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RESEARCH

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Role of mechanical thrombectomy among large vessel stroke patients during the coronavirus disease (COVID-19) pandemic

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Abstract

Purpose The aim of our study is to provide insights derived from experience at multiple centers regarding the outcomes of mechanical thrombectomy (MT) for large vessel occlusion (LVO) in COVID-19 patients and compare them with those in non-COVID-19 patients during the coronavirus disease (COVID-19) pandemic.

Results COVID-19 positive patients were younger than COVID-19 negative patients (62.1 ± 2.69 versus 69.5 ± 2.2, P < 0.001). There was a significant difference between COVID-19 and non-COVID-19 groups in the median D-dimer levels (6 vs. 4.5; P < 0.001), median ESR levels (63 vs. 38; P < 0.001) and median CRP levels (110 vs. 48.5; P < 0.001), respectively. Median time from stroke symptoms onset to hospital admission was significantly higher among COVID-19 positive patients (366 vs. 155 min; P < 0.001). COVID-19 positive patients with LVO presented with a higher median NIH Stroke Scale score at presentation (16 versus 8, P < 0.001) and lower median Alberta Stroke Program Early CT Score (ASPECTS) on admission (6 versus 8, P < 0.001). Patients with COVID-19 had significantly higher percentages of poor functional outcomes as scored using the mRS grades 3–5 in comparison to non-COVID-19 patients (69.2% vs. 13.6%; P = 0.002), but there was no significant difference between both groups in complications such as early cerebral re-occlusion, intracerebral hemorrhage, or in-hospital mortality (P > 0.05).

Conclusion Mechanical thrombectomy has effectively managed patients with LVO stroke. LVO stroke in COVID-19 patients occur at a young age, and have multi-territory vascular involvement. Poor functional outcomes post thrombectomy in COVID-19 patients, irrespective of timely, successful angiographic recanalization.

Keywords Mechanical thrombectomy, Large vessel stroke, COVID-19 pandemic

Background

Thromboembolic occurrences are prevalent between COVID-19 patients, significantly contributing to elevated morbidity and mortality rates [1]. Various inflammatory and prothrombotic mechanisms have been implicated in the occurrence of blood coagulation in COVID-19 cases, including endothelial dysfunction, and an exacerbated inflammation leading to a "cytokine storm" [2]. After the beginning of the COVID-19 pandemic, a notable proportion of individuals infected with the virus have experienced various thrombosis sequelae, notably acute ischemic stroke (AIS). Reports suggest that the incidence of stroke in COVID-19 cases reached 1.3% [3].

Mechanical thrombectomy (MT) has gained widespread acceptance as the primary treatment for cases experiencing emergent large vessel occlusion (ELVO) stroke. This intervention has also been utilized in

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managing ELVO stroke occurring in COVID-19 cases [4]. However, throughout the COVID-19 pandemic, numerous MT procedures were either extended or canceled entirely. Consequently, the pandemic has influenced the clinical outcomes and the occurrence of severe adverse events associated with these procedures [5]. Our study aims to provide insights derived from experiences at multiple centers regarding the outcomes of mechanical thrombectomy for large vessel occlusion (LVO) in COVID-19 cases and compare them with those in non-COVID-19 cases during the COVID-19 pandemic (Fig. 1).

Methods

Ethical statement

This cross-sectional retrospective study performed on 35 cases with acute ischemic stroke, who experienced mechanical thrombectomy at multiple centers during the period from December 2020 to June 2023. The study received approval from our Institutional Review Board under the reference number 11414. The need for explicit informed consent was waived. All protocols adhered to the principles outlined in the Declaration of Helsinki (Figs. 2, 3, 4).

Study population

The study population included 35 patients clinically and radiologically diagnosed with AIS, who experienced mechanical thrombectomy for emergent large vessel occlusion (ELVO) during the period from December 2020 to June 2023. Patients were classified into 2 distinct groups based on their COVID-19 status. The COVID-19 group encompassed 13 cases with either active or past COVID-19 infection (within a span of 12 months), while the non-COVID-19 group consisted of 22 cases who tested negative for SARS-CoV-2 upon admission and had no documented history of prior COVID-19 infection. Patients who did not test for COVID-19 upon admission, or lacking either comprehensive laboratory test results, or detailed endovascular procedure documentation, or outcome data were excluded from the study.

At our institution; prior to MT, all cases underwent a Stroke protocol, which included a non- contrast brain CT scan, cerebral MR angiography, to ascertain their eligibility for mechanical thrombectomy.

All the MT procedures were conducted with approved endovascular devices using aspiration technique or a combination technique (aspiration and stent retrieval). Follow-up non-contrast head CT scans for all cases were done 24 h after MT.

