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ORIGINAL RESEARCH

Changes in clinical features and outcomes in three major critical diseases after COVID-19 pandemic: acute myocardial infarction, stroke, and cardiac arrest

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Abstract

A few months after the onset of the coronavirus Disease 2019 (COVID-19) pandemic, the worse prognoses of acute myocardial infarction, ischemic and hemorrhagic stroke, and cardiac arrest were reported. This study aimed to investigate the changes in the characteristics and prognoses of these diseases in the emergency department (ED) over a year after pandemic's onset. This was a retrospective observational study. The year 2019 was defined as the pre-period, while the year from February 2020 to January 2021 was defined as the post-period. Adult patients diagnosed with acute myocardial infarction, ischemic stroke, hemorrhagic stroke, or cardiac arrest during the study period were included. The primary outcome was in-hospital mortality. Time series analyses using autoregressive integrated moving average (ARIMA)(p,d,q) model were performed to evaluate the changes between periods. A multivariable logistic regression analysis of factors affecting in-hospital mortality was performed. The proportions of patients with acute myocardial infarction (0.8% vs. 1.1%, $p < 0.001$), hemorrhagic stroke (1.0% vs. 1.2%, $p = 0.011$), and cardiac arrest (0.9% vs. 1.1%, $p = 0.012$) increased in the post-period. The post-period was independently associated with in-hospital mortality in acute myocardial infarction (adjusted odds ratio (aOR) 2.54, 95% confidence interval (95% CI) 1.06–6.08, $p = 0.037$) and hemorrhagic stroke (aOR 1.74, 95% CI 1.11–2.73, $p = 0.016$), but not for ischemic stroke or cardiac arrest. Over a year after onset of the COVID-19 pandemic in Korea, the number of patients with acute myocardial infarction, hemorrhagic stroke, and cardiac arrest in the ED increased. An independent association between the post-period and mortality was observed for acute myocardial infarction, and hemorrhagic stroke. This study provides important information for future studies and policies.

Keywords

COVID-19; Emergency department; Acute myocardial infarction; Stroke; Cardiac arrest

1. Introduction

The coronavirus disease 2019 (COVID-19), first diagnosed in December 2019 [1], soon became a global pandemic. COVID-19 affects healthcare behaviors and policies nationwide in terms of social distancing, wearing appropriate personal protective equipment, recruiting isolation units with negative pressure in emergency departments (EDs), and patient screening prior to hospital entry [2]. COVID-19 also affects hospital utilization [3–6]. The number of emergency department visits [3, 4], elective surgeries [5], and outpatient visits [6] decreased substantially in the COVID-19 era. Evaluating the effect of COVID-19 on the healthcare system is essential for establishing future strategies and policies regarding COVID-19 and other emerging infectious diseases.

Acute myocardial infarction, ischemic stroke, hemorrhagic stroke, and cardiac arrest are important time-sensitive diseases treated in the ED. Rapid transport to the hospital and reperfusion therapy are crucial for improving outcomes of acute myocardial infarction [7] and stroke [8]. Delayed basic and advanced life support significantly impact the outcome of cardiac arrest [9]. The worsening outcomes of time-sensitive diseases were reported during the COVID-19 pandemic [10–13].

The effect of the COVID-19 pandemic differs by disease entity, capacity of the healthcare system, number of COVID-19 patients, and cultural characteristics of a country or region [2–6, 10–14]. During the early months of the COVID-19 pandemic, the mortality rate of cardiac arrest increased in the United States [10]. The mortality rate and adverse cardiac outcomes of acute myocardial infarction increased during this period in Korea and Germany [11, 12]. The admission rate of stroke decreased, while its mortality rate increased during the lockdown period in France [13].

Previous studies evaluated short-term changes that occurred after the onset of the COVID-19 pandemic. To our knowledge, a year-long effect of the COVID-19 on EDs has yet to be studied in Korea, especially for time-sensitive diseases. This study aimed to investigate the changes in the characteristics and prognosis of acute myocardial infarction, ischemic stroke, hemorrhagic stroke, and cardiac arrest in the ED over the year before and the year after emergence of the COVID-19 pandemic.

2. Methods

2.1 Study design and setting

This retrospective observational study was conducted in the ED of the Korea University Ansan Hospital, a tertiary academic teaching hospital. Approximately 50,000 patients visit the ED annually. This study was approved by the institutional review board of Korea University (2021AS0167), which waived the requirement for informed consent owing to its retrospective nature.

2.2 Definitions

The first COVID-19 patient in Korea was diagnosed in January 2020 [14]. The post-period was defined as February 2020 to January 2021, while the year 2019 was defined as the pre-period. The year 2018 was not included because the ED at the Korea University Ansan Hospital was undergoing remodeling and reconstruction during that period, due to which its capacity was reduced. A one-year duration was selected to minimize seasonal effects.

