

# Experience in the Department of Diagnostic Laboratory Medicine at a University Hospital in Daegu During the COVID-19 Pandemic

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## Abstract

The first case of coronavirus disease 2019 (COVID-19) in Korea was reported in January 2020. As the secondary transmissions accelerated within the country, the government revised the outbreak alert for COVID-19 from attention to caution. Mid-February, when a massive outbreak was reported from a church in Daegu, our institution initiated testing for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). More than 300 laboratory tests were performed within the first 2 months before the number of cases began to decline. Here, we describe our experience of 4 months at the Department of Laboratory Medicine, Keimyung University Dongsan Hospital, located in Daegu, where a massive COVID-19 outbreak occurred.

## Keywords

COVID-19  
Daegu  
Laboratory medicine  
PCR  
SARS-CoV-2

## 1. February 2020 in Daegu, on the eve of the storm

After the first case of severe acute respiratory syndrome coronavirus type 2 (SARS-CoV-2) was reported in December 2019 in Wuhan City, Hubei Province, China, the first case of coronavirus disease 2019 (COVID-19) was confirmed in Korea on 20 January 2020 in a woman of Chinese origin, raising the alert level of the Korea Centers for Disease Control and Prevention (CDC) from attention to caution<sup>[1,2]</sup>. Until

early February, there was no confirmed case in Daegu, and each medical institution in Daegu responded to COVID-19 according to the policies provided by the CDC and their infectious disease management policies. Due to the rapid response of the Korean Society of Diagnostic Laboratories, training on urgent testing for COVID-19 was initiated under the coordination of the Korea CDC, and our hospital also participated in the second training, recognizing the need for in-house diagnostic testing. After participating in the

training on February 13 and conducting external quality control hosted by the Korean Association for Clinical Laboratory Quality Management on February 17, three medical institutions in Daegu City, including our hospital, were selected as eligible institutions for diagnostic testing of the COVID-19 on February 19 based on the private medical institution genetic test management project for COVID-19 infection. Therefore, we were able to start diagnostic testing for SARS-CoV-2 on 20 February and decided to use Seegene's Allplex 2019-nCoV (Seegene, Seoul, Korea) among the test kits approved for emergency use by the Ministry of Food and Drug Safety at that time. Looking back at the massive spread of COVID-19 in Daegu since 20 February, the timing of the approval of our diagnostic test is dizzyingly timely.

## **2. Details of the hospital's SARS-CoV-2 diagnostic test operation**

### **2.1. Test practitioner operation**

Before the COVID-19 pandemic, a total of four clinical pathologists were in charge of about 2,000 tests per month in the molecular diagnostic laboratory of Dongshan Hospital of Kyungmyeong University. However, after 20 February, to provide rapid SARS-CoV-2 diagnostic tests, most of the molecular diagnostic tests that were previously in charge of molecular diagnostic tests were transferred to external referrals, and SARS-CoV-2 diagnostic tests were conducted by all four clinical pathologists. At the beginning of the test introduction, the maximum number of tests per day was set at 90, and tests on weekends and public holidays were referred to external contractors, but as the number of infected people in Daegu City increased rapidly, the diagnostic test operation method was inevitably adjusted again. From the beginning of March, more than 300 diagnostic tests were performed per day, not only at the screening clinic of Dongshan Hospital but also at the consignment test for patients referred from Daegu Dongdaemun

Hospital, where molecular diagnostic tests were not available. In addition to the four clinical pathologists in the original molecular diagnostic laboratory, four more were added with the support of two clinical pathologists from other departments and two from Daegu Dongdaemun Hospital. A total of eight people formed two teams of four, and the daytime team performed diagnostic tests from 7:30 a.m. to 4:30 p.m. and the nighttime team from 2:30 p.m. to 10:30 p.m. If there was an emergency request for SARS-CoV-2 diagnostic tests at a later time, it was adjusted so that additional tests could be performed separately through emergency contact. From May, the number of SARS-CoV-2 diagnostic tests was kept below 200 on average per day, and the number was reduced to six when two people from other departments returned to work, and three people operated in day and night teams.