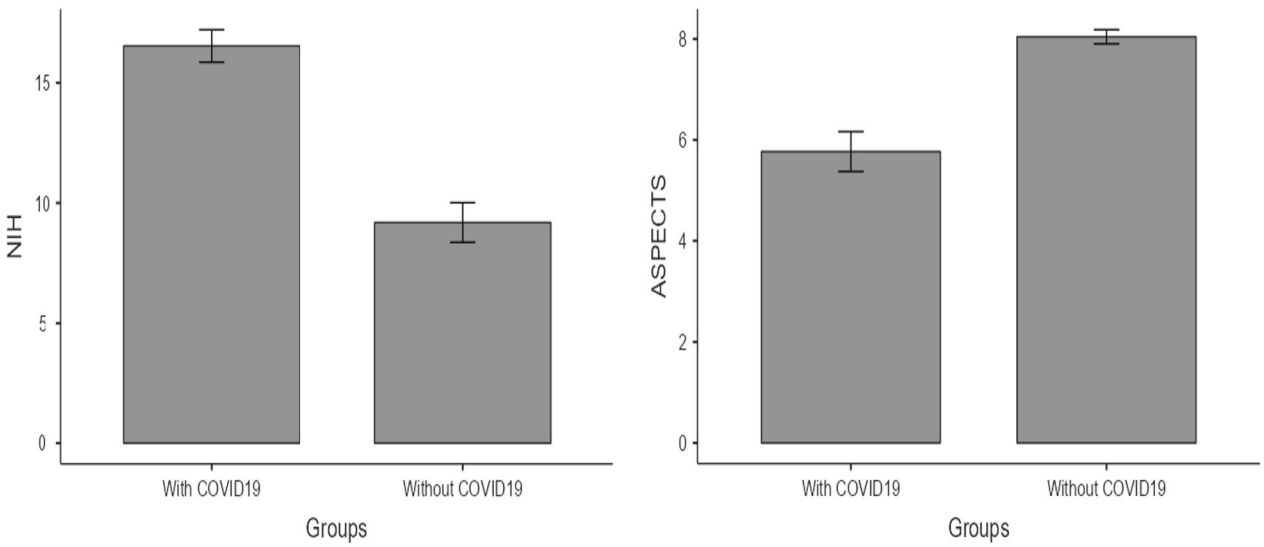

Fig. 1 Bar graph showing NIH Stroke Scale score at presentation and ASPECTS on admission among the studied groups

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Fig. 2 A 60-year-old man presented with left-sided hemiparesis, facial droop, and aphasia. The patient had fever and cough 7 days prior to stroke onset. He tested positive for COVID-19 upon admission. The patient is a smoker and had a history of hypertension, and diabetes mellitus. **A** MRA & **B** DSA revealed complete occlusion of M1 segment of the right MCA (white arrow). **C** DSA shows a stent retriever was deployed in the right MCA. **D** Frontal & **E** lateral views of post thrombectomy DSA show restoration of normal caliber and flow of the right MCA. **F** Follow up axial non-contrast CT brain after 24 h shows no hemorrhage or ischemia

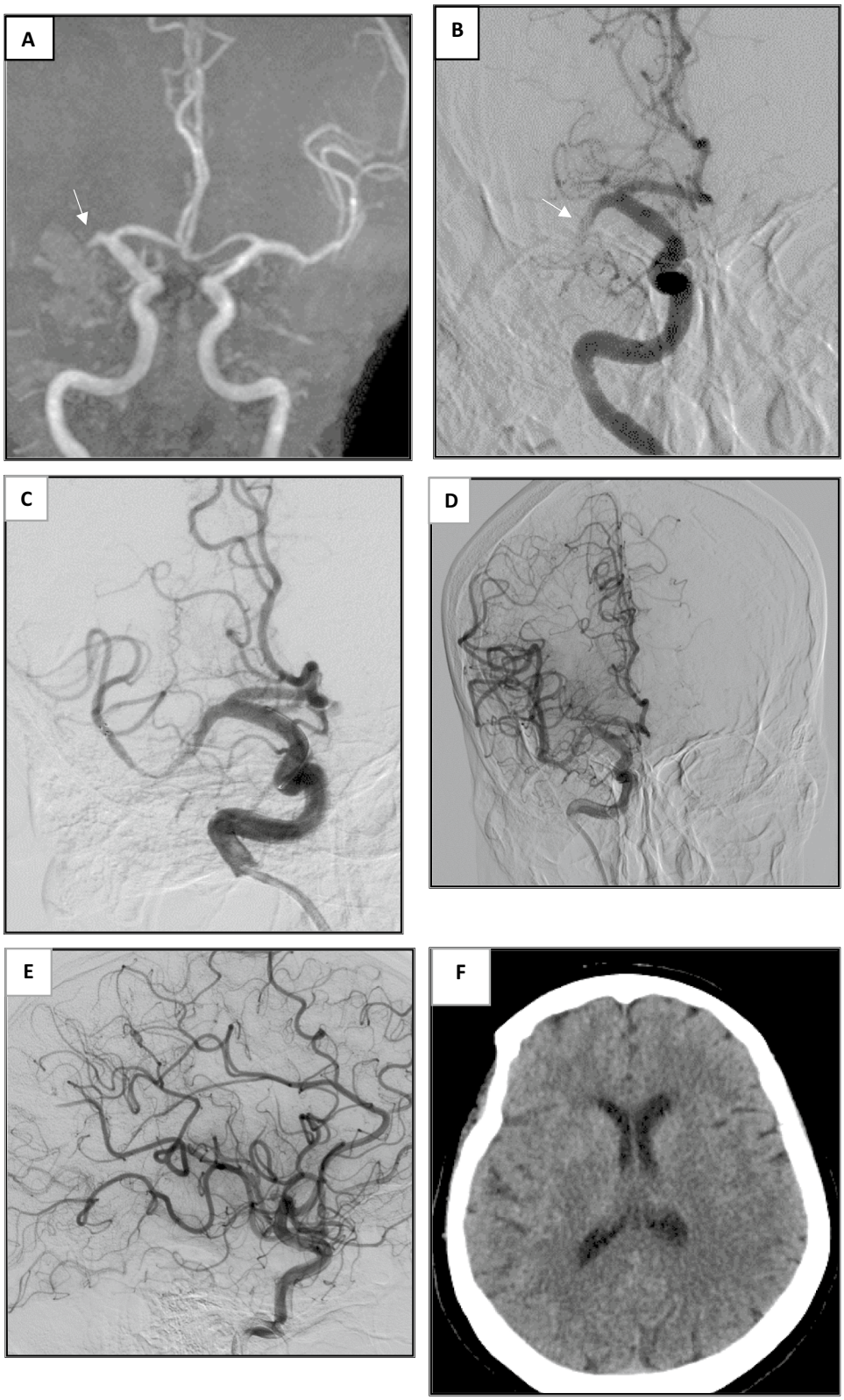

Fig. 2 (See legend on previous page.)

