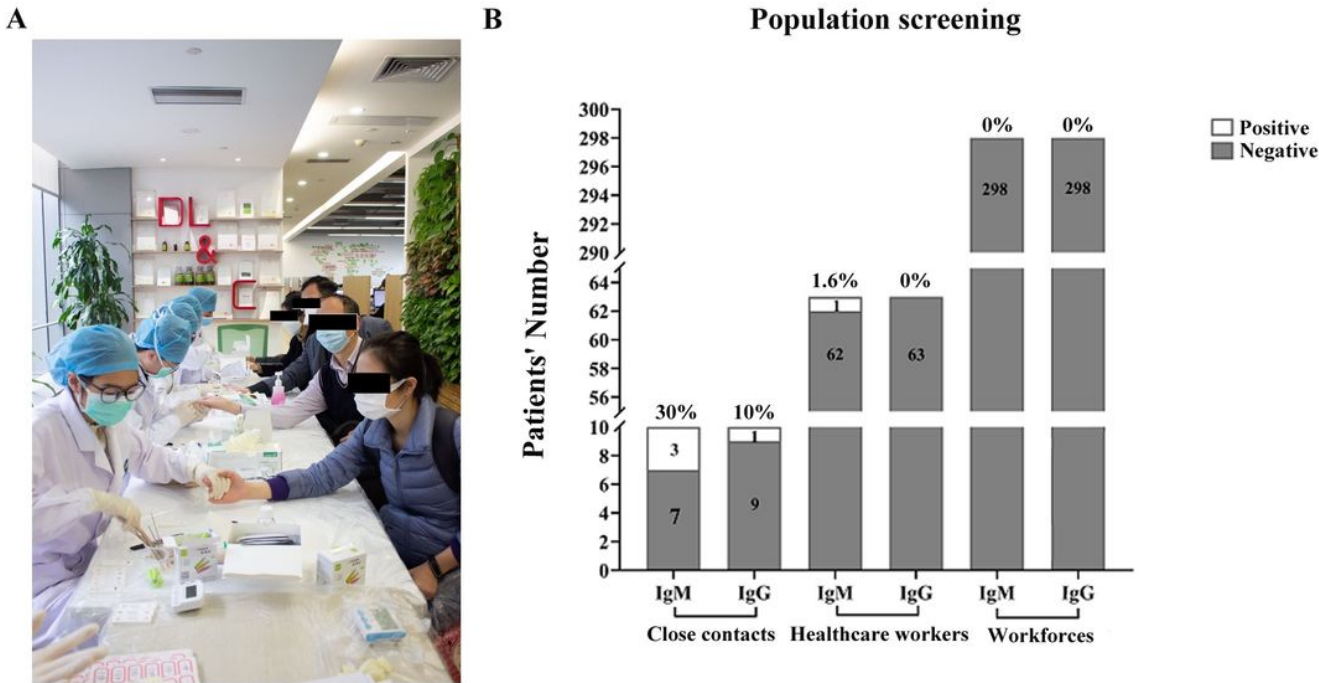
Figure 4

Figure 4

Population screening with rapid IgM-IgG combined antibody test for SARS-CoV‑2 in peripheral blood. A was a picture showed the screening site. B shows the screening results, including Close contacts, healthcare workers and workforces.

Supplementary Files

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- SupplementaryTable.docx