# Utilization and Outcomes of Acute Revascularization Treatments in Ischemic Stroke Patients with SARS-CoV-2 Infection

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*Objectives:* Acute ischemic stroke patients with severe acute respiratory syndrome coronavirus maybe candidates for acute revascularization treatments (intravenous thrombolysis and/or mechanical thrombectomy). *Materials and Methods:* We analyzed the data from 62 healthcare facilities to determine the odds of receiving acute revascularization treatments in severe acute respiratory syndrome coronavirus infected patients and determined the odds of composite of death and non-routine discharge with severe acute respiratory syndrome coronavirus infected and non-infected patients undergoing acute revascularization treatments after adjusting for potential confounders. *Results:* Acute ischemic stroke patients with severe acute respiratory syndrome coronavirus infection were significantly less likely to receive acute revascularization treatments (odds ratio 0.6, 95% confidence interval 0.5−0.8, $p = 0.0001$). Among ischemic stroke patients who received acute revascularization treatments, severe acute respiratory syndrome coronavirus infection was associated with increased odds of death or non-routine discharge (odds ratio 3.0, 95% confidence interval 1.8−5.1). The higher odds death or non-routine discharge (odds ratio 2.1, 95% confidence interval 1.9−2.3) with severe acute respiratory syndrome coronavirus infection were observed in all ischemic stroke patients without any modifying effect of acute revascularization treatments (interaction term for death ($p = 0.9$) or death or non-routine discharge ($p = 0.2$). *Conclusions:* Patients with acute ischemic stroke with severe acute respiratory syndrome coronavirus infection were significantly less likely to receive acute revascularization treatments. Severe acute respiratory syndrome coronavirus infection was associated with a significantly higher rate of death or non-routine discharge among acute ischemic stroke patients receiving revascularization treatments.
**Key Words:** SARS-CoV-2—Mechanical thrombectomy—Thrombolysis—Acute ischemic stroke—Revascularization

## Introduction

Our understanding of outcomes in acute ischemic stroke patients with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection following acute revascularization treatments (as intravenous thrombolysis and/or thrombectomy) is based on small case series.[1-3] An international panel[4] cautioned regarding the potential for high rate of death or disability and post thrombolytic intracerebral hemorrhage (ICH)s in acute ischemic stroke patients with SARS-CoV-2 infection due to elevated concentrations of inflammation and hypercoagulability markers such as leukocytosis, and C reactive protein and D dimers and multisystem dysfunction.[4-7] and recommended further studies to address these concerns.[4] We performed this analysis to understand utilization and associated outcomes of acute revascularization treatments in acute ischemic stroke patients with SARS-CoV-2 infection.

## Methods

We analyzed the data from the Cerner de-identified COVID-19 dataset.[8-14] which included data from 62 contributing Cerner Real-World Data health systems from United States between December 1, 2019 and January 1, 2021. The dataset is available through Cerner Corporation after submission and approval of research protocol and analysis plan. The dataset includes data for patients who qualified for inclusion based on the following criteria:

(1) Patient has a minimum of one emergency department or inpatient encounter with a discharge diagnosis code that could be associated with exposure to or clinical suspicion of SARS-CoV-2 infection; OR
(2) Patient has a minimum of one emergency department or inpatient encounter with a positive laboratory test for a SARS-CoV-2 infection.

Our analysis included patients with prior medical history from the past 5 years to ensure completeness of the records of potential comorbidities which constituted approximately 76% of the total cohort. Patients in whom no previous medical encounter occurred during the past 5 years were excluded. Encounters with missing data for certain non-essential variables such as gender were included.

In general, the Cerner de-identified COVID-19 dataset comprise more than 100 clinical and nonclinical variables associated with hospital stays, including primary and secondary diagnoses, primary and secondary procedures, patients' admission and discharge status, and patient demographic information. Cerner Corporation has established Health Insurance Portability and Accountability Act-compliant operating policies to establish de-identification for Cerner Real-World Data.