Clinical analysis

Data retrieval encompassed patient admission sheets, medical files, discharge sheets, and follow-up visits to extract comprehensive patient data, which included demographic information such as age, sex, documented COVID-19 history, laboratory results, stroke risk factors, and associated comorbidities such as diabetes, hypertension, and atrial fibrillation.

Pre-intervention assessment

Pre-intervention data were meticulously recorded using admission sheets to document the National Institutes of Health Stroke Scale (NIHSS) upon admission, along with the identification of the duration from symptom onset to hospital presentation.

The initial imaging analysis included non-contrast CT (NCCT) scans to identify early ischemic changes and quantitatively assess their extent using the Alberta Stroke Program Early CT Score (ASPECTS). The ASPECTS is a 10-point quantitative topographic CT scan score used to assess ischemic changes in anterior circulation stroke patients.Variations of the ASPECT scoring system have been described for use in the posterior circulation and referred to as pc-ASPECTS. As in the case for the anterior circulation, the pc-ASPECTS is a 10 point scale, where points are lost for each region affected. Unlike ASPECTS, the pons and the midbrain are worth 2 points each. Furthermore, MR angiography were employed to determine the site of occlusion and infarction.

Post-intervention assessment

Post-endovascular revascularization responses were documented through hospitalization reports, discharge sheets, and follow-up visit records. The primary clinical efficacy outcome was determined by measuring functional independence using the modified Rankin Scale (mRS).

Intervention procedures and post-intervention reports were analyzed using the modified thrombolysis in cerebral infarction (mTICI) scale to assess reperfusion. Successful reperfusion was defined as mTICI 2B, 2C, or 3. Follow-up non-contrast head CT scans were done 24 h after MT.

Statistical analysis

Data analysis was performed using Statistical Package for the Social Sciences version 26 software (IBM Corporation, Armonk, NY, USA). Median or mean ± standard deviation (SD) were reported for continuous variables, while percentage for categorical variables. Data were analyzed using Student's t-test and Mann–Whitney U-test for continuous variables after testing of normality using Shapiro-Walik test, whereas the chi-square test and Fisher exact test were used for categorical variables. Bivariate analysis was used to determine the association between variables. P value ≤ 0.05 was considered statistically significant.

Results

A total of 35 patients, 23 men (65.7%) and 12 women (34.3%), mean age 66.8 ± 4.35 years, admitted with acute ischemic stroke at multiple centers during the period from December 2020 to June 2023.

37.14% (13/35) had positive SARS-CoV2 reverse transcription polymerase chain reaction (RT-PCR) tests. The other 62.86% (22/35) had negative RT-PCR tests.

LVOs were found in 100% of the included patients, 4 patients (11.43%) had multiple vascular territory occlusions, with a total of 41 occlusions (19 occlusions among COVID-19 patients and 22 occlusions among non-COVID-19 patients). All 35 cases were treated with mechanical thrombectomy.

COVID-19 positive patients (N = 13)

The mean age of COVID-19 positive cases was 62.1 ± 2.69 years. 11 patients (84.6%) were male. 9 patients were active cases and 4 patients had a previous COVID-19 infection (within twelve months prior to stroke onset).

In symptomatic COVID-19 positive patients, the median time from COVID-19 symptoms onset to stroke onset was 10 days (range, 4–15 days). With regard to COVID-19 symptoms, fever presented in 6 cases (46.15%), cough presented in 4 cases (30.77%), and shortness of breath presented in 3 cases (23.1%). 5 patients (38.46%) had pneumonia on chest CT performed upon admission. 7 patients (53.8%) were asymptomatic.

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Fig. 3 A 57-year-old man presented with global aphasia and right hemiplegia. He had a history of hypertension, and coronary artery disease. He tested positive for SARS-CoV-2 upon admission. His NIHSS was 20 and ASPECTS was 7 at presentation. MR cerebral angiography showed occlusion at the left carotid terminus. Patient received intravenous thrombolysis and was taken for mechanical thrombectomy with resultant TICI 3 revascularization following 3-pass aspiration. **A** Frontal & **B** lateral views DSA revealed total occlusion of the left carotid termination with contrast filling defect denoting thrombus (white arrow). **C** Frontal & **D** lateral views DSA, a stent retriever was deployed in the left MCA. **E** Frontal & **F** lateral views, post thrombectomy DSA revealed restoration of the anterior circulation. **G** & **H** Follow up axial CT brain after 24 h revealed hemorrhagic transformation with effaced left ventricular system