### **2.2. Systematization of diagnostic test turnaround time and result reporting time**

After the SARS-CoV-2 diagnostic test was implemented, it was necessary to systematically operate the time to perform the test and the time to report the test results in order to quickly and accurately perform the many tests referred from the screening clinic at Dongshan Hospital of Kyungmyeong University and Daegu Dongdaemun Hospital. In the early days of diagnostic testing, the time for testing was not specified to expedite the reporting of results, and tests were performed for each referral for diagnostic testing so that test results could be reported within three hours from the moment they were received by the Department of Diagnostic Testing. This form of work put a heavy workload on laboratory workers and specialists who read the results, and everyone had a hard time. In response, the testing time and reporting time were adjusted, and a total of six tests, which were conducted up to eight times a day on average, were circulated in the hospital, four during the day and two at night. Since the screening clinics and referral tests

at Daegu Dongdaemun Hospital were concentrated in the morning, the tests were conducted in the morning and afternoon so that the test time did not exceed 4 hours. During the night shift's work until 10:30 p.m., diagnostic tests requested on the same day were completed, and diagnostic tests requested afterward were performed first thing the next day to prevent further delays in reporting results after reading.

### **2.3. Changing the location of the examination room**

Before the implementation of the SARS-CoV-2 diagnostic test, the molecular diagnostic laboratory consisted of a separate sample preparation room, nucleic acid extraction room, PCR amplification room, and electrophoresis room for nucleic acid extraction and amplification. Due to the rapid increase in the number of tests, a new laboratory dedicated to SARS-CoV-2 diagnostic testing was opened on 25 February, shortly after the start of testing. With the full support of the hospital's management to cope with the explosion in the number of tests, the laboratory was equipped with new nucleic acid extraction equipment, examination tables, biological safety boxes, and dedicated refrigerators and freezers, all of which are essential for testing. Currently, the number of diagnostic tests is significantly lower than before due to the decrease in the number of COVID-19 patients, so we are not using all the new labs and equipment, but we are always ready to use them in case of future situations.

### **2.4. Reading a SARS-CoV-2 diagnostic test result**

From 20 February, SARS-CoV-2 diagnostic tests were administered and the results of the tests were discussed by two diagnostic laboratory physicians with a clinical pathologist for interpretation. The diagnosis was made using the E (envelope) gene, RdRp (RNA-dependent RNA polymerase) gene, and N (nucleocapsid) gene

in the case of Seagen Allplex, and was based on the appropriate Ct value ( $< 40$ ) provided by the manufacturer. However, in indeterminate cases where all E, RdRp, and N genes were not amplified, and only one or two genes appeared, the original specimen was reextracted and confirmed once more with other reagents. Based on the recommendation of the Korean Society of Diagnostic Laboratories that the Ct value of the RdRp gene in new patients should be based on 33.5 in the guidelines for diagnostic tests, we created our own criteria for the confirmed diagnosis and new patients (**Table 1**), and based on the recommendation of the Korean Society of Diagnostic Laboratories that the Ct value of RdRp gene in new patients should be based on 33.5, it was continuously revised and supplemented about four times until the final fifth edition so that it could be read through the confirmation of clinical symptoms and comparison with other reagents<sup>[3,4]</sup>. In our institution, we initially used Kogene's PowerChek 2019-nCoV (KogeneBiotech, Seoul, Korea) for comparative confirmation, but due to inconveniences such as the need for two PCR tubes per specimen and the results of the comparative test, we determined that the sensitivity of SD's Standard M nCoV Real-Time Detection (SD Biosensors, Suwon, Korea) kit was higher, so we changed to this reagent when rechecking. In the case of indeterminate results in new patients, the results were read according to **Table 2** and retested after re-extraction of the specimen; however, in the case of persistent indeterminate results, the result was given as indeterminate and the attending physician was advised to retake the respiratory specimen.

From a total of 12,582 diagnostic tests performed on new patients in our hospital from 20 February to 30 June 2020, there were 42 cases where some of the E, RdRp, and N genes were not amplified and read as "Indeterminate". Upon re-extraction, 22 (52.4%) were ultimately reported as "Negative", 14 (33.3%) were reported as "Positive", and 6 (14.3%) were reported as "Indeterminate". Of the six "Indeterminate" cases, only one specimen was retaken and retested, with a