We used the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) primary diagnosis codes I63, I65 and I66 to identify the patients admitted with acute ischemic stroke. We also used ICD-10 procedure codes to estimate the proportion of patients who underwent mechanical thrombectomy (03CG3ZZ, 03CG3Z7, 03CH3Z7, 03CJ0ZZ, 03CJ3ZZ, 03CK3Z7, 03CK3ZZ, 03CL3Z7, 03CL3ZZ, 03CL0ZZ, 03CP3ZZ, 03CY3ZZ, 00C73ZZ) and/or intravenous thrombolysis administration (3E03317 and 3E06317). The ICD-10-CM codes were also used to identify the patients with other medical co-morbidities and in-hospital events: hypertension (I10, O10.0, O10.9, I16 and I67.4), diabetes mellitus (E08, E09, E10, E11 and E13), atrial fibrillation (I48), hyperlipidemia (E78), malignancy (Z85), nicotine dependence (F17), subarachnoid hemorrhage (I60), ICH (I61 and I62.9), pulmonary embolism (I26), acute myocardial infarction (I21), transient cerebral ischemic attack (G45), congestive heart failure (I09.81, I11.0 and I50) and peripheral vascular disease (I71, I79.0, I73.9, Z95.8 and Z95.9), pneumonia (J12-J18), respiratory failure (J96), urinary tract infection (N30.0, N30.9, N34.1, N34.2 and N39.0), acute kidney injury (AKI) (N17), septic shock (A41 and R65.21), hepatic failure (K72), cardiac arrest (I46), systemic inflammatory response syndrome(SIRS) (R65.1), and deep venous thrombosis (I82).

The primary outcome was in-hospital death. The secondary outcome was a composite of death or non-routine discharge (discharge to destinations other than home, such as short-term hospitals or other facilities including intermediate care and skilled nursing homes).

### Statistical analysis

We performed a logistic regression analysis including all ischemic stroke patients to identify the odds of receiving acute revascularization treatments in the presence of SARS-CoV-2 infection after adjusting for age (age strata), gender, race/ethnicity, hypertension, diabetes mellitus, atrial fibrillation, hyperlipidemia, malignancy, nicotine dependence, previous ischemic stroke, previous subarachnoid hemorrhage, previous ICH, previous acute myocardial infarction, previous transient cerebral ischemic attack, congestive heart failure, peripheral vascular disease, deep venous thrombosis, or previous pulmonary embolism.

We performed four logistic regression analyses to determine the independent effect of SARS-CoV-2 infection on 1/. death and 2/. death or non-routine discharge. Analysis 1 and 2 included patients who underwent acute revascularization treatments and analysis 3 and 4 included all acute ischemic stroke patients. Potential confounders included age (age strata), gender, race/ethnicity, hypertension, diabetes mellitus, atrial fibrillation, hyperlipidemia, malignancy, nicotine dependence, previous ischemic stroke, previous subarachnoid hemorrhage,