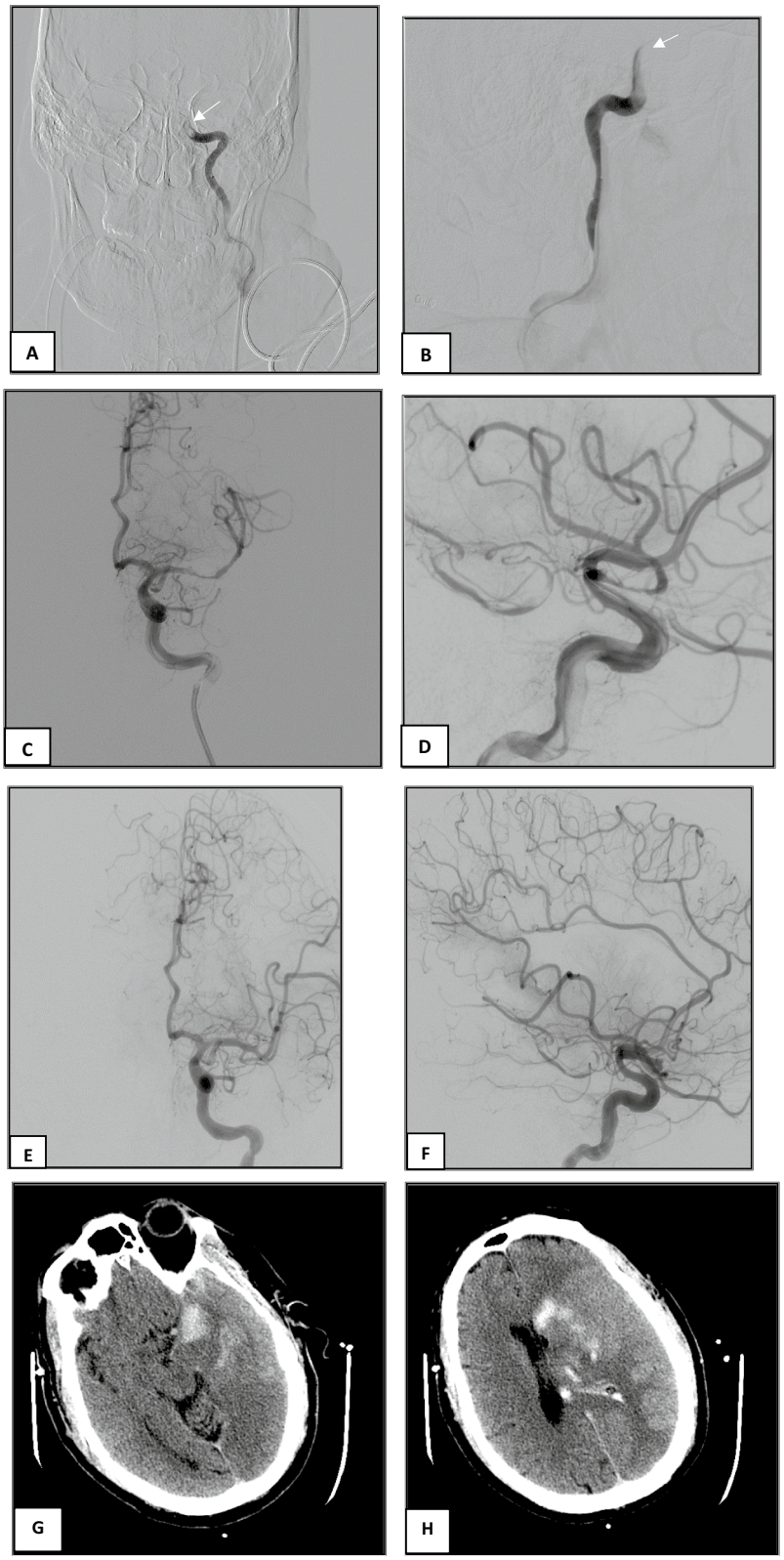

Fig. 3 (See legend on previous page.)

Hypertension was present in 10 patients (76.9%), diabetes mellitus in 7 patients (53.8%), and dyslipidemia in 5 patients (38.5%). The median time from AIS symptoms onset to hospital admission was 366 min (range, 360 – 369 min).

The median NIHSS score at presentation, ASPECTS and pc-ASPECTS on admission were 16 (range, 12–20), 6 (range, 4–8), and 6 (range, 6–7), respectively as shown in Table 1.

Multi-territory LVOs were observed in 4 patients. The most commonly observed LVO was middle cerebral artery segments M1-M2 occlusion present in 69.3%. The second most frequent occlusion was the internal carotid artery present in 30.8%, as shown in Table 2.

Table 3 shows that intravenous thrombolysis was indicated in 3 cases (23.1%). Aspiration technique was performed in 6 cases (46.2%), while a combination technique (aspiration and stent retrieval) was performed in 7 cases (53.8%). Successful recanalization (TICI score ≥ 2b) occurred in 12 patients (92.3%), with a median time from stroke-onset to recanalization equals 295 min (range, 280–350). None of the COVID-19 positive patients achieved first-pass effect, with a median number of passes equals 4 passes per patient.

Within 24 h postthrombectomy, 2 cases (15.4%) had symptomatic intracerebral hemorrhage, while reocclusion of middle cerebral artery occurred in 1 case (7.7%). 2 cases (15.4%) died during their hospital stay; mortality was secondary to severe cerebral edema in both patients.

COVID-19 negative patients (N = 22)

COVID-19 negative cases were older than COVID-19 positive cases (69.5 ± 2.2 versus 62.1 ± 2.69, P < 0.001). There was no significant difference in comorbidities between the two groups.

As regards laboratory investigations, there was a significant difference between COVID-19 and non-COVID-19 groups in the median D-dimer levels (6 vs. 4.5; P < 0.001), median ESR levels (63 vs. 38; P < 0.001) and median CRP levels (110 vs. 48.5; P < 0.001), respectively. Median time from stroke symptoms onset to hospital admission was significantly higher among COVID-19 positive patients (366 vs. 155 min; P < 0.001).

COVID-19 negative patients with LVO presented with a lower median NIHSS score at presentation (8 versus 16, P < 0.001) and higher median ASPECTS and pc-ASPECTS on admission (8 versus 6, P < 0.001) and (9 versus 6, P < 0.001), as shown in Table 1.

Thrombi in the anterior circulation and posterior circulation were seen in 19/22 patients (86.36%) and 3/22 patients (13.64%), respectively, as shown in Table 2.

Median clot burden score was significantly higher among COVID-19 negative patients (7 vs. 6; P = 0.03). Treatment with intravenous thrombolysis was administered in 10 patients (45.5%), there was a non-significant difference in thrombolysis administration between the 2 groups (23.1% COVID-19 positive patients versus 45.5% COVID-19 negative patients, P = 0.3).

10 patients (45.5%) were treated with aspiration technique only and 12 patients (54.5%) were treated with combination technique (aspiration and stent retriever). Complete recanalization after one pass (i.e. first-pass effect) occurred in 6 COVID-19 negative cases (27.3%). The median number of passes was significantly lower among COVID-19 negative patients (3 vs. 4; P = 0.04).