**Table 1.** Criteria for the interpretation of SARS-CoV-2 molecular tests in the confirmed patients

Ct values for				Interpretation (1 <sup>st</sup> Ed)	Interpretation (5 <sup>th</sup> Ed)
E	RdRp	N	IC		
< 40	< 40	< 40	< 40	Positive	Positive
< 40	< 40	< 40	≥ 40	Positive	Positive
≥ 40	≥ 40	≥ 40	< 40	Negative	Negative
≥ 40	< 40	< 40	≥ 40	Repeat (Seegene)	Repeat after re-extraction (Seegene)
< 40	≥ 40	< 40			
< 40	< 40	≥ 40			
≥ 40	≥ 40	< 40			
≥ 40	< 40	≥ 40			
< 40	≥ 40	≥ 40			
≥ 40	≥ 40	≥ 40			
≥ 40	< 40	< 40	< 40		
< 40	≥ 40	< 40		Indeterminate	Indeterminate
< 40	< 40	≥ 40			
≥ 40	≥ 40	< 40			
≥ 40	< 40	≥ 40			
≥ 40	≥ 40	≥ 40			
< 40	≥ 40	≥ 40			

Abbreviations: Ct, the cycle of threshold; E, envelope gene; RdRp, RNA-dependent RNA polymerase gene; N, nucleocapsid gene; IC, internal control.

**Table 2.** Initial interpretation criteria of SARS-CoV-2 molecular tests in the suspected patients

Seegene	Ct values for				Interpretation (1 <sup>st</sup> Ed)	Interpretation (5 <sup>th</sup> Ed)
	E	RdRp	N	IC		
	< 40	< 33.5	< 40	< 40	Positive	Positive
	< 40	< 33.5	< 40	≥ 40	Positive	Positive
	≥ 40	≥ 40	≥ 40	< 40	Negative	Negative
	≥ 40	< 33.5	< 40	≥ 40	Repeat (Seegene)	Repeat after re-extraction (Seegene)
	< 40	≥ 33.5	< 40			
	< 40	< 33.5	≥ 40			
	≥ 40	≥ 33.5	< 40			
	≥ 40	< 33.5	≥ 40			
	< 40	≥ 33.5	≥ 40			
	≥ 40	≥ 33.5	≥ 40			
	≥ 40	< 33.5	< 40	< 40		
	< 40	≥ 33.5	< 40		Repeat (Seegene + Kogene*)	Repeat after re-extraction (Seegene + SD)
	< 40	< 33.5	≥ 40			
	≥ 40	≥ 33.5	< 40			
	≥ 40	< 33.5	≥ 40			
	< 40	≥ 33.5	≥ 40			
SD	Ct values for			Interpretation		
	E	ORF lab	IC			
	≤ 36	≤ 36	≤ 32		Positive	
	> 36	≤ 36	≤ 32		Same after repeat, Positive	
	≤ 36	> 36	≤ 32		Same after repeat, Negative	
	> 36	> 36	≤ 32		Negative	
> 36	> 36	> 32	Invalid, repeat			

\*When the test is repeated with Kogene, the positive criteria for the RdRp gene is ≤35. Abbreviations: Ct, the cycle of threshold; E, envelope gene; RdRp, RNA-dependent RNA polymerase gene; N, nucleocapsid gene; IC, internal control; ORF, open-reading frame gene.

final result of “Negative”. A total of 42 cases with “Indeterminate” results using the Seagen Allplex in new patients were analyzed and re-extracted and read, with 31 cases (73.8%) having a Ct value of less than 40 (mean 37.3) for the N gene alone, with 17 cases reported as final “Negative” and 8 cases reported as “Positive”. There were 5 cases (11.9%) where both RdRp and N genes had Ct values below 40, with 1 case reported as “Negative” and 4 cases reported as “Positive”. In 4 cases (9.5%), the E and N genes had a Ct value of less than 40, with 3 cases being “Negative” and 1 case being “Positive”. In one case, the E and RdRp genes had a Ct value of less than 40 and was reported as “Positive”, and in one case, the RdRp gene alone was present and was reported as a final “Negative” (Figure 1).