**Table 1.** *Characteristics and outcomes for ischemic stroke patients according to SARS-CoV-2 infection status.*

| Items | Patients with new ischemic stroke | | | Ischemic stroke patients who received acute revascularization treatments | | |
|---|---|---|---|---|---|---|
| | SARS-CoV-2 infection-present | SARS-CoV-2 infection -absent | *p*-value | SARS-CoV-2 infection-present | SARS-CoV-2 infection -absent | *p*-value |
| Total | 2122 | 22217 | | 96 | 1588 | |
| Age (in years) | 69.8 ± 13.5 | 70.5 ± 13.7 | 0.8693 | | | |
| < 35 | 38(1.8%) | 401(1.8%) | 0.9626 | 2(2.1%) | 38(2.4%) | 0.8466 |
| 35−49 | 124(5.8%) | 1218(5.5%) | 0.4861 | 10(10.4%) | 131(8.2%) | 0.4566 |
| 50−65 | 553(26.1%) | 5588(25.2%) | 0.3573 | 25(26%) | 441(27.8%) | 0.7131 |
| > 65 | 1407(66.3%) | 15010(67.6%) | 0.2383 | 59(61.5%) | 978(61.6%) | 0.9799 |
| Gender* | | | | | | |
| Men | 1167(55%) | 11183(50.3%) | 0.0004 | 63(65.6%) | 799(50.3%) | 0.0036 |
| Women | 947(44.6%) | 10953(49.3%) | 0.0004 | 33(34.4%) | 783(49.3%) | 0.0045 |
| Race/ethnicity | | | | | | |
| White, Non-Hispanic | 924(43.5%) | 13488(60.7%) | < 0.0001 | 47(49.0%) | 1000(63.0%) | 0.0060 |
| African American | 462(21.8%) | 3537(15.9%) | < 0.0001 | 10(10.4%) | 187(11.8%) | 0.6874 |
| Asian or Pacific Islander | 34(1.6%) | 454(2%) | 0.1659 | 1(1.0%) | 29(1.8%) | 0.5725 |
| Hispanic | 510(24%) | 3280(14.8%) | < 0.0001 | 26(27.1%) | 266(16.8%) | 0.0094 |
| Other | 192(9%) | 1458(6.6%) | < 0.0001 | 12(12.5%) | 106(6.7%) | 0.0299 |
| **Pre-existing medical conditions** | | | | | | |
| Hypertension | 1884(88.8%) | 19837(89.3%) | 0.4746 | 78(81.3%) | 1405(88.5%) | 0.0340 |
| Diabetes mellitus | 1315(62%) | 11085(49.9%) | < 0.0001 | 49(51%) | 676(42.6%) | 0.1035 |
| Atrial fibrillation | 735(34.6%) | 7380(33.2%) | 0.1852 | 34(35.4%) | 497(31.3%) | 0.3989 |
| Hyperlipidemia | 1680(79.2%) | 17270(77.7%) | 0.1276 | 72(75%) | 1211(76.3%) | 0.7785 |
| Malignancy | 351(16.5%) | 4355(19.6%) | 0.0006 | 12(12.5%) | 257(16.2%) | 0.3387 |
| Nicotine dependence | 443(20.9%) | 5896(26.5%) | < 0.0001 | 21(21.9%) | 437(27.5%) | 0.2275 |
| Previous ischemic stroke | 837(39.4%) | 8954(40.3%) | 0.441 | 23(24%) | 640(40.3%) | 0.0015 |
| Previous subarachnoid hemorrhage | 47(2.2%) | 296(1.3%) | 0.001 | 1(1%) | 10(0.6%) | 0.6266 |
| Previous intracerebral hemorrhage | 43(2%) | 419(1.9%) | 0.6506 | 2(2.1%) | 23(1.4%) | 0.6174 |
| Previous pulmonary embolism | 54(2.5%) | 485(2.2%) | 0.2793 | 3(3.1%) | 24(1.5%) | 0.2216 |
| Previous acute myocardial infarction | 183(8.6%) | 1893(8.5%) | 0.8705 | 4(4.2%) | 106(6.7%) | 0.3341 |
| Previous transient cerebral ischemic attack | 143(6.7%) | 1981(8.9%) | 0.0007 | 6(6.3%) | 114(7.2%) | 0.7312 |
| Congestive heart failure | 818(38.5%) | 7666(34.5%) | 0.0002 | 34(35.4%) | 445(28%) | 0.1189 |
| Peripheral vascular disease | 709(33.4%) | 7532(33.9%) | 0.6485 | 18(18.8%) | 461(29%) | 0.0302 |
| **New in-hospital events** | | | | | | |
| Pneumonia | 1398(65.9%) | 5871(26.4%) | < 0.0001 | 48(50%) | 298(18.8%) | < 0.0001 |
| Respiratory failure | 1236(58.2%) | 6417(28.9%) | < 0.0001 | 53(55.2%) | 432(27.2%) | < 0.0001 |
| Urinary tract infection | 848(40%) | 7493(33.7%) | < 0.0001 | 29(30.2%) | 431(27.1%) | 0.5125 |
| Acute kidney injury | 1215(57.3%) | 8793(39.6%) | < 0.0001 | 46(47.9%) | 467(29.4%) | 0.0001 |
| Septic shock | 872(41.1%) | 4867(21.9%) | < 0.0001 | 27(28.1%) | 228(14.4%) | 0.0003 |
| Hepatic failure | 96(4.5%) | 573(2.6%) | < 0.0001 | 0(0%) | 21(1.3%) | 0.2569 |
| Subarachnoid hemorrhage | 56(2.6%) | 486(2.2%) | 0.1781 | 6(6.3%) | 73(4.6%) | 0.4570 |
| Intracerebral hemorrhage | 89(4.2%) | 943(4.2%) | 0.9124 | 10(10.4%) | 157(9.9%) | 0.8660 |
| Acute myocardial infarction | 279(13.1%) | 2202(9.9%) | < 0.0001 | 5(5.2%) | 98(6.2%) | 0.7022 |
| Transient ischemic attack | 107(5%) | 1530(6.9%) | < 0.0001 | 2(2.1%) | 93(5.9%) | 0.1197 |
| Cardiac arrest | 166(7.8%) | 842(3.8%) | < 0.0001 | 7(7.3%) | 51(3.2%) | 0.0333 |
| Pulmonary embolism | 126(5.9%) | 993(4.5%) | 0.002 | 4(4.2%) | 58(3.7%) | 0.7950 |
| Systemic inflammatory response syndrome | 76(3.6%) | 682(3.1%) | 0.1947 | 2(2.1%) | 36(2.3%) | 0.9063 |
| Deep venous thrombosis | 218(10.3%) | 1957(8.8%) | 0.0238 | 2(2.1%) | 115(7.2%) | 0.0536 |