Successful recanalization of TICI score ≥ 2b occurred in 18 patients (81.8%), with a median groin-to-recanalization time of 42.5 min (range, 35–55 min).

Patients with COVID-19 had significantly higher percentages of poor functional outcomes as scored using the mRS grades 3–5 in comparison to non-COVID-19 patients (69.2% vs. 13.6%; P = 0.002), but there was no significant difference between both groups in post thrombectomy complications such as early cerebral reocclusion, intracerebral hemorrhage, or in-hospital mortality (P > 0.05) as shown in Table 3.

Discussion

Despite COVID-19 disease worldwide impact because of severe pulmonary involvement, widespread vaccination has reduced the infections and fatalities caused by this virus [6].

Khedr et al. [7] reported an increased risk of thromboembolic complications in COVID-19 cases, as acute ischemic stroke, myocardial infarction, deep vein thrombosis, and pulmonary embolism.

Misra et al. [8] stated in a study on 145,721 COVID-19 cases that one in every fifty COVID-19 positive patients developed a stroke. Alhashim et al. [9] suggested that COVID-19 infection is an independent risk factor for

(See figure on next page.)

Fig. 4 A 63-year-old man who presented with unequal pupils and unconsciousness. The patient was feverish 13 days prior to stroke onset. He tested positive for COVID-19 upon admission. A non-contrast CT scan of the brain revealed a hyperdense basilar artery which indicated an acute thrombus at the basilar tip. Subsequent CT angiography revealed an occlusion of the distal basilar artery. **A** Frontal & **B** lateral views, Left vertebral angiogram revealed occlusion of the distal basilar artery (arrow). **C** Frontal & **D** Lateral views without subtraction, a stent retriever (arrow) was deployed in the basilar artery. **E** Frontal & **F** lateral views, post thrombectomy DSA revealed restoration of the posterior circulation

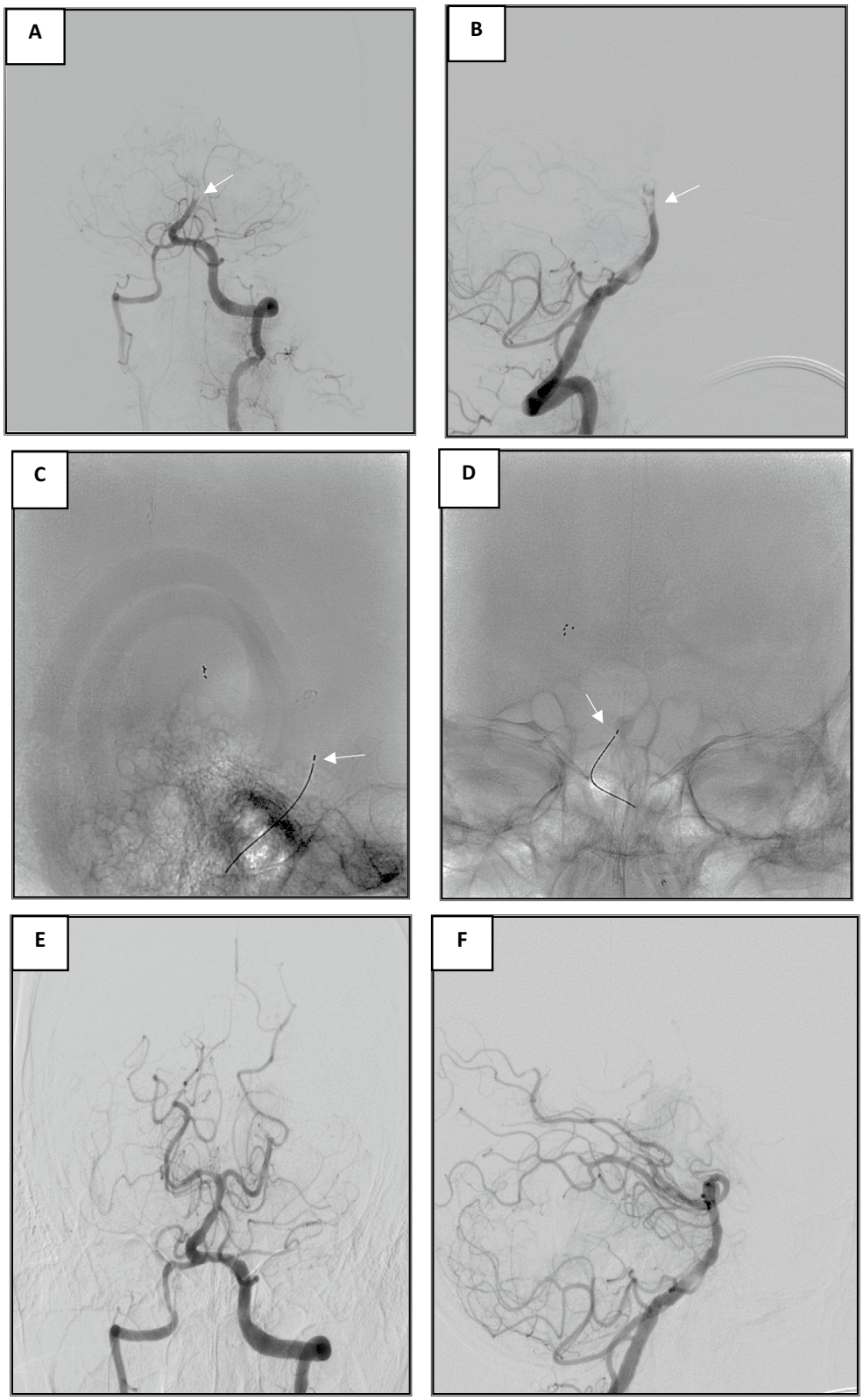

Fig. 4 (See legend on previous page.)