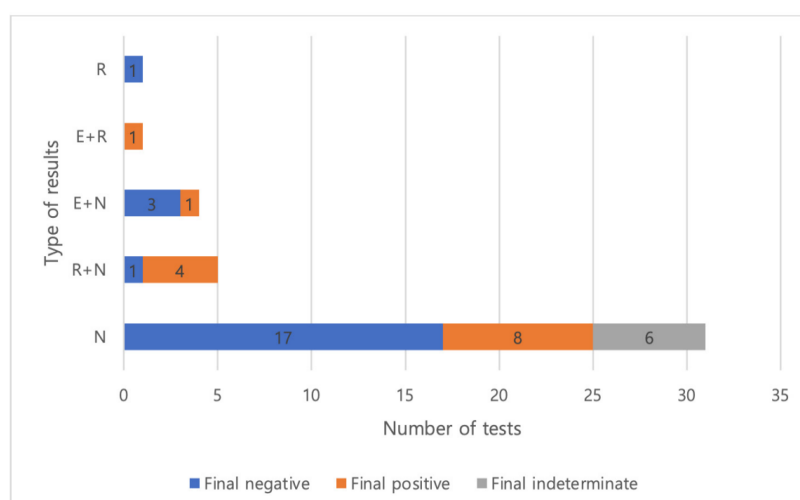
### 2.5. Laboratory operations on weekends and public holidays

From the beginning of March to the end of April, the number of diagnostic tests on weekends and public holidays averaged more than 100 due to the operation of our screening clinics and inpatients at Daegu Dongdaemun Hospital. Four clinical pathologists worked in groups of four until 10:30 p.m. on weekends and public holidays to report the results of screening clinics operating on Saturdays and emergency

department patients needing confirmation of test results on weekends and public holidays. In May, the two shifts were maintained due to continuous requests for diagnostic tests, but the number of tests was adjusted from four to three, and in June, the number of tests was reduced to less than 50 due to the transfer of sample collection from the screening clinic to the emergency department and the decrease in inpatients at Daegu Dongdaemun Hospital, so the number of workers was reduced to one.

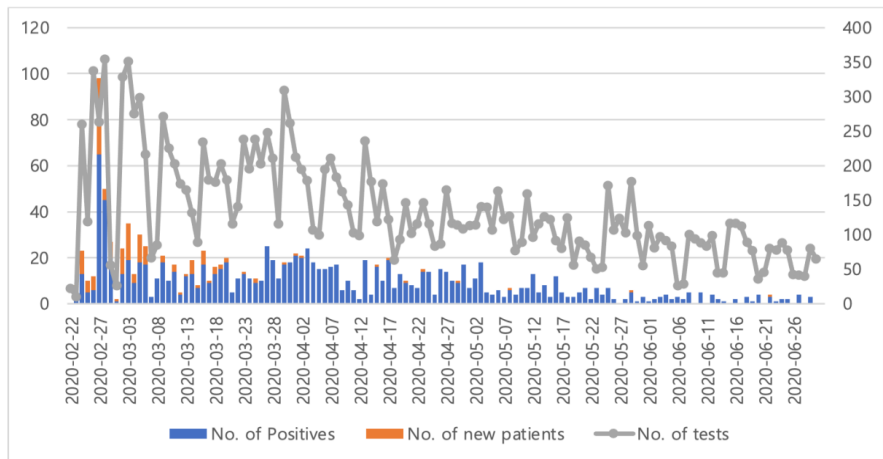
### 3. Our COVID-19 testing information and forecast

On 24 February 2020, Kyungmyeong University Dongsan Hospital set up a screening clinic next to the emergency department, and on 5 March 2020, due to a surge in patients, it operated a container screening clinic to provide medical treatment and diagnostic tests for patients. From 20 February 2020 to 30 June 2020, a total of 17,368 diagnostic tests for COVID-19 were performed, including those referred from Daegu Dongshan Hospital, and 1,161 cases were reported as “Positive”. “Positive” cases in Daegu continued to occur until late February and mid-March, but have been rare since June (Figure 2). A total of 12,582 tests were performed on new patients, excluding tests performed during the hospitalization of confirmed cases, and 218