*(Continued)*

**Table 1** (*Continued*)

| Items | Patients with new ischemic stroke | | | Ischemic stroke patients who received acute revascularization treatments | | |
|---|---|---|---|---|---|---|
| | SARS-CoV-2 infection-present | SARS-CoV-2 infection -absent | *p*-value | SARS-CoV-2 infection-present | SARS-CoV-2 infection -absent | *p*-value |
| **Treatments provided** | | | | | | |
| Received thrombolysis or thrombectomy | 96(4.5%) | 1588(7.1%) | < 0.0001 | - | - | - |
| Received only thrombolysis | 55(2.6%) | 751(3.4%) | 0.0525 | - | - | - |
| Received only thrombectomy | 35(1.6%) | 729(3.8%) | < 0.0001 | - | - | - |
| Intubation/mechanical ventilation | 344(16.2%) | 1514(6.8%) | < 0.0001 | 23(24%) | 173(10.9%) | 0.0001 |
| **Outcome** | | | | | | |
| Non-routine discharge | 1615(76.1%) | 13412(60.4%) | < 0.0001 | 76(79.2%) | 895(56.4%) | < 0.0001 |
| Expired in hospital | 455(21.4%) | 1556(7%) | < 0.0001 | 21(21.9%) | 104(6.5%) | < 0.0001 |

Abbreviation used: SARS-CoV-2: severe acute respiratory syndrome coronavirus 2
Information regarding gender was not available in a small number of records

previous ICH, previous acute myocardial infarction, previous transient cerebral ischemic attack, congestive heart failure, peripheral vascular disease, deep venous thrombosis, previous pulmonary embolism. We entered use of acute revascularization treatments as an interaction term in analysis 3 and 4. Any p-values less than 0.05 are considered significant. All the analyses were done using R (version 3.6.1).

## Results

### Overall cohort of ischemic stroke patients

The proportions of men, African American, and Hispanic, and patients with diabetes mellitus, previous subarachnoid hemorrhage, congestive heart failure and deep venous thrombosis were significantly higher among those with SARS-CoV-2 infection (see Table 1). The in-hospital mortality (21.4% versus 7.0%, $p < 0.0001$) and non-routine discharges (76.1% versus 60.4%, $p < 0.0001$) were higher among acute ischemic stroke patients with SARS-CoV-2 infection than in those without SARS-CoV-2 infection (see Table 1).

### Utilization of acute revascularization treatment

The proportions of patients who received acute revascularization treatments among acute ischemic stroke patients with SARS-CoV-2 infection were lower than those without SARS-CoV-2 infection (4.5% versus 7.1%, $p < 0.0001$). Among ischemic stroke patients, 55(2.6%) and 751 (3.4%) received intravenous thrombolysis only, 35 (1.6%) and 729 (3.8%) received mechanical thrombectomy only, and 6 (0.3%) and 108 (0.5%) received both, in patients with and without SARS-CoV-2 infection, respectively. Patients with SARS-CoV-2 infection were significantly less likely to receive acute revascularization treatments among patients with ischemic stroke (odds ratio [OR] 0.6, 95% confidence interval [CI] 0.5-0.8, $p = 0.0001$). Other factors associated

with receiving receive acute revascularization treatments were African American race (OR 0.6, 95% CI 0.6-0.8, $p < 0.0001$), diabetes mellitus (OR 0.7, 95% CI 0.7−0.8, $p < 0.0001$), malignancy (OR 0.8, 95% CI 0.7−1.0, $p = 0.01$), previous subarachnoid hemorrhage (OR 0.5, 95% CI 0.3−0.9, $p = 0.02$), congestive heart failure (OR 0.8, 95% CI 0.7−0.9, $p = 0.002$), and peripheral vascular disease (OR 0.8, 95% CI 0.7−0.9, $p = 0.001$).