The diagnosis of patients was defined according to Korean Standard Classification of Diseases-8 (KCD-8) codes, a modification of the International Statistical Classification of Diseases and Related Health Problems-10 codes. When a patient visited the ED multiple times, each visit was considered if the patient was diagnosed with different diseases. The onset time was defined as the time of symptom presentation as reported by the patient or witnessed by others if the patient was unconscious.

2.3 Study population

Among adult patients who visited the ED, those who were diagnosed or presented with acute myocardial infarction, ischemic stroke, hemorrhagic stroke, or cardiac arrest either out-of-hospital or in-ED during the study period were included. Patients who were younger than 18 years, who visited the ED for other reasons such as medical certification, or for whom outcomes were missing were excluded.

2.4 Data collection

Patient data were extracted automatically from their electronic medical records. Data pertaining to the sex, age, time of arrival at the ED, use of emergency medical services (EMS), initial mental status, initial vital signs, onset time, disposition and results at the ED, and length of stay in the ED were collected. Data regarding ventilator use in the ED, ICU admission, and in-hospital mortality were also collected.

2.5 Statistical analysis

Continuous and normally distributed variables were expressed as means and standard deviations and were compared using the Student's t-test. Non-normally distributed continuous variables were expressed as medians and interquartile ranges and were compared using the Mann-Whitney test. Categorical variables were expressed as numbers and percentages and were compared using the chi-square test or Fisher's exact test.

The time-series analysis was performed using the autoregressive integrated moving average (ARIMA)(p,d,q) model [15–17]. The stationarity, autocorrelation function (ACF), and partial autocorrelation function (PACF) were used to determine the ARIMA(p,d,q) model. The ARIMA(p,d,q) model exhibiting the lowest Akaike information criterion (AIC) was selected for forecasting using the "auto.arima" function in the "forecast" package for R. The Box-Ljung test was used to evaluate any white noise from the ARIMA(p,d,q) model's residuals. The data from the pre-period were used for ARIMA modeling to forecast the time interval from February 2020 to January 2021. The forecasted data were considered as predicted values that would have been expected if COVID-19 pandemic had not occurred. The actual data (post-period) were visually compared with the forecasted data in the plot, with a 95% confidence interval (CI).

Variables with a level of significance of less than 0.1 on univariable logistic regression and those selected by the investigators were included in the multivariable logistic regression and linear regression models. Multivariable logistic regression and linear regression analyses were performed to evaluate the independent association between variables and outcomes.

p values of less than 0.05 were considered significant. The statistical analyses were performed using R version 4.0.2 software (R Foundation for Statistical Computing, Vienna, Austria).

2.6 Outcomes

The study primarily focused on the changes in patient characteristics following a diagnosis of acute myocardial infarction, ischemic stroke, hemorrhagic stroke, or cardiac arrest during the specified periods.

The primary outcome was in-hospital mortality. The secondary outcomes were length of stay in the ED, ventilator use, and ICU admission.

3. Results

During the study period, 101,808 patients visited the ED. A total of 72,312 adult patients (37,576 in the pre-period, 34,736 in the post-period) were screened in this study after patient exclusions (25,672 pediatric patients, 3824 visits for other reasons). During the study period, 675 patients were diagnosed with acute myocardial infarction, 1131 with ischemic stroke, 785 with hemorrhagic stroke, and 726 with cardiac arrest.

As shown in Table 1, the proportion of patients with acute myocardial infarction (0.8% vs. 1.1%, $p < 0.001$), hemor-

TABLE 1. Numbers and proportions of acute myocardial infarction, ischemic stroke, hemorrhagic stroke, and cardiac arrest patients during the study periods.

	Pre-period	Post-period	p-value
	(n = 37,576)	(n = 34,736)	
Acute myocardial infarction	299 (0.8%)	376 (1.1%)	<0.001**
Ischemic stroke	565 (1.5%)	566 (1.6%)	0.183
Hemorrhagic stroke	372 (1.0%)	413 (1.2%)	0.011*
Cardiac arrest	343 (0.9%)	383 (1.1%)	0.012*

$*p < 0.05$, $**p < 0.001$.
Data are expressed as number (%).

TABLE 2. In-hospital mortality of acute myocardial infarction, ischemic stroke, hemorrhagic stroke, and cardiac arrest patients during the study period.

	Pre-period	Post-period	p-value
Acute myocardial infarction	24 (8.0%)	36 (9.6%)	0.572
Ischemic stroke	28 (5.0%)	26 (4.6%)	0.884
Hemorrhagic stroke	69 (18.5%)	101 (24.5%)	0.055
Cardiac arrest	279 (81.3%)	323 (84.3%)	0.332

Data are expressed as number (%).

TABLE 3. Length of stay (h) in the emergency department of acute myocardial infarction, ischemic stroke, hemorrhagic stroke, and cardiac arrest patients during the study period.

