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Does the COVID-19 Screening Test Affect the Postoperative Prognosis of Patients Who Undergo Emergency Surgery for Cerebral Hemorrhage?

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ABSTRACT

Objective: The coronavirus disease 2019 (COVID-19) pandemic has affected all medical fields, including neurosurgery. Particularly, performing preoperative screening tests has become mandatory, potentially extending the time from admission to the emergency room and operating room, thus possibly affecting patients' prognosis. This study aimed to determine the influence of COVID-19 screening time on patients' postoperative prognosis.
Methods: From September 10, 2020, to May 31, 2021, we retrospectively evaluated 54 patients with cerebral hemorrhage who underwent emergency surgery in the emergency room after the screening test. The control group included 89 patients with cerebral hemorrhage who underwent emergency surgery between January 2019 and March 2020, i.e., the period before the COVID-19 pandemic. Prognosis was measured using the Glasgow Coma Scale scores, which were obtained preoperatively, postoperatively, and at discharge, and the modified Rankin Scale (mRS). Additionally, unfavorable outcomes (mRS score 3–6) and in-hospital mortality rates were investigated for postoperative prognostic assessments.
Results: No remarkable differences were observed in the time to surgical intervention and prognostic evaluation scores between patients with cerebral hemorrhage who underwent COVID-19 screening tests and subjects in the control group.
Conclusion: This study confirmed that patient treatment and prognosis were not significantly affected by additional preoperative screening testing times during the pandemic. We believe that our results are informative for the evaluation and performance of emergency neurosurgery during the pandemic.

Keywords: COVID-19; Cerebral hemorrhage; COVID-19 testing; Emergency service, hospital

INTRODUCTION

In December 2019, a severe acute respiratory disease caused by a novel virus, initially called 2019-novel coronavirus (2019-nCoV), was reported in Wuhan City, Hubei Province, China. The disease was officially named coronavirus disease 2019 (COVID-19).[8,9,16] On March 11, 2020, COVID-19 was declared a pandemic by the World Health Organization.[2] COVID-19 has ushered in a new paradigm and affected all areas of society, culture, and politics. In

particular, the medical profession and surgical practice have been threatened and disrupted because of the COVID-19 pandemic, including neurosurgery.[20,28] Most patients with cerebral hemorrhage (spontaneous intracranial hemorrhage [sICH], acute subdural hemorrhage [ASDH], epidural hemorrhage [EDH], and aneurysmal subarachnoid hemorrhage [aSAH]) often have a severe and urgent presentation to the emergency room (ER). As several patients with cerebral hemorrhage requiring emergency surgery are admitted to our hospital, which is a regional emergency medical center, screening for COVID-19 became mandatory for preventing the spread of COVID-19 infection and ensuring the safety of medical staff. From September 10, 2020, the COVID-19 rapid real-time reverse transcriptase-polymerase chain reaction (RT-PCR) screening test kit (**FIGURE 1**) has been used for patients who needed emergency surgery in our hospital.[12] Various factors affect the prognosis of a patient with cerebral hemorrhage, including the time to emergency surgery.[29] The rapid screening test kit used in our hospital requires approximately 50–60 minutes from the sample collection to the confirmation of the test result. Hence, we suspected that the RT-PCR screening prolongs the time between admission to the ER and skin incision, thus influencing the prognosis of patients with cerebral hemorrhage. Therefore, we conducted a retrospective study to determine the influence of the delay due to the screening tests on the postoperative prognosis of patients with cerebral hemorrhage.

MATERIALS AND METHODS

Patient selection
Patients who received the screening test for COVID-19 were classified as the screening group, and those who were not screened were included in the control group. The control group consisted of patients with cerebral hemorrhage who underwent emergency surgery from January 2019 to March 2020, the period before the pandemic. Patients with cerebral hemorrhage who underwent surgery following a COVID-19 rapid screening test in the ER from September 10, 2020, to May 31, 2021, were retrospectively compared with those of the control group.
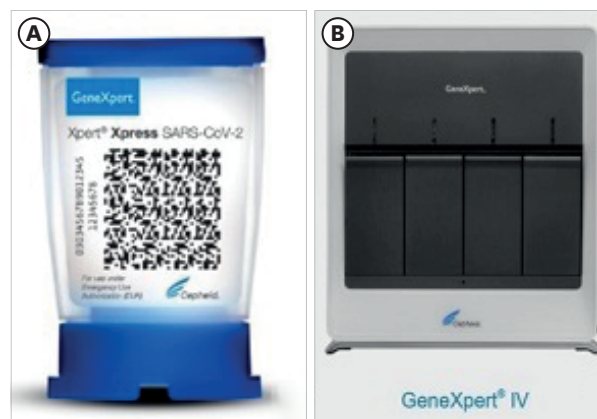
FIGURE 1. The GeneXpert® system (A: Test cartridge, B: Platform): a rapid, real-time RT-PCR test intended for the qualitative detection of the nucleic acid from the SARS-CoV-2 in upper respiratory specimens (i.e., nasopharyngeal, oropharyngeal, nasal) collected from individuals suspected to have COVID-19 by their healthcare providers.
RT-PCR: real-time reverse transcriptase-polymerase chain reaction, SARS-CoV-2: severe acute respiratory syndrome coronavirus 2, COVID-19: coronavirus disease 2019.