### Characteristics and outcomes of patients receiving acute revascularization treatment

Patients with SARS-CoV-2 infection who received acute revascularization treatments were more likely to have pneumonia, respiratory failure, AKI, septic shock, cardiac arrest, and require intubation/mechanical ventilation. The proportion of patients who died during hospitalization (21.9% versus 6.5%, $p < 0.0001$) and those with non-routine discharge (79.2% versus 56.4%, $p < 0.0001$) were significantly higher among patients with SARS-CoV-2 infection compared with those without SARS-CoV-2 infection (See Table 1). The proportion of patients who experienced subarachnoid hemorrhage (1% versus 0.6%) or ICH (2.1% versus 1.4%) were similar between patients with and without SARS-CoV-2 infection.

Among all ischemic stroke patients who received acute revascularization treatments, SARS-CoV-2 infection was associated with increased odds of death (OR 4.1, 95% CI 2.3-7.2) **(see** Table 2**)** and death or non-routine discharge (OR 3.0, 95% CI 1.8−5.1) **(see** Table 2**)** after adjusting for potential confounders.

### Outcomes of acute ischemic stroke patients and interaction between SARS-CoV-2 infection and acute revascularization treatment

SARS-CoV-2 infection was associated with increased odds of death (OR 3.4, 95% CI 3.0−3.9) **(see** Table 2**)** and death or non-routine discharge (OR 2.1, 95% CI 1.9−2.3)