	Pre-period	Post-period	p-value
Acute myocardial infarction	5.1 [2.5–9.5]	6.0 [2.8–11.4]	0.021*
Ischemic stroke	3.9 [2.9–5.6]	4.8 [3.5–7.8]	<0.001**
Hemorrhagic stroke	3.3 [2.1–5.2]	4.8 [3.0–8.8]	<0.001**
Cardiac arrest	2.1 [0.9–5.4]	2.0 [1.1–6.2]	0.038*

$*p < 0.05$, $**p < 0.001$.
Data are expressed as median [interquartile range].

rhagic stroke (1.0% vs. 1.2%, p = 0.011), and cardiac arrest (0.9% vs. 1.1%, p = 0.012) increased in the post-period. Although not statistically significant, the number of patients with ischemic stroke was greater in the post-period.

The ARIMA(0,1,1) model was used to forecast the proportion of patients with acute myocardial infarction (Fig. 1A). During the post-period, the proportion of patients with acute myocardial infarction was greater than the upper 95% CI of the forecasted value in the late phase of post-period. The ARIMA(1,0,0) model was used to forecast the proportion of patients with ischemic stroke (Fig. 1B). During the post-period, the proportion of patients with ischemic stroke was only slightly greater than the upper 95% CI of the forecasted value in the early phase of the post-period. The ARIMA(0,0,1) model was used to forecast the proportion of patients with hemorrhagic stroke (Fig. 1C). The proportion of patients with hemorrhagic stroke was greater than the upper 95% CI of the forecasted value in the early phase of the post-period. The ARIMA(0,0,1) model was used to forecast the proportion of patients with cardiac arrest (Fig. 1D). The proportion of patients with cardiac arrest was greater than the upper 95% CI of the forecasted value in the early and late phases of the post-period. The Box-Ljung test showed that the residuals of the ARIMA models could be considered white noise (all $p >$ 0.05).

3.1 Acute myocardial infarction

In the univariate analysis, patients with acute myocardial infarction were older, stayed longer in the ED (5.1 [2.5–9.5] hours vs. 6.0 [2.8–11.4] hours), and fewer were admitted to the ICU (54.5% vs. 35.1%) in the post- versus pre-period (all $p < 0.05$). In-hospital mortality (8.0% vs. 9.6%, p = 0.572) and ventilator use in the ED did not differ significantly between the periods (Tables 2,3 **Supplementary Table 1**).

Compared to the forecasted value in the ARIMA(0,1,1) model, the onset to hospital arrival time was within the 95% CI except in the early phase of the post-period (Fig. 2A). The length of stay in the ED was greater than 95% CI of the forecasted value for several months in the post-period in the ARIMA(1,0,0) model (Fig. 2B). Compared to the forecasted value in the ARIMA(3,0,0) model, patients were less often admitted to the ICU during the late phase of the post-period (Fig. 2C). The mortality rate was within the 95% CI of the forecasted value in the ARIMA(1,0,0) model (Fig. 2D). The Box-Ljung test showed that the residuals of the ARIMA mod-