This study included patients with cerebral hemorrhage (sICH, ASDH, EDH, and aSAH) who required emergency surgery immediately based on the results of a brain computed tomography (CT) scan and physical examination after arrival in the ER. Patients with the following characteristics were excluded from the study: patients with ICH aspiration only, since aspiration does not progress within 24 hours of the onset[3]; patients who required multiple additional CT scans before surgery; and patients who did not require emergency surgery, such as those with traumatic subarachnoid hemorrhage, chronic subdural hemorrhage, or cerebral contusion.

The study protocol was approved by the Institutional Review Board (IRB) of Pusan National University Yangsan Hospital (IRB approval No. 05-2021-074), which waived the requirement for informed consent owing to the retrospective nature of this study.

Operation indication

Surgery was indicated for patients with sICH with large lobe hemorrhage measuring >30 mL or with signs of increased intracranial pressure.[22,24] Patients with sICH underwent either decompression craniectomy alone or craniotomy or craniectomy with sICH removal. Hematomas were evacuated by craniectomy or craniotomy in patients with ASHD and EDH. Patients with ASDH with a hematoma thickness >10 mm or midline shift >5 mm underwent surgery regardless of the Glasgow Coma Scale (GCS) status.[7] Similarly, EDH measuring >30 mL was surgically evacuated, regardless of the GCS score.[26] Clipping or endovascular coil embolization was performed on patients with aSAH according to treatment guidelines.[5,13,27] If there was no other cause related to the loss of consciousness, surgery was performed in patients whose level of consciousness was below stupor (GCS <13), regardless of the type of bleeding.[4,11,21]

Methods of clinical assessment

Patients were grouped into the sICH, trauma (ASDH+EDH), and aSAH groups. Their data were compared with those of patients in the control group to determine the influence of the time required for the screening test on the interval between the skin incision and the arrival in the ER. To evaluate the patients' neurological prognosis, the GCS was compared in each group upon arrival in the ER (initial; iGCS), immediately after surgery (postoperative; pGCS), and at discharge (dGCS); iGCS was further compared within the groups according to the severity.[17] Additionally, the modified Rankin Scale (mRS) scores,[15,23] unfavorable outcomes (mRS score 3–6 points),[6] and the in-hospital mortality rate were recorded in each group.

Statistical analysis

Continuous and categorical variables were expressed as means with standard deviations and frequencies with percentages, respectively. Group differences in clinical outcomes were evaluated using Student's *t*-tests and the Mann-Whitney *U* tests for continuous variables and the χ^2 and Fisher's exact tests for categorical variables. The Shapiro-Wilk test was used to confirm normal distribution ($p>0.05$). Adjusted odds ratios and 95% confidence intervals were reported for the factors included in the logistic regression model. All analyses were performed using IBM SPSS Statistics version 26.0 (IBM Co., Armonk, NY, USA). Statistical significance was set at $p<0.05$.

RESULTS

A total of 143 patients were enrolled in this study. There were 54 patients (33 females and 21 male individuals, mean age 59.96±14.70 years) in the screening group and 89 patients (49 females and 40 male individuals, mean age 55.34±14.91 years) in the control group. No statistical differences were observed in age, sex, underlying disease, alcohol consumption, smoking, and anticoagulant/antiplatelet drug use. A comparison of demographic characteristics between the screening and control groups is presented in TABLE 1.

TABLE 2 summarizes the characteristics of cerebral hemorrhage requiring surgery in the screening and control groups. The hemorrhage types were as follows: sICH (n=18, 12.6%), EDH (n=16, 11.2%), ASDH (n=22, 15.4%), and aSAH (n=87, 60.8%). The differences in characteristics of each cerebral hemorrhage were not statistically significant between the 2 groups.