Table 1 Patients demographics, clinical presentation, stroke scales, laboratory investigations and comorbidities

	Total (N = 35 patients)	COVID-19 positive patients (N = 13 patients)	COVID-19 negative patients (N = 22 patients)	*P*-value
Sex				
Male (No.) (%)	23 (65.7)	11 (84.6)	12 (54.5)	0.1
Female (No.) (%)	12 (34.3)	2 (15.4)	10 (45.5)	
Age (mean ± SD) (years)	66.8 ± 4.35	62.1 ± 2.69	69.5 ± 2.2	< 0.001
Median NIH Stroke Scale score on admission	10	16	8	< 0.001
Median ASPECTS on admission	8	6	8	< 0.001
Median pc-ASPECTS on admission	7	6	9	< 0.001
Vascular risk factors				
Hypertension (No.) (%)	28 (80)	10 (76.9)	18 (81.8)	0.7
Diabetes mellitus (No.) (%)	17 (48.6)	7 (53.8)	10 (45.5)	0.5
Dyslipidemia (No.) (%)	15 (42.9)	5 (38.5)	10 (45.5)	0.7
Smoking (No.) (%)	9 (25.7)	2 (15.4)	7 (31.8)	0.4
Coronary artery disease (No.) (%)	10 (28.6)	3 (23.1)	7 (31.8)	0.6
Atrial fibrillation (No.) (%)	10 (28.6)	2 (15.4)	8 (36.4)	0.3
Congestive heart failure (No.) (%)	6 (17.1)	1 (7.7)	5 (22.7)	0.4
Median D- Dimer level (μg/mL)	5	6	4.5	< 0.001
Median Erythrocyte sedimentation rate (mm/h)	39	63	38	< 0.001
Median C- reactive protein level (mg/L)	55	110	48.5	< 0.001
Median time from stroke-symptom onset to hospital presentation (minutes)	158	366	155	< 0.001

Table 2 Anatomic thrombus location in 35 patients (4 patients had multiple vascular territories occlusions; Total occlusions = 41, COVID-19 patients occlusions = 19, Non- COVID-19 occlusions = 22)

	Total (N = 35)	COVID-19 positive patients (N = 13)	COVID-19 negative patients (N = 22)	*P*-value
Anterior circulation stroke				
Middle cerebral artery segments M1 and M2 (No.) (%)	23 (65.7)	9 (69.3)	14 (63.6)	0.7
Internal carotid artery (No.) (%)	9 (25.7)	4 (30.8)	5 (22.7)	0.7
Anterior cerebral artery (No.) (%)	1 (2.86)	1 (7.7)	0 (0)	0.4
Posterior circulation stroke				
Basilar artery (No.) (%)	2 (5.71)	2 (15.4)	0 (0)	0.1
Vertebral artery (No.) (%)	4 (11.43)	1 (7.7)	3 (13.6)	1.00
Posterior cerebral artery segments P1 and P2 (No.) (%)	2 (5.71)	2 (15.4)	0 (0)	0.1

acute ischemic stroke (AIS), as COVID-19 cases with AIS who included in their study were healthy middle-aged males with irrelevant cerebrovascular risk factors.

Jabbour et al. [10] reported that most of COVID-19 cases with LVO were at the early phase or during the course of COVID-19 infection. However, Mowla et al. [11] stated the possibility of a prolonged prothrombotic state after a complete recovery from COVID-19 infection.

Papanagiotou et al. [12] mentioned that there are 4 processes which are responsible for developing stroke in COVID 19 cases, these include neuroinvasion, endotheliitis, ACE2 suppression, and hypercoagulable state.

In this study, COVID-19 cases with LVO were younger than non-COVID-19 cases, the mean age was 62.1 ± 2.69 years versus 69.5 ± 2.2 years, P < 0.001. This is in agreement with a study done by Ramsay et al. [13] who stated that the COVID-19 cohort had a mean age of 64.3 ± 14.4 years compared with 69.4 ± 14.5 years in the non-COVID-19 cohort (P = 0.0014).

In this study, COVID-19 positive patients with LVO presented with a median NIHSS score at presentation, ASPECTS and pc- ASPECTS on admission equal

Table 3 Acute treatments including intravenous thrombolysis and mechanical thrombectomy procedure and post-procedural outcome

	Total (N = 35)	COVID-19 positive patients (N = 13)	COVID-19 negative patients (N = 22)	*P*-value
Median Clot Burden Score	6	6	7	0.03
Intravenous thrombolysis (No.) (%)	13 (37.1)	3 (23.1)	10 (45.5)	0.3
Mechanical thrombectomy (No.) (%)	Treated with aspiration technique = 16 (45.7)	Treated with aspiration technique = 6 (46.2)	Treated with aspiration technique = 10 (45.5)	0.96
	Treated with a combination technique (aspiration and stent retrieval) = 19 (54.3)	Treated with a combination technique (aspiration and stent retrieval) = 7 (53.8)	Treated with a combination technique (aspiration and stent retrieval) = 12 (54.5)	
Median Time from stroke-onset to arterial puncture (minutes)	300	250	335	< 0.001
Median Door to groin (minutes)	80	85	80	0.6
Median Time from stroke-onset to recanalization (minutes)	350	295	385	< 0.001
Median Groin to recanalization (minutes)	42	38	42.5	0.9
Median number of passes	3	4	3	0.04
First pass effect (No.) (%)	6 (17.1)	0 (0)	6 (27.3)	0.06
Angiographic outcome:				
TICI score ≥ 2b (No.) (%)	30 (85.7)	12 (92.3)	18 (81.8)	0.6
Clinical outcomes and complications				
Poor functional outcomes (mRS 3–5) (No.) (%)	12 (34.3)	9 (69.2)	3 (13.6)	0.002
In-hospital mortality (No.) (%)	3 (8.6)	2 (15.4)	1 (4.5)	0.5
Early cerebral re-occlusion (No.) (%)	1 (2.9)	1 (7.7)	0 (0)	0.4
Symptomatic intracranial hemorrhage (No.) (%)	3 (8.6)	2 (15.4)	1 (4.5)	0.5

16 (range, 12–20), 6 (range, 4–8) and 6 (range, 6–7), respectively.