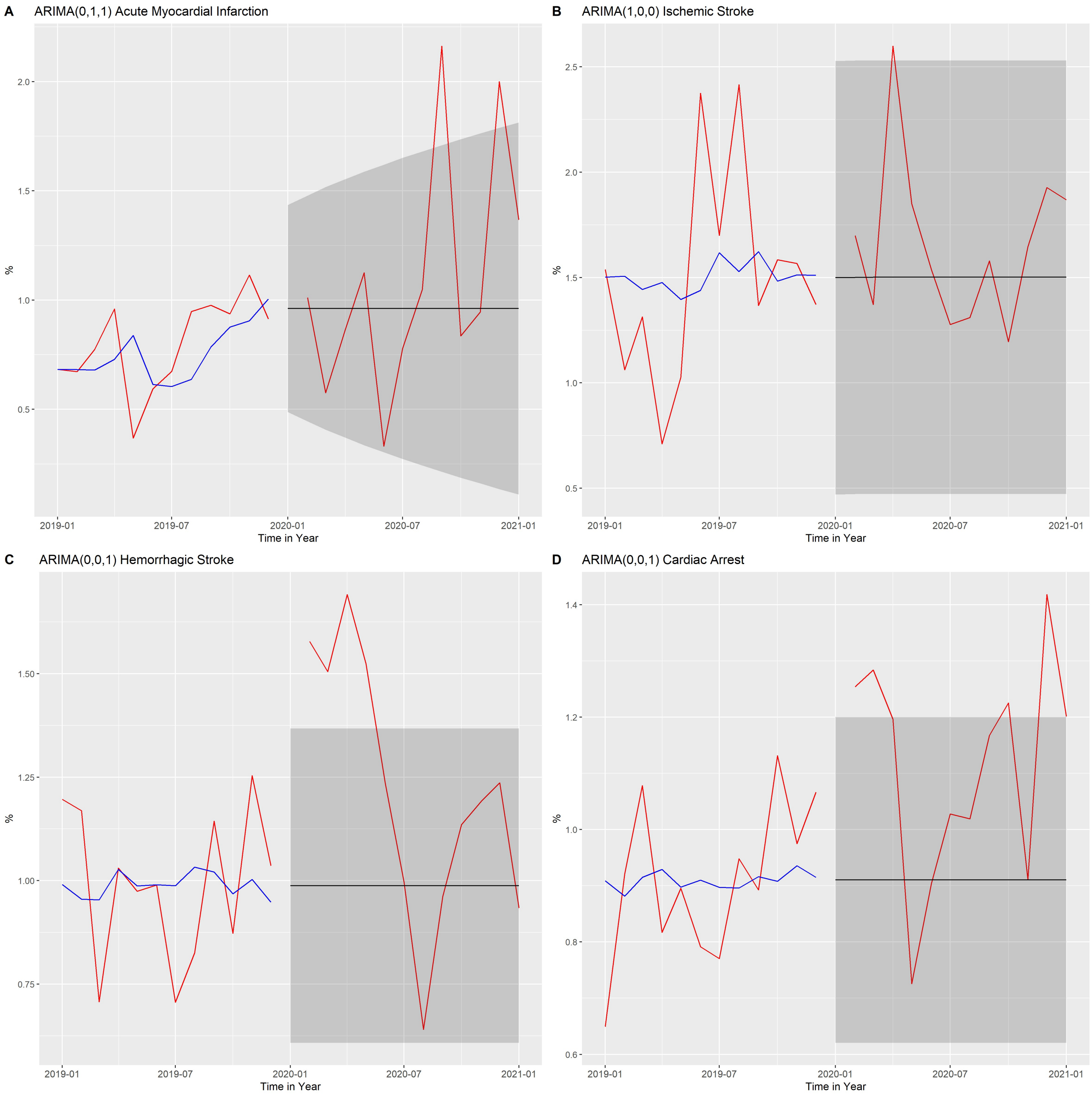

FIGURE 1. Time-series analysis of proportion of each disease using the ARIMA model. (A) Time-series analysis of proportion of acute myocardial infarction. (B) Time-series analysis of proportion of ischemic stroke. (C) Time-series analysis of proportion of hemorrhagic stroke. (D) Time-series analysis of proportion of cardiac arrest. Red line, observed data; blue line, ARIMA model; black line, forecasted value; and shadowed area, 95% confidence interval of the forecasted value. ARIMA, autoregressive integrated moving average.

els could be considered white noise (all $p > 0.05$).

In the multivariable logistic regression model, age, heart rate, ICU admission, ventilator use, and the post period (aOR 2.54; 95% CI 1.06–6.08; $p = 0.037$) were independently associated with in-hospital mortality (Table 4). In contrast, the post period was not independently associated with length of stay in ED in the multivariable linear regression model (beta-coefficient, 0.997; 95% CI, –0.464–2.457; $p = 0.181$).

3.2 Ischemic stroke

In the univariate analysis, the patients were older and stayed longer in the ED (3.9 [2.9–5.6] hours vs. 4.8 [3.5–7.8] hours) in the post period (all $p < 0.05$). The onset to hospital arrival time was longer in the post period (246 [64.0–1054.0] min vs. 361.5 [67.0–1479.0] min; $p = 0.008$), while the proportion of onset to hospital arrival time within 4.5 hours, the time interval indicated for intravenous thrombolysis [8], was lower in the post period (54.0% vs. 45.2%; $p = 0.004$). The differences