When the patients were grouped according to the hemorrhage type, no significant difference was observed in the time between the skin incision and the ER arrival compared with

TABLE 1. Demographic characteristics of patients with cerebral hemorrhage requiring emergency surgery

Characteristics	Control group	Screening group	p-value
Number of patients	89	54	
Age (years)	55.34±14.91	59.96±14.70	0.083
Sex (male:female)	40:49 (44.9:55.1)	21:33 (38.9:61.1)	0.492
Underlying disease			
Hypertension	33 (37.1)	21 (20.4)	0.829
Diabetes mellitus	12 (13.7)	10 (8.3)	0.477
Dyslipidemia	5 (5.6)	4 (3.4)	0.730
Chronic kidney disease	5 (4.4)	2 (3.4)	0.760
Cardiovascular disease	2 (2.2)	1 (1.9)	0.999
History of stroke	3 (3.4)	2 (3.7)	0.917
Anticoagulant	0	1 (1.9)	0.378
Antiplatelet	8 (9.0)	9 (16.7)	0.171
Smoking	13 (14.6)	11 (20.4)	0.489
Alcohol	18 (20.2)	13 (24.1)	0.676

Values are presented as mean ± standard deviation or number (%).
Control group, patients who were not screened for COVID-19 (patients who underwent emergency surgeries before the COVID-19 pandemic); Screening group, patients who underwent screening for COVID-19.
COVID-19: coronavirus disease 2019.

TABLE 2. Characteristics of cerebral hemorrhage types among patients presenting to the emergency room in our hospital

Characteristics	Control group	Screening group	p-value
Type of cerebral hemorrhage			
sICH	12	6	
Volume (mL)	59.04±34.98	52.45±41.03	0.726
Midline shift (cm)	0.75±0.56	0.80±0.72	0.884
EDH	10	6	
Depth (cm)	2.27±0.88	1.91±0.93	0.371
Midline shift (cm)	0.44±0.42	0.68±0.25	0.262
ASDH	15	7	
Depth	1.58±0.76	1.74±0.58	0.638
Midline shift (cm)	1.20±0.37	1.20±0.79	0.984
aSAH	52	35	
Modified fisher grade	2.65±1.18	3.05±0.72	0.076

Values are presented as mean ± standard deviation or number (%).
Control group, patients who were not screened for COVID-19 (patients who underwent emergency surgeries before the COVID-19 pandemic); Screening group, patients who underwent screening for COVID-19.
sICH: spontaneous intracranial hemorrhage, EDH: epidural hemorrhage, ASDH: acute subdural hemorrhage, aSAH: aneurysmal subarachnoid hemorrhage, COVID-19: coronavirus disease 2019.

the corresponding in the control group (sICH: 165.16±54.93 vs. 164.66±93.00, *p*<0.991, Trauma: 157.92±49.23 vs. 134.60±64.94, *p*<0.264, aSAH: 157.65±48.29 vs. 155.76±78.82, *p*<0.890). Moreover, the iGCS, pGCS, dGCS, mRS, unfavorable outcomes, and mortality rates investigated for prognostic evaluation did not show significant differences between the screening and control groups (**TABLES 3**, **4**, **5**).

Additionally, we graphed the change in the time from the ER arrival to the skin incision after the COVID-19 rapid screening test was started to be applied. As suggested by the overall trend, no evident increasing or decreasing trend was observed in the screened patient group after the introduction of the rapid screening test (**FIGURE 2**).

DISCUSSION

Our hospital has been conducting COVID-19 screening tests for patients in the ER since March 2020; however, a standardized protocol using a rapid screening test kit has only been applied from September 10, 2020. Patients with cerebral hemorrhage who develop poor

TABLE 3. Characteristics of patients with spontaneous intracranial hemorrhage

Characteristics	Control group	Screening group	*p*-value
Number of patients	12	6	
ER arrival to skin incision time (minutes)	164.66±93.00	165.16±54.93	0.991
iGCS severity			
Mild (13–15)	0	2	0.098
Moderate (9–12)	3	1	0.999
Severe (3–8)	9	3	0.343
iGCS	6.75±2.41	8.50±3.88	0.254
pGCS	6.00±2.29	5.16±1.16	0.420
dGCS	7.08±4.18	7.50±4.50	0.848
mRS	5.16±0.83	4.33±1.96	0.359
Unfavorable outcomes	12 (100)	5 (83.3)	0.333
In-hospital mortality	5 (41.7)	2 (33.3)	0.740

Values are presented as mean ± standard deviation or number (%).
Control group, patients who were not screened for COVID-19 (patients who underwent emergency surgeries before the COVID-19 pandemic); Screening group, patients who underwent screening for COVID-19.
ER: emergency room, iGCS: initial Glasgow Coma Scale, pGCS: postoperative Glasgow Coma Scale, dGCS: discharge Glasgow Coma Scale, mRS: modified Rankin Scale, COVID-19: coronavirus disease 2019.