In a study done by Dmytriw et al. [14] on 302 COVID-19 positive cases developed LVO stroke, the median NIHSS score was 22 at presentation, while the median admission ASPECTS was 5. Tsuchiya et al. [15] stated that pc- ASPECTS was 9/10 in their studies on COVID with acute ischemic stroke due to basilar artery occlusion.

In this study, the most commonly observed LVO in COVID-19 positive cases, was middle cerebral artery segments M1-M2, presented in 69.3%. The second most frequent occlusion was the internal carotid artery presented in 30.8%. Multi-territory LVOs were observed in 4 COVID-19 positive cases. While in COVID-19 negative cases, thrombi in anterior circulation and posterior circulation were seen in 19/22 patients (86.36%) and 3/22 patients (13.64%), respectively. Median clot burden score was significantly lower among COVID-19 positive patients (6 vs. 7; P = 0.03).

Styczen et al. [16] reported in their study on 111 cases of LVO with COVID-19 infection, that internal carotid artery and anterior cerebral artery strokes presented in 9.2% and 2.6%, respectively. Nannoni et al. [17] and Zhang et al. [18] stated that multi-territory LVO occurred in 50% of COVID-19 positive cases (MCA occlusion and either ACA or PCA occlusion), because of the coagulation and microcirculation disorders in COVID-19 cases.

In this study, regarding COVID-19 positive cases, intravenous thrombolysis was administered to 23.1%. 46.2% were treated with aspiration technique and 53.8% were treated with a combination technique (aspiration and stent retrieval). 92.3% had successful recanalization (median time from stroke-onset to recanalization equals 295 min). None of COVID-19 positive cases achieved one pass effect (median number equal 4 passes / patient). 15.4% had symptomatic hemorrhagic conversion, and 7.7% had early MCA reocclusion within 24 h.

In a study done by Escalard et al. [19] on 10 COVID positive cases, 50% were treated with intravenous thrombolysis. 100% were treated with MT, 90% had successful recanalization, with a median time from stroke-onset to recanalization equals 302 min, none of their cases achieved first-pass effect, with a median number of 3.5 passes/ patient.

Zureigat et al. [20] reported that post thrombectomy care is essential in LVO stroke management. In a study done by Kojundžić et al. [21] that included 68 patients with AIS, none of the COVID-19 cases had post thrombectomy complications, however, in the non-COVID cases, 3 patients (5.4%) had subarachnoid hemorrhage and 7 (12.7%) had intracerebral hematoma, 24 h post thrombectomy. Similar rates were reported by Cagnazzo et al. [22].

Wang et al. [23] stated that early arterial reocclusion was documented in 40% of the COVID-19 cases in multiple case series, due to the procoagulant state associated with COVID-19 infection.

In this study, 2 COVID-19 patients (15.4%) died during their hospital stay, mortality was secondary to severe cerebral edema. There was no significant difference in mortality among COVID-19 negative versus COVID-19 positive cases (4.5% versus 15.4%, $P=0.5$), respectively.

Elezkurtaj et al. [24] stated that 32.87% of COVID-19 patients died, compared to 5.68% of COVID-19 negative patients with LVO, with a statistically significant difference ($p \leq 0.00001$). Bekelis et al. [25] reported that COVID-19 cases with AIS had 9-times higher mortality rate compared with those without the infection.

There are several limitations in our study; first, its retrospective design, second, the sample size is small, third, we used the reference standard of RT-PCR from a nasal swab which has a sensitivity as low as 70%, fourth, its short term follow up of patients.

Conclusion

Mechanical thrombectomy has effectively managed patients with LVO stroke. LVO stroke in COVID-19 cases occur at a young age, and have multi-territory vascular involvement. Poor functional outcomes post thrombectomy in COVID-19 cases, despite of timely, successful recanalization.

Abbreviations

AIS	Acute ischemic stroke
ASPECTS	Alberta Stroke Program Early CT Score
COVID-19	Coronavirus disease
ELVO	Emergent large vessel occlusion
LVO	Large vessel occlusion
mRS	Modified Rankin Scale
MT	Mechanical thrombectomy
mTICI:	Modified thrombolysis in cerebral infarction
NIHSS	National Institutes of Health Stroke Scale
pc-ASPECTS	Posterior circulation- Alberta Stroke Program Early CT Score
RT-PCR	Reverse transcription polymerase chain reaction

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Not applicable

Author contributions

D.A.E. put the idea of the study, participated in the study design, performed the statistical analysis and contributed to data collection. M.G.N, K.K.L and Y.I.L contributed to the study design, data acquisition, manuscript preparation, and manuscript editing. All authors have read and approved the manuscript.

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Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

All procedures performed in studies involving human participants were in accordance with the ethical standards of our institutional research committee of Zagazig University. Informed written consent was obtained from all individual participants included in the study.

Consent for publication

All patients included in this research gave written informed consent to publish the data contained within this study.

Competing interests

All authors declared that they had no competing interests.