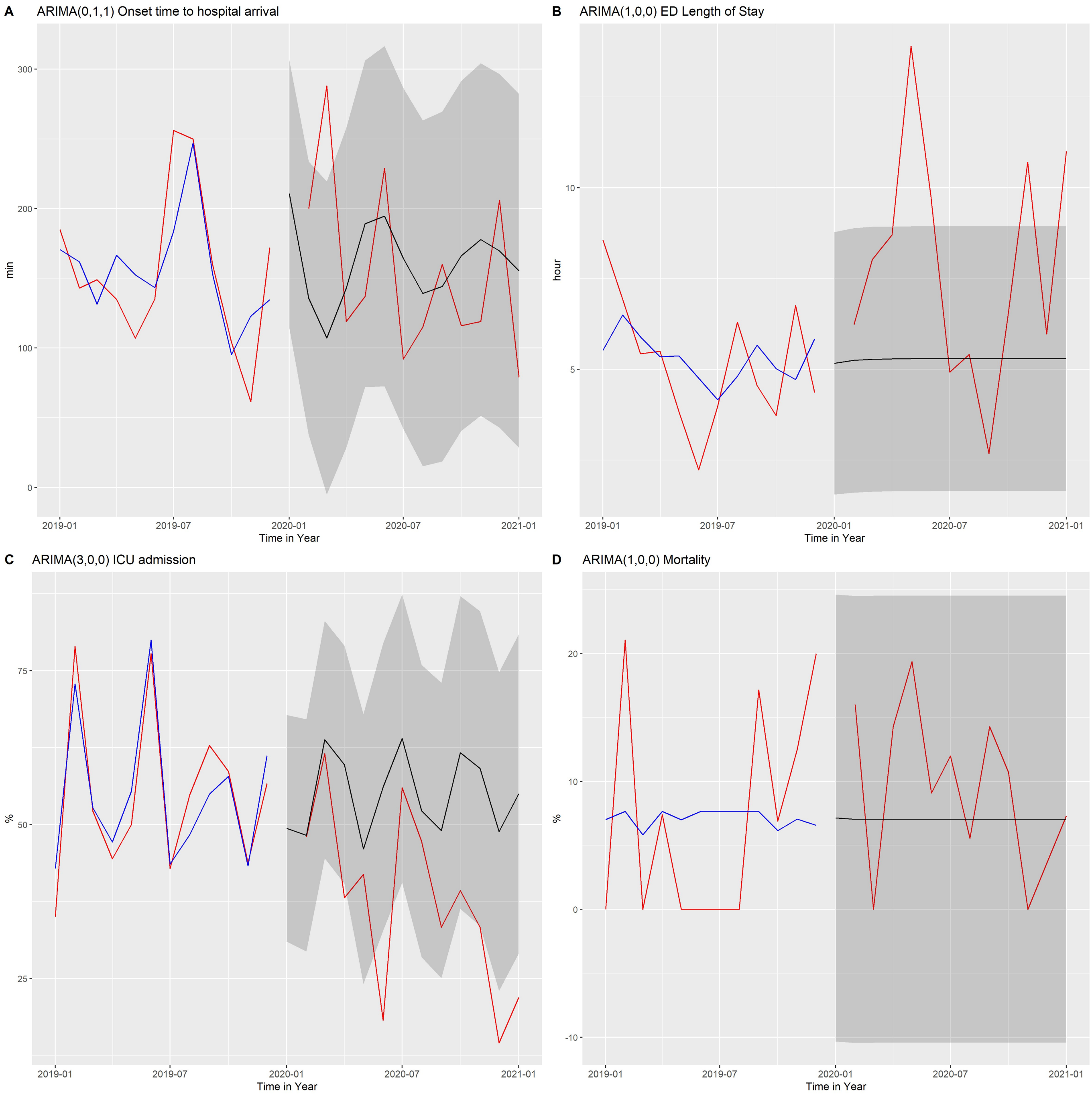

FIGURE 2. Time-series analysis of onset time to hospital arrival and outcomes of patients with acute myocardial infarction using the ARIMA model. (A) Time-series analysis of onset time to hospital arrival. (B) Time-series analysis of ED length of stay. (C) Time-series analysis of ICU admission. (D) Time-series analysis of mortality. Red line, observed data; blue line, ARIMA model; black line, forecasted value; and shadowed area, 95% confidence interval of the forecasted value. ARIMA, autoregressive integrated moving average.

in in-hospital mortality, ICU admission, and ventilator use in the ED were not statistically significant (Tables 2 and 3 **Supplementary Table 2**).

The onset to hospital arrival time spiked in the post period compared to the 95% CI of the forecasted value in the ARIMA(1,0,0) model (Fig. 3A). The length of stay in the ED was greater than the 95% CI of the forecasted value in the ARIMA(1,0,0) model in the later phase of the post-period (Fig. 3B). The ICU admission rate was within the 95% CI of the forecasted value (Fig. 3C). Except for a month in the early post-period, the mortality rate was within the 95% CI of the forecasted value in the ARIMA(2,0,0) model (Fig. 3D). The Box-Ljung test showed that the residuals of the ARIMA models could be considered white noise (all $p > 0.05$).

In the multivariable analysis, age, sex, mental status, systolic blood pressure (SBP), length of stay in the ED (aOR 1.04; 95% CI 1.00–1.07; p = 0.029), and ventilator use in the ED were independently associated with in-hospital mortality. The post-period was not independently associated with in-hospital mortality (aOR 0.60; 95% CI 0.29–1.26; p = 0.181) (Table 4).