TABLE 4. Characteristics of patients with acute subdural hemorrhage or epidural hemorrhage (trauma group)

Characteristics	Control group	Screening group	*p*-value
Number of patients	25	13	
ER arrival to skin incision time (minutes)	134.60±64.94	157.92±49.23	0.264
iGCS severity			
Mild (13–15)	9	3	0.486
Moderate (9–12)	2	3	0.315
Severe (3–8)	14	7	0.899
iGCS	8.84±4.50	8.46±4.13	0.862
pGCS	8.80±4.71	9.07±5.07	0.868
dGCS	9.84±5.28	9.38±5.62	0.807
mRS	3.32±2.11	3.23±2.58	0.910
Unfavorable outcomes	14 (56.0)	7 (53.8)	0.899
In-hospital mortality	5 (20)	4 (30.8)	0.459

Values are presented as mean ± standard deviation or number (%).
Control group, patients who were not screened for COVID-19 (patients who underwent emergency surgeries before the COVID-19 pandemic); Screening group, patients who underwent screening for COVID-19.
ER: emergency room, iGCS: initial Glasgow Coma Scale, pGCS: postoperative Glasgow Coma Scale, dGCS: discharge Glasgow Coma Scale, mRS: modified Rankin Scale, COVID-19: coronavirus disease 2019.

TABLE 5. Characteristics of patients with aneurysmal subarachnoid hemorrhage group

Characteristics	Control group	Screening group	p-value
Number of patients	52	35	
ER arrival to skin incision time (minutes)	155.76±78.82	157.65±48.29	0.890
iGCS severity			
Mild (13–15)	32	18	0.383
Moderate (9–12)	5	6	0.338
Severe (3–8)	15	11	0.815
iGCS	11.46±4.29	11.02±4.09	0.640
pGCS	11.92±4.32	10.14±4.42	0.660
dGCS	12.38±4.04	11.31±4.28	0.241
mRS	2.19±1.94	2.80±2.13	0.173
Unfavorable outcomes	18 (34.6)	18 (14.5)	0.128
In-hospital mortality	4 (7.7)	3 (8.6)	0.882

Values are presented as mean ± standard deviation or number (%).
Control group, patients who were not screened for COVID-19 (patients who underwent emergency surgeries before the COVID-19 pandemic); Screening group, patients who underwent screening for COVID-19.
ER: emergency room, iGCS: initial Glasgow Coma Scale, pGCS: postoperative Glasgow Coma Scale, dGCS: discharge Glasgow Coma Scale, mRS: modified Rankin Scale, COVID-19: coronavirus disease 2019.
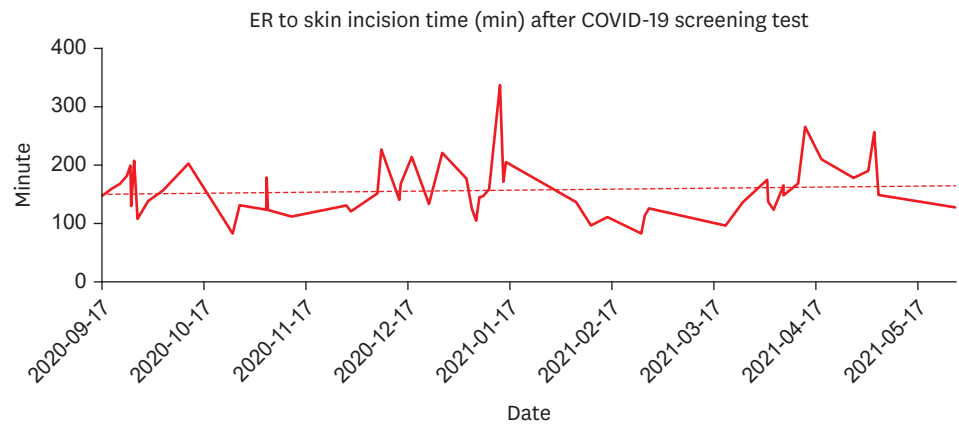

FIGURE 2. Trend graph of the time required from the ER arrival to the skin incision for the group of patients who received the screening test during the investigation period.
ER: emergency room, COVID-19: coronavirus disease 2019.

consciousness require emergency surgery.[10,27,31] The patients' postoperative prognosis may be affected by the length of time consumed before the surgery.[29,32] COVID-19 pandemic necessitated the performance of screening tests in all patients, including those with cerebral hemorrhage that requires emergency surgery. Although most neurosurgical emergencies expedite patient evaluations and surgical decisions in the ER to save time between admission and surgery, mandatory screening tests were expected to prolong the time from the ER arrival to the skin incision and thereby affect the patients' prognosis.