**Table 2.** *Summary of the results of the multivariate models.*

| Variables | Odds Ratio (95% Confidence Intervals) | | | |
| --- | --- | --- | --- | --- |
| | Patients who underwent acute revascularization treatments | | All ischemic stroke patients | |
| | Predictors of death | Predictors of death or non-routine discharge | Predictors of death | Predictors of death or non-routine discharge |
| Age < 35 years | 1.0(1.0−1.0) | 1.0(1.0−1.0) | 1.0(1.0−1.0) | 1.0(1.0−1.0) |
| Age 35-49 years | 2.9(0.6−14.7) | 1.3(0.6−2.7) | 1.3(0.8−2.1) | 1.3(1.0−1.6) |
| Age 50-65 years | 1.4(0.3−6.7) | 1.4(0.7−2.8) | 1.3(0.9−2.0) | 1.6(1.3−2.0) |
| Age > 65 years | 2.2(0.5−10.5) | 2.0(1.0−4.0) | 1.6(1.0−2.3) | 2.4(1.9−2.9) |
| Men | 1.0(0.7−1.5) | 0.8(0.6−1.0) | 1.2(1.1−1.4) | 0.9(0.9−1.0) |
| White | 1.0(1.0−1.0) | 1.0(1.0−1.0) | 1.0(1.0−1.0) | 1.0(1.0−1.0) |
| African American | 0.9(0.5−1.6) | 1.1(0.8−1.5) | 1.1(1.0−1.3) | 0.9(0.8−1.0) |
| Asian or Pacific Islander | 0.8(0.2−3.7) | 1.3(0.6−3.0) | 1.2(0.9−1.7) | 0.8(0.7−1.0) |
| Hispanic | 1.2(0.7−2.0) | 1.3(0.9−1.7) | 1.1(1.0−1.3) | 0.9(0.8−0.9) |
| Other race/ethnicity | 1.0(0.5−2.1) | 0.8(0.5−1.1) | 1.2(1.0−1.4) | 0.8(0.7−0.9) |
| Hypertension | 0.8(0.5−1.4) | 1.5(1.1−2.1) | 0.7(0.6−0.8) | 1.2(1.1−1.3) |
| Diabetes mellitus | 1.0(0.7−1.6) | 1.1(0.9−1.4) | 1.2(1.1−1.4) | 1.4(1.3−1.4) |
| Atrial fibrillation | 1.4(0.9-2.1) | 1.6(1.3-2.0) | 1.7(1.5-1.8) | 1.5(1.4−1.6) |
| Hyperlipidemia | 0.4(0.3−0.6) | 0.8(0.6−1.0) | 0.6(0.6−0.7) | 0.8(0.8−0.9) |
| Malignancy | 1.5(0.9−2.4) | 1.5(1.1−2.0) | 1.1(0.9−1.2) | 1.1(1.0−1.2) |
| Nicotine dependence | 0.5(0.3−0.9) | 1.2(0.9−1.5) | 0.9(0.8−1.0) | 1.1(1.0−1.1) |
| Previous ischemic stroke | 0.7(0.5−1.1) | 0.6(0.5−0.8) | 0.7(0.7−0.8) | 0.7(0.7−0.8) |
| Previous subarachnoid hemorrhage | 0(0−9999) | 0.8(0.2−2.9) | 1.1(0.8-1.6) | 1.4(1.1−1.8) |
| Previous intracerebral hemorrhage | 1.0(0.1−8.1) | 1.3(0.5−3.2) | 1.4(1.0−1.9) | 1.4(1.1−1.8) |
| Previous acute myocardial infarction | 1.3(0.6−2.7) | 0.9(0.6−1.3) | 1.0(0.9−1.2) | 1.0(0.9−1.1) |
| Previous transient cerebral ischemic attack | 0.6(0.2−1.6) | 0.6(0.4−0.9) | 0.8(0.6−0.9) | 0.9(0.8−1.0) |
| Congestive heart failure | 2.0(1.3−3.0) | 1.9(1.5−2.4) | 1.6(1.5−1.8) | 1.5(1.4−1.6) |
| Peripheral vascular disease | 1.4(0.9−2.1) | 0.9(0.7−1.1) | 1.2(1.1-1.3) | 1.0(1.0−1.1) |
| Deep venous thrombosis | 1.8(1.0−3.4) | 1.9(1.2−3.1) | 1.3(1.2−1.5) | 1.6(1.5−1.8) |
| Previous pulmonary embolism | 0.7(0.2−2.7) | 2.0 (0.7−5.3) | 1.0(0.7−1.3) | 1.0(0.8−1.2) |
| **SARS-CoV-2 infection** | **4.1(2.3−7.2)** | **3.0 (1.8−5.1)** | **3.4(3.0−3.9)** | **2.1(1.9−2.3)** |
| **Received acute revascularization treatments** | **-** | **-** | **1.0(0.8−1.2)** | **0.9(0.8−1.0)** |
| Interaction between acute revascularization treatments and SARS-CoV-2 infection | - | - | 1.0(0.6−1.8) | 1.4(0.9−2.4) |

Abbreviation used: SARS-CoV-2: severe acute respiratory syndrome coronavirus-2

(see Table 2) after adjusting for potential confounders. Utilization of acute revascularization treatments was not associated with significantly higher odds of death (OR 1.0, 95% CI 0.8−1.2) (see Table 2) and death or non-routine discharge (OR 0.9, 95% CI 0.8−1.0) (see Table 2). The interaction term between SARS-CoV-2 infection and acute revascularization treatments was not significant for either death ($p = 0.9$) or death or non-routine discharge ($p = 0.2$) in the multivariate model.

## Discussion

### Utilization of acute revascularization treatments

Patients who have acute ischemic stroke with SARS-CoV-2 infection are significantly less likely to receive acute revascularization treatments even though SARS-CoV-2 infection is not considered a contraindication for such treatments.[4,15] Current guidelines recommend prompt revascularization treatments during the current pandemic because of the high mortality rate and severe neurological disability in untreated patients.[16−18] Several studies have reported a reduction in rates of utilization of acute revascularization treatments, and increase in time to treatment among acute ischemic stroke patients during the SARS-CoV-2 infection pandemic.[19−22] A relative reduction in number of mechanical thrombectomy procedures performed during the pandemic has been reported ranging from 21% in France, 25.3% in China, and 33% in in New York city compared with the procedures performed before the SARS-CoV-2 infection pandemic.[16,21,23] An international study from 11 institutions from the United States and 7 international institutions found 8% reduction in mechanical thrombectomy procedures between 2019 and 2020, which was more prominent in regions with high prevalence of SARS-CoV-2 infection.[22] Another study from 187 comprehensive stroke centers.[24] reported a 12.7% decrease in mechanical thrombectomy procedures during SARS-CoV-2 infection pandemic with

greater reduction in hospitals with higher SARS-CoV-2 infected patient admissions. Our findings suggest that the disproportionately lower utilization of acute revascularization treatments in SARS-CoV-2 infected patients may be contributing the overall decline observed in previous studies.