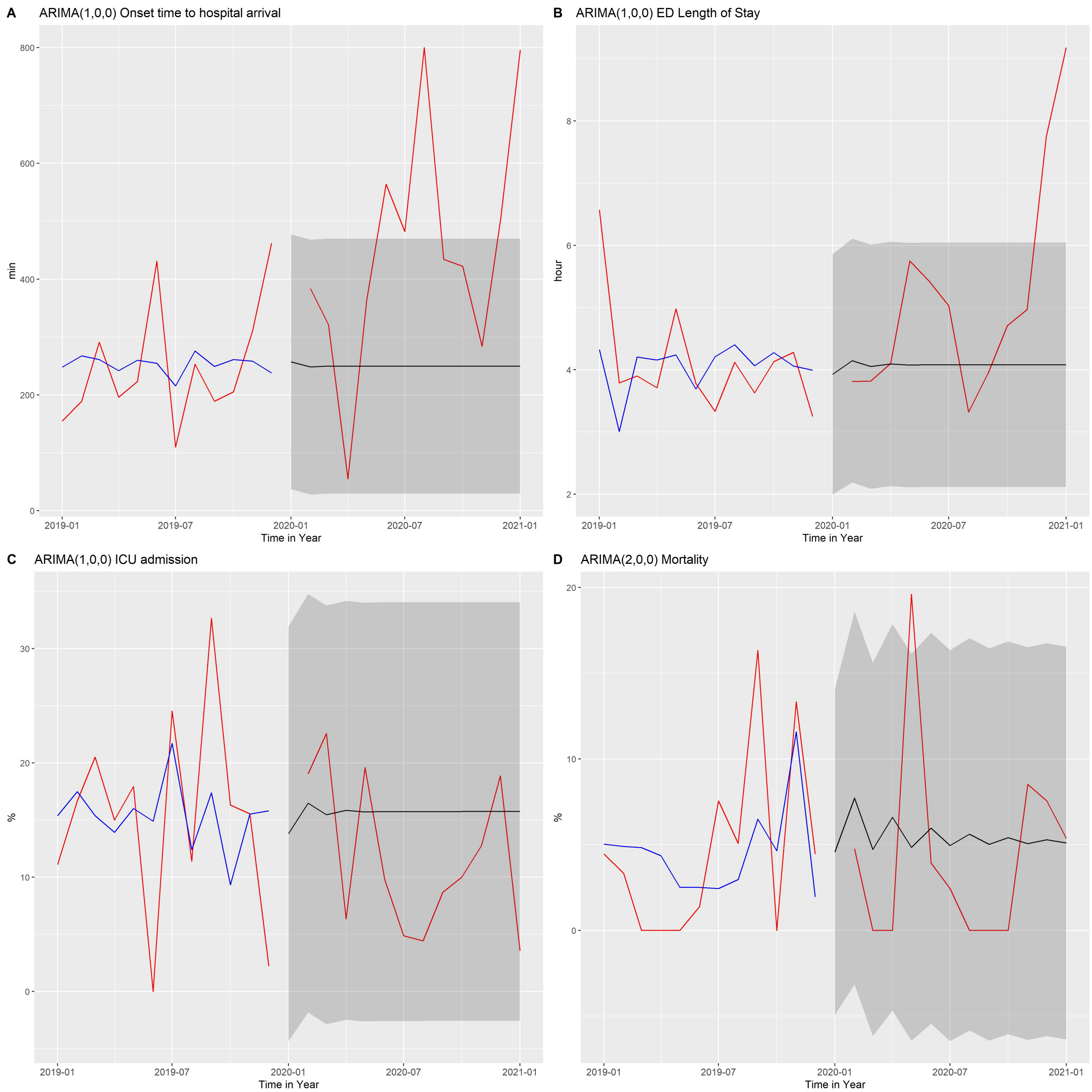

FIGURE 3. Time-series analysis of onset time to hospital arrival time and outcomes of patients with ischemic stroke using the ARIMA model. (A) Time-series analysis of onset time to hospital arrival. (B) Time-series analysis of ED length of stay. (C) Time-series analysis of ICU admission. (D) Time-series analysis of mortality. Red line, observed data; blue line, ARIMA model; black line, forecasted value; and shadowed area, 95% confidence interval of forecasted value. ARIMA, autoregressive integrated moving average.

In the multivariable linear regression model, mental status, SBP, heart rate, and post-period (beta-coefficient 2.135; 95% CI 1.365–2.904; $p < 0.001$) were independently associated with length of stay in the ED (all $p < 0.05$).

3.3 Hemorrhagic stroke

In the univariate analysis, patients stayed longer in the ED in the post-period (3.3 [2.1–5.2] hours vs. 4.8 [3.0–8.8] hours; $p < 0.001$). Although not statistically significant, an increased trend in in-hospital mortality was detected in the post-period (18.5% vs. 24.5%; $p = 0.055$). ICU admission and ventilator use were not statistically different between the two periods. (Tables 2,3 **Supplementary Table 3**).