In this study, we aimed to evaluate whether the additional screening time had an effect on patient prognosis. Therefore, patients who underwent only ICH aspiration without immediate surgical management and those who underwent additional CT examinations before surgery were excluded from the study to ensure that the screening test was the only variable that potentially affected the time from the ER arrival to skin incision. We expected an increase in the time from the ER arrival to the skin incision due to the screening test, potentially affecting the patients' prognosis negatively. However, patients who underwent the screening test had no significant difference compared with the control group regarding the delay in the time to skin incision and prognosis. The lack of significant difference between

the groups, particularly regarding the delay in surgery, may be attributed to the simultaneous, rather than sequential, performance of screening tests and surgery preparation following rapid patient evaluation and decision-making for patients who required emergency surgery. Especially, it was judged that the most of time required for the screening test was included in the surgery preparation time because the preparation was carried out while the screening test was performed.

Moreover, the COVID-19 pandemic has affected neurosurgical treatments through the cancellation of elective procedures and decrease in outpatient activity. Similarly, this study found a decrease in the number of cerebral hemorrhage patients visiting the emergency room compared to the control group. This trend may be attributed to several factors, including the avoidance of outside activities, which reduced the risk of traumatic events, and the social distancing protocols enacted during the pandemic, which decreased the number of patients transferred to hospitals.[18] Ultimately, the decrease in the number of patients with trauma led to a decrease in the number of patients requiring emergency surgery.

In addition, the decrease in the number of outpatients and patients transferring from other hospitals led to a decrease in elective surgeries, and these factors made the hospital's operating room manpower and surgical instruments more slack. In our work, there was no difference between the entire operating room manpower and the surgical instruments. In addition there was no change in the number of operators between the two groups. Therefore, we did not consider the difference according to the timing of the surgical treatment by operator and the surgical room availability. Before the COVID-19 pandemic, surgeries had been sometimes delayed owing to a large number of patients in need of emergency surgery or a limited number of operating room staff and surgical instruments. However, after the COVID-19 pandemic, as the shortage of staff in the operating room and the supply of instruments were resolved, the delay in emergency surgeries was also somewhat resolved. We suggest that this is the other reason why the difference in the time from the ER arrival to the skin incision between the two groups could be diminished. Prognosis after surgery did not show a significant difference, which was presumed to be attributed to the lack of significant difference in the time from the ER arrival to the skin incision between the screening and control groups.

In Korea, patients who are COVID-19 positive are treated by regional designated hospitals. As our hospital is not designated, we transfer patients with COVID-19 to other designated hospitals for treatment. However, in cases of patients with COVID-19 who are difficult to be transferred (i.e., cases of patients whose' vital signs are unstable or urgent care is required), we perform surgery in an operating room equipped with a negative pressure facility. Moreover, the route of patients with COVID-19 to the operating room was completely separated from that of other patients. Interestingly, none of the patients was tested positive for COVID-19. If there were patients who received a positive screening test result, the findings might have been completely different from our study results, and the study design would have been different. Nevertheless, in this study, all screening test results were negative; therefore, the variables were controlled accordingly, leading to the herein study design.

This study revealed that there was no delay in operation time because of the COVID-19 screening test and that the screening test did not significantly affect the patients' prognosis. However, the patients' prognosis difference between the two groups was compared through a simple comparison of the skin incision time rather than a multivariate analysis because of the

small total number of participants in each group and the subgroup heterogeneity. Moreover, these results are limited to neurosurgery in our hospital. In the literature, there are also reports of poor prognosis and death of patients because of the delay in patient classification, treatment time, and transfer to other hospitals after the COVID-19 outbreak.[14,25] Therefore, all medical staff should make an effort to maintain the best medical service by supplementing the shortcomings of each medical center and reorganizing the medical system based on the data reported by each medical institution.

Through the Middle Eastern respiratory syndrome, severe acute respiratory syndrome, and COVID-19 pandemics, a lot of experience has been gained.[1,19,30] We believe that the accumulation of these experiences will serve as a defense against the upcoming pandemic. We also hope that our observations will be helpful to other medical staff as well.

CONCLUSION

In this study, we confirmed that patient prognosis during the COVID-19 pandemic did not significantly differ from that before the pandemic because of the additional COVID-19 screening time, which can be considered as an impediment with a minimal effect on emergency surgeries and outcomes. Although not generalizable as a whole, we believe that our results will be informative for physicians and medical staff in the assessment and performance of emergency neurosurgeries during the pandemic period.

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