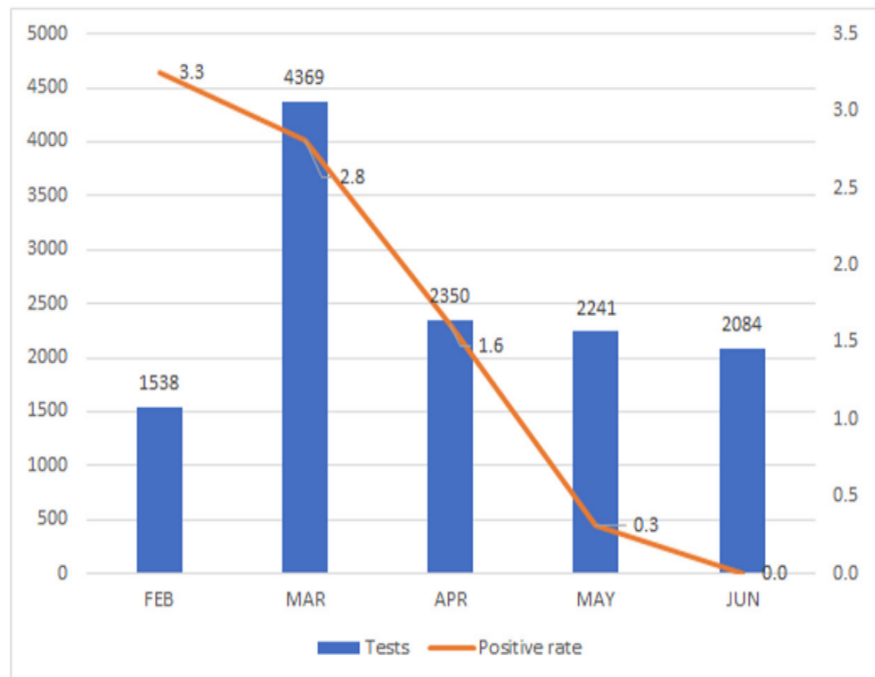


**Figure 1.** Distribution of “Indeterminate” results according to three specific genes, separately or in combination. Abbreviations: R, RNA-dependent RNA polymerase gene; E, envelope gene; N, nucleocapsid gene.

**Figure 2.** Status of SARS-CoV-2 molecular tests with newly confirmed cases. The newly confirmed cases are displayed in orange within positive cases (blue bar).



**Figure 3.** Cumulative monthly number of SARS-CoV-2 molecular tests and positive rate.



were “Positive”, for a positivity rate of approximately 1.7%. The number of tests performed per month was highest in March, with more than 4,000, and has been gradually decreasing since then. Due to the explosion of infections among members of the Shincheonji Church, the positive rate of diagnostic tests in February was the highest at 3.3% and has been steadily decreasing since March (**Figure 3**). Although we had no experience with drive-through screening clinics operated by some hospitals in Daegu, we were able to treat many patients efficiently with our screening clinic. Currently, our screening clinic has been moved next to the entrance of

the emergency department since 1 June and is operating at a reduced scale.

Based on the above trends, it seems that the end of COVID-19 in Daegu will be possible within 2020, but the recent increase in COVID-19 in other regions such as Seoul and Gyeonggi, sporadic cases of mass infection in various places, and the outbreak of new patients due to overseas infections are still ongoing, so it is necessary to carefully monitor the future outlook. Continuous wearing of masks, social and physical distancing, and thorough infection control and diagnostic testing are essential for the management of

COVID-19.

#### 4. Summary

On 20 January 2020, the Korean CDC raised its alert level from watch to caution after the first case of COVID-19 was detected in South Korea. About a month later, the pandemic began rapidly in Daegu when the first case was confirmed in the Shincheonji Church, and on 20 February, the Dongshan Hospital

of Kyungmyeong University conducted a molecular diagnostic test for SARS-CoV-2. The daily average of more than 300 diagnostic tests began to gradually decrease after about two months, and the number of new patients decreased sharply. We would like to share the experience of the Department of Diagnostic Laboratory Medicine at Kyeomyung University Dongshan Hospital over the past four months.

#### Disclosure statement

The authors declare no conflicts of interest.

#### References

- [1] Kim JY, Choe PG, Oh Y, et al., 2020, The First Case of 2019 Novel Coronavirus Pneumonia Imported Into Korea from Wuhan, China: Implication for Infection Prevention and Control Measures. *J Korean Med Sci*, 35: e61.
- [2] Ge H, Wang X, Yuan X, et al., 2020, The Epidemiology and Clinical Information about COVID-19. *Eur J Clin Microbiol Infect Dis*, 39: 1011–1019.
- [3] Hong KH, Lee SW, Kim TS, et al., 2020, Guidelines for Laboratory Diagnosis of Coronavirus Disease 2019 (COVID-19) in Korea. *Ann Lab Med*, 40: 351–360.
- [4] Sung H, Roh KH, Hong KH, et al., 2020, COVID-19 Molecular Testing in Korea: Practical Essentials and Answers from Experts Based on Experiences of Emergency Use Authorization Assays. *Ann Lab Med*, 40: 439–447.

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