The restricted use of acute revascularization treatments in SARS-CoV-2 infected patients may be due to increased delays from stroke onset to treatment consideration.[16,21,23] attributed to screening and preventive strategies to reduce transmission[25] in initial evaluation, and performance of neuroimaging, and mechanical thrombectomy. There may be reluctance in using acute revascularization treatments due to presence of elevated concentration of inflammation and hypercoagulability markers[4,6,7] and reports of high mortality in patients with SARS-CoV-2 infection who were treated with acute revascularization treatments.[1−3] Patients with SARS-CoV-2 infection may be excluded due to hepatic dysfunction[5] and coagulopathy (elevated pro-thrombin time, international normalized ratio, activated partial thromboplastin time, or reduced platelet count). The relatively high rate of renal insufficiency with subsequent AKI in patients with SARS-CoV-2 infection[26] may delay or preclude administration of contrast for computed tomography angiography and/or perfusion to identify appropriate candidates.

### Outcomes of patients receiving acute revascularization treatments

Among patients who received acute revascularization treatments, patients with SARS-CoV-2 infection had significantly higher adjusted odds for in hospital death (OR 4.1) and also for death and non-routine discharge (OR 3.0). However, the higher rates for in hospital death and also for non-routine discharge were also seen in SARS-CoV-2 infected patients in overall cohort of acute ischemic stroke patients suggesting no unique effect of acute revascularization treatments. These adverse outcomes are related to higher rates of pneumonia, respiratory failure, AKI, septic shock, cardiac arrest, and requirement for intubation/mechanical ventilation in SARS-CoV-2 infected ischemic stroke patients. We did not see any modifying effect (interaction term $p > 0.05$) of acute revascularization treatments in the relationship between SARS-CoV-2 infection and in hospital death or composite end-point of death and non-routine discharge. The proportions of patients with post-treatment ICH or subarachnoid hemorrhage were similar in patients with and without SARS-CoV-2 infection receiving acute revascularization treatments.

### Implications for practice

Our results do not support withholding acute revascularization treatments in SARS-CoV-2 infected patients as we did not identify any higher risk of post treatment ICH

or subarachnoid hemorrhage. However, the outcome of patients with SARS-CoV-2 infection and ischemic stroke is probably determined by the severity of multi-organ dysfunction and may obscure some or all of the benefit of acute revascularization treatments. An international panel[4] recommended assessment of the magnitude of organ dysfunction using Sequential Organ Failure Assessment score[27] to delineate the overall care paradigm in acute stroke patients in accord with the expected prognosis. Other factors such as older age, cardiovascular diseases, secondary infections, acute respiratory distress syndrome, acute renal injury and laboratory findings of lymphopenia and elevated hepatic enzymes, and inflammatory markers associated with increased mortality may have to considered at time of decision making.[28−30]

### Limitations

We used Cerner de-identified COVID-19 dataset[9,14] which provides minimal details on the time interval between symptom onset to arrival, severity of neurological deficits, and diagnostic study results (neuroimaging and laboratory tests), or the exact reasons for exclusion from acute revascularization treatments. There is probably a selection bias towards inclusion of patients with greater severity of symptoms by limiting the analysis to emergency department and hospitalized patients. The dataset also depends on the accuracy of diagnosis and procedures codes. ICD-10 diagnosis codes have a high positive predictive value to identify acute ischemic stroke from the principle discharge diagnosis.[31] The ICD-10 codes can identify 98% of all patients receiving intravenous thrombolysis and 87% of all patients receiving mechanical thrombectomy.[32] The discharge functional outcome cannot be measured with the available data, and the closest index was using the destination of discharge as done in previous studies using Nationwide Inpatient Sample data.[33,34]

### Conclusions

Patients with acute ischemic stroke patients with SARS-CoV-2 infection were significantly less likely to receive acute revascularization treatments and had higher rates of death or non-routine discharge regardless of use of acute revascularization treatments.

## Declaration of Competing Interest

AIQ has received consultation fees from AstraZeneca.

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