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References

1. Siddiqi HK, Libby P, Ridker PM (2021) COVID-19: a vascular disease. Trends Cardiovasc Med 31:1–5
2. Klok FA, Kruip MJHA, van der Meer NJM et al (2020) Incidence of thrombotic complications in critically ill ICU patients with COVID-19. Thromb Res 191:145–147
3. Spiezia L, Boscolo A, Poletto F et al (2020) COVID-19-related severe hypercoagulability in patients admitted to intensive care unit for acute respiratory failure. Thromb Haemost 120:998–1000
4. de Havenon A, Yaghi S, Mistry EA et al (2020) Endovascular thrombectomy in acute ischemic stroke patients with COVID-19: prevalence, demographics, and outcomes. J Neurointerv Surg 12:1045–1048
5. Sagris D, Papanikolaou A, Kvernland A et al (2021) COVID-19 and ischemic stroke. Eur J Neurol 28:3826–3836
6. Granados-Mendoza SC, Florez-Perdomo WA, Chavda V, Lu B, Janjua T, Agrawal A, Moscote-Salazar LR (2023) Large-vessel occlusion stroke associated with Covid-19: a systematic review and meta-analysis of outcomes. J Neurointensive Care 6(1):26–34
7. Khedr E, Soliman R, Abo-Elfetof N et al (2021) Clinical and radiological characteristics of acute cerebrovascular diseases among Egyptian patients with COVID-19 in upper Egypt. Front Neurol 12:635856. https://doi.org/10.3389/fneur.2021.635856
8. Misra S, Kolappa K, Prasad M, Radhakrishnan D, Thakur KT, Solomon T, Michael BD, Winkler AS (2021) Frequency of neurologic manifestations in COVID-19: a systematic review and meta-analysis. Neurology 97(23):e2269–e2281. https://doi.org/10.1212/WNL.0000000000012930
9. Alhashim A, Alqarni M, Alabdali M, Alshurem M, Albakr A, Hadhiah K, Aljaafari D, Alyami R (2021) Large vessel occlusion causing cerebral ischemic stroke in previously healthy middle-aged recently recovered from severe COVID-19 infection. Int Med Case Rep J 14:577–582. https://doi.org/10.2147/IMCRJ.S327196
10. Jabbour P, Dmytriw AA, Sweid A, Piotin M, Bekelis K, Sourour N et al (2022) Characteristics of a COVID-19 cohort with large vessel occlusion: a multicenter international study. Neurosurgery 90:725–733
11. Mowla A, Sizdahkhani S, Sharifian-Dorche M et al (2020) Unusual pattern of arterial macrothrombosis causing stroke in a young adult recovered from COVID. J Stroke Cerebrovasc Dis 29(12):105353. https://doi.org/10.1016/j.jstrokecerebrovasdis.2020.105353

12. Papanagiotou P, Parrilla G, Pettigrew LC (2021) Thrombectomy for treatment of acute stroke in the COVID-19 pandemic. Cerebrovasc Dis 50:20–25
13. Ramsay IA, Fountain H, Elarjani T, Govindarajan V, Silva M, Abdelsalam A, Burks JD, Starke RM, Luthe E (2023) Outcomes in patients with large vessel occlusion strokes undergoing mechanical thrombectomy with concurrent COVID-19: a nationwide retrospective analysis. J NeuroInterv Surg 5:1–6. https://doi.org/10.1136/jnis-2023-020263
14. Dmytriw AA, Ghozy S, Sweid A et al (2022) International controlled study of revascularization and outcomes following COVID-positive mechanical thrombectomy. Eur J Neurol 29:3273–3287
15. Tsuchiya T, Koizumi S, Tomioka A, Miyawaki S, Saito N (2021) Acute ischemic stroke due to basilar artery occlusion with CoronaVirus Disease 2019: a case report. NMC Case Rep J 8:579–585
16. Styczen H, Maus V, Goertz L et al (2022) Mechanical thrombectomy for acute ischemic stroke in COVID-19 patients: multicenter experience in 111 cases. J Neurointerv Surg 14:858–862
17. Nannoni S, de Groot R, Bell S et al (2021) Stroke in COVID-19: a systematic review and meta-analysis. Int J Stroke 16:137–149
18. Zhang Y, Xiao M, Zhang S, Xia P, Cao W, Jiang W, Chen H, Ding X, Zhao H, Zhang H et al (2020) Coagulopathy and antiphospholipid antibodies in patients with Covid-19. N Engl J Med 382:e38. https://doi.org/10.1056/NEJMc2007575
19. Escalard S, Maïer B, Redjem H, Delvoye F, Hébert S, Smajda S, Ciccio G, Desilles JP, Mazighi M, Blanc R, Piotin M (2020) Treatment of acute ischemic stroke due to large vessel occlusion with COVID-19 experience from Paris. Stroke 51:2540–2543. https://doi.org/10.1161/STROKEAHA.120.030574
20. Zureigat H, Alhusban M, Cobia M (2021) Mechanical thrombectomy outcomes in COVID-19 patients with acute ischemic stroke. Neurologist 26(6):261–267. https://doi.org/10.1097/NRL.0000000000000360
21. Kojundžić SL, Sablić S, Mršić DB, Guić MM et al (2023) Mechanical thrombectomy in acute ischemic stroke COVID-19 and non-COVID-19 patients: a single comprehensive stroke center study. Life (Basel) 13(1):186. https://doi.org/10.3390/life13010186
22. Cagnazzo F, Piotin M, Escalard S et al (2021) European multicenter study of ET-COVID-19. Stroke 52:31–39
23. Wang A, Mandigo GK, Yim PD et al (2020) Stroke and mechanical thrombectomy in patients with COVID-19: technical observations and patient characteristics. J Neurointerv Surg 12:648–653
24. Elezkurtaj S, Greuel S, Ihlow J et al (2021) Causes of death and comorbidities in hospitalized patients with COVID-19. Sci Rep 11:4263
25. Bekelis K, Missios S, Ahmad J et al (2020) Ischemic stroke occurs less frequently in patients with COVID-19: a multicenter cross sectional study. Stroke 51:3570–3576

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