In the time-series analysis, the length of stay in the ED was greater than the forecasted value in the ARIMA(1,0,0) model in the post-period (**Supplementary Fig. 1**). The onset to hospital arrival time, ICU admission rate, and mortality rate were within the 95% CI of the forecasted values (**Supplementary Fig. 1**). The Box-Ljung test showed that the residuals of the

TABLE 4. Multivariable logistic regression analysis of in-hospital mortality.

	aOR	95% CI	*p*-value
Post-period			
Acute myocardial infarction[a]	2.54	1.06–6.08	0.037*
Ischemic stroke[b]	0.60	0.29–1.26	0.181
Hemorrhagic stroke[c]	1.74	1.11–2.73	0.016*
Cardiac arrest[d]	1.40	0.91–2.16	0.129

aOR, adjusted odds ratio; CI, confidence interval; ED, emergency department; EMS, emergency medical services; HR, hazard ratio; ICU, intensive care unit; RR, respiratory rate.
$*p < 0.05$.
[a]Adjusted for sex, age, EMS use, mental status, SBP, HR, RR, ED length of stay, ICU admission, ventilator use in ED.
[b]Adjusted for sex, age, transfer-in, EMS use, mental status, SBP, HR, RR, onset to hospital arrival time, ED length of stay, ICU admission, ventilator use in ED.
[c]Adjusted for sex, age, EMS use, mental status, SBP, HR, RR, onset to hospital arrival time, ICU admission, ventilator use in ED.
[d]Adjusted for sex, age, EMS use, transfer-in, ICU admission, ventilator use in ED.

ARIMA models could be considered white noise (all $p > 0.05$).

In the multivariable logistic regression, sex, age, initial mental status, ICU admission, ventilator use in the ED, and post-period (aOR 1.74; 95% CI 1.11–2.73; p = 0.016) were independently associated with in-hospital mortality (Table 4). In the multivariable linear regression model, the post-period was independently associated with length of stay in the ED (beta-coefficient 2.590; 95% CI 1.844–3.335; $p < 0.001$).

3.4 Cardiac arrest

In the univariate analysis, patients in the post-period were more likely female with a shorter stay in the ED. In-hospital mortality did not differ significantly between the periods (Tables 2,3 **Supplementary Table 4**).

In the time-series analysis, onset to hospital arrival time, length of stay in the ED, ICU admission, and mortality were within the 95% CI of the forecasted value except for length of stay in ED in one month within the post-period (**Supplementary Fig. 2**). The Box-Ljung test showed that the residuals of the ARIMA models could be considered white noise (all $p > 0.05$).

In the multivariable analysis, the post-period was not independently associated with in-hospital mortality (aOR 1.40; 95% CI 0.91–2.16; p = 0.129) (Table 4) or length of stay in the ED (beta-coefficient 0.665; 95% CI –0.098–1.612; p = 0.148).

4. Discussion

In our study, an increased proportion of patients with acute myocardial infarction, hemorrhagic stroke, and cardiac arrest visited the ED in the post-period. Among patients with acute myocardial infarction and hemorrhagic stroke, the post-period was independently associated with in-hospital mortality. The post-period was independently associated with the length of stay in the ED in cases diagnosed with hemorrhagic stroke but not in those with acute myocardial infarction. In ischemic stroke patients, the post-period was not associated with mortality but was independently associated with length of stay in the ED, which was associated with the in-hospital mortality. However, no association was observed between the period and mortality or length of stay in the ED among with cardiac arrest patients.

4.1 Acute myocardial infarction

In our study, the proportion of patients with acute myocardial infarction increased during the post-period. Previous studies reported a decrease in acute myocardial infarction among patients within 1–6 months after the COVID-19 outbreak [3, 11, 12, 18, 19]. The difference between previous studies and our study can be explained by the increase in the number of patients in the latter 6 months of the post-period. The capacity of secondary hospitals that can manage acute myocardial infarction might be decreased due to the burden of COVID-19. As a result, more patients with acute myocardial infarction might have visited to tertiary hospital.

Primessnig *et al*. [12] reported that mortality rates increased within 2 months after the COVID-19 pandemic onset. In our study, multivariable logistic regression analysis revealed that the post-period was associated with mortality. According to Sung *et al*. [11], mortality rates was increased in men but not women within 3 months after the COVID-19 outbreak, suggesting a sex-based difference in outcomes. This suggests that men with acute myocardial infarction require greater attention.

4.2 Ischemic stroke

The time from onset to ED arrival has increased substantially during the COVID-19 era. In addition, the proportion of patients who arrived at the ED within the time limit for intravenous thrombolysis indication [8] decreased during the pandemic. These might be resulted from not only fear of COVID-19 transmission but also reduction of early detection rate by family or guardians due to social distancing regulations and the COVID-19 lockdown. Thus, public education on the warning signs of ischemic stroke and healthcare policies for reducing the onset time to ED arrival are needed. Considering the substantial increase in the ED length of stay in the late phase of the post-period, an overload on the ED can be suggested. A rapid triage system and the establishment of a cohort zone for patients with indications for thrombolysis upon arrival will help solve this problem.

Gabet *et al*. [13] reported that mortality increased during the lockdown period in France and subsequently returned to the baseline. In our study, the mortality rate peaked in the early post-period and returned to the expected rate. However, the post-period was associated with ED length of stay, which was associated with mortality. A rapid COVID-19 screening tool would be needed to reduce the ED length of stay to reduce the mortality rates.

4.3 Hemorrhagic stroke

Our study showed an increased proportion of patients with hemorrhagic stroke and an independent association with mortality in the post-period. John *et al*. [20] reported an increasing trend on numbers and mortality of hemorrhagic stroke during the first 3 months of the COVID-19 pandemic. Lee *et al*. [21] reported an increased trend of mortality of patients who underwent brain surgery during the COVID-19 pandemic. Both studies included only a small number of patients (42 and 32 at COVID-19 pandemic). The larger cohort size in our study might contribute to statistical significance.

4.4 Cardiac arrest

The proportion of out-of-hospital cardiac arrest patients increased in the United States during the COVID-19 pandemic [10], a finding that is consistent with our study findings. The previous study reported that the onset to hospital time and mortality rate increased substantially during the early COVID-19 pandemic. However, these were not significantly different between the two periods in our study. A year-long effort of EMS paramedics and ED physicians might reduce the increased onset to hospital arrival time and mortality rate during the early COVID-19 pandemic. Furthermore, more frequent non-shockable rhythms, respiratory causes, and fewer public places were reported in patients with out-of-hospital cardiac arrest within a month after the onset of the COVID-19 pandemic [10]. Utstein variables were not collected in our study because this study is designed to report changes over a year after the onset of the COVID-19 pandemic in multiple time-sensitive diseases in the ED.

4.5 Limitations and strengths

This study had several limitations. First, its retrospective observational study design might have lacked covariates. Second, the diagnoses were defined by using the KCD-8 code at the ED, suggesting possible misdiagnoses or missed patient populations. Third, since the data were automatically retrieved from the ED's electronic medical records, covariates such as comorbidities, National Institute of Health Stroke Scale in ischemic stroke, and Utstein variables in cardiac arrest were not collected. Fourth, this study was conducted at a single tertiary center. Hospital admission policies may differ; thus the results cannot be generalized to other hospitals or general populations. Fifth, only a year was used for the ARIMA(p,d,q) modeling in the time-series analyses because the capacity of the ED was exceptionally small in 2018 and increased substantially thereafter. If a longer period was used in the ARIMA(p,d,q) modeling, unrevealed seasonal effects or forecasts may have been revealed. In addition, other factors were not adjusted in the time-series analyses. Sixth, in-hospital mortality was used as the outcome. Further studies evaluating the short- or long-term mortality outcomes at specific time-points, such as 30 and 90 days, are warranted.

To our knowledge, this is the first study to evaluate the impact of COVID-19 on time-sensitive diseases in the ED in Korea over a one-year period. This study may provide important information for future studies and policies including: (1) increased numbers of patients diagnosed with acute myocardial infarction in the last 6 months of the COVID-19 pandemic and suggestions for sex-based differences in mortality; (2) emphasizing the need for public education and policies for patients with ischemic stroke requiring intravenous thrombolysis; (3) increased numbers of patients with hemorrhagic stroke and mortality; and (4) normalization of onset to hospital arrival time and mortality in cardiac arrest patients during the one-year COVID-19 pandemic. The capacities of EDs and associated facilities should be increased to reduce overloads on emergency care system during prolonged COVID-19 pandemic. Further studies with larger cohorts are needed to investigate the long-term effects of the COVID-19 pandemic on major time-sensitive diseases in the ED.

5. Conclusions

Over a year after the onset of the COVID-19 pandemic in Korea, the proportion of patients with acute myocardial infarction, hemorrhagic stroke, and cardiac arrest in the ED has increased. The post-period was independently associated with mortality in patients with acute myocardial infarction, and hemorrhagic stroke. The findings of this study may provide important information for future studies and policies. Further studies are warranted to determine the long-term effects of the COVID-19 pandemic on emergency medicine.

AUTHOR CONTRIBUTIONS

HL, HC, SM, SA contributed to the study conception and design; JP, JK, JS, SA contributed to the data analysis and interpretation; HL, SA contributed to the manuscript drafting; HC, SM, SA are the guarantors of the study. All authors approved the final article.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Institutional Review Board of Korea University (2021AS0167), which waived the need for informed consent owing to its retrospective nature.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at https://oss.signavitae.com/mre-signavitae/article/1476089636612653056/attachment/Supplementary%20material.docx.

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