Impact of the COVID-19 pandemic on the process and outcome of thrombectomy for acute ischemic stroke

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ABSTRACT

Background The novel coronavirus disease 2019 (COVID-19) pandemic is still spreading across the world. Although the pandemic has an all-round impact on medical work, the degree of its impact on endovascular thrombectomy (EVT) for patients with acute ischemic stroke (AIS) is unclear.

Methods We continuously included AIS patients with large artery occlusion who underwent EVT in a comprehensive stroke center before and during the Wuhan shutdown. The protected code stroke (PCS) for screening and treating AIS patients was established during the pandemic. The efficacy and safety outcomes including the rate of successful reperfusion (defined as modified Thrombolysis In Cerebral Infarction (mTICI) graded 2b or 3) and time intervals for reperfusion were compared between two groups: pre-pandemic and pandemic.

Results A total of 55 AIS patients who received EVT were included. The baseline characteristics were comparable between the two groups. The time from hospital arrival to puncture (174 vs 125.5 min; p=0.002) and time from hospital arrival to reperfusion (213 vs 172 min; p=0.047) were significantly prolonged in the pandemic group compared with the pre-pandemic group. The rate of successful reperfusion was not significantly different between the two groups (85.7% (n=18) vs 88.2% (n=30); OR 0.971, 95%CI 0.785 to 1.203; p=1.000).

Conclusion The results of this study suggest a proper PCS algorithm which combines the COVID-19 screening and protection measures could decrease the impact of the disease on the clinical outcomes of EVT for AIS patients to the lowest extent possible during the pandemic.

INTRODUCTION

Although the pandemic of the novel coronavirus disease 2019 (COVID-19) in China has been brought under control to some extent, as indicated by the end of the Wuhan shutdown on April 8, 2020, the virus is still spreading rapidly around the rest of the world and it is too early for us to ease off. Official data from the website of the World Health Organization (WHO) showed that up to April 14, more than 1840000 patients were diagnosed as confirmed cases all over the world, including 117021 deaths.1

During the pandemic, almost all elective operations have been deferred or even stopped because of the need for SARS-CoV-2 infection prevention and relocation of limited medical resources.2 Emergency surgeries such as endovascular thrombectomy (EVT) for acute ischemic stroke (AIS) must be performed without any delay even during the pandemic, in order to rescue important functions and save lives.3 4 However, the impact of the pandemic may be inevitable, because the hospitals have to take the necessary measures to prevent further spread of SARS-CoV-2 among medical personnel and patients.5 It can be expected that, given the current situation of the pandemic, strict prevention and control measures will remain and be implemented across the world for at least the next few months. It is still unclear whether the evaluation and treatment process and clinical outcomes of AIS patients who need EVT have been affected, and what we can do to ensure the quality of treatment of AIS patients as well as avoid the spread of SARS-CoV-2 during the pandemic.

Therefore, based on the data from a comprehensive stroke center, we compared the evaluation and treatment process as well as clinical outcomes of AIS patients who underwent EVT before and during the pandemic, with the aim of evaluating the impact of the pandemic on the process and outcome of EVT implementation for AIS patients.

METHODS

Patient selection and data collection

We continuously included all AIS patients treated with EVT in a comprehensive stroke center between January 23 and March 7, 2020 (44 days in total from the date of the Wuhan shutdown to the date of no newly confirmed cases locally) as the pandemic group. Similar patients with the same time span (44 days) between December 1, 2019 and January 14, 2020 were included as the pre-pandemic group. The Stroke Code team in our center was composed of seven attending physicians, five residents, eight nurses, five technicians and three anesthetists. All confirmed and suspected COVID-19 patients were transferred to designated hospitals in accordance with the guidelines of the National Health Commission6 and thus excluded from this study. The following data were obtained from our prospective database: patient demographics, past medical history, presenting National Institutes of Health Stroke Scale (NIHSS), Alberta Stroke Program Early CT Score (ASPECTS), site of thrombus, side of thrombus, therapeutic interventions, preintervention and postintervention modified Thrombolysis In Cerebral Infarction (mTICI)
The screening and interventional process for acute ischemic stroke patients during the COVID-19 pandemic. CTA, CT angiography; CTP, CT perfusion.

**Figure 1**

Proceedure
Local anesthesia was recommended during the procedure, but general anesthesia was chosen if the patient was irritable and uncooperative. Intravenous heparin would be administered if thrombolysis was not performed. Any mechanical stent retriever (Solitaire, Medtronic and Trevo, Stryker; Irvine, CA, and Freemont, CA, respectively) or aspiration catheter (Penumbra System, Penumbra, Alameda, CA) and distal access catheter (Navien, Medtronic, Sofia Plus, MicroVention and Catalyst, Stryker; Irvine, CA, Tustin, CA and Freemont, CA, respectively) were approved for use. Any procedure such as a direct aspiration first-pass technique (ADAPT), stent retrieval, or stent retriever combined with aspiration (Solumbra technique) was permitted to be performed.9–11 The decisions as to whether to use a rescue therapy and which technique to use were left at the discretion of the surgeon. Permitted rescue techniques were intra-arterial tirofiban and angioplasty with or without stenting. Angiographic success was defined as achieving thrombolysis in mTICI grade 2b or 3.

**Outcomes**
The primary outcome was the rate of successful reperfusion defined as an mTICI grade 2b or 3 assessed on angiography.

Secondary outcomes included the change in the NIHSS score from baseline to 3 days after the procedure, and the safety outcome which was defined as a composite of all-cause mortality at 3 days after the procedure, intracerebral hemorrhage (ICH) on brain imaging at 24±12 hours after the procedure, and procedure-related serious adverse events (arterial perforation, arterial dissection, and subarachnoid hemorrhage (SAH)).

**Statistical analysis**
Categorical variables are reported as frequencies and percentages. Quantitative variables are reported as mean±SD or median (IQR) for non-normal distribution. Differences in continuous variables were assessed with the Mann-Whitney U test with non-normal distribution. Differences between proportions were assessed with the χ² test or Fisher’s exact test. Differences were considered statistically significant at p<0.05. Data were analyzed using SPSS version 22.0 software package (IBM Corp, Armonk, NY).
The primary outcome, the rate of successful reperfusion, was not significantly different in the pre-pandemic group versus the pandemic group (88.2% (n=30) vs 85.7% (n=18); OR 0.971, 95%CI 0.785 to 1.203; p=1.000) (table 2, figure 2).

Compared with the pre-pandemic group, hospital arrival to puncture time (174 vs 125.5 min, p=0.002) and hospital arrival to reperfusion time (213 vs 172 min, p=0.047) in the pandemic group was prolonged significantly. No difference in anesthesia approaches (67.6% vs 85.7%; OR 1.267, 95%CI 0.68 to 2.30; p=0.231), and the first-line choice of thrombectomy technique and rescue treatment after first-line strategy (29.4% vs 23.8%; OR 0.810, 95%CI 0.321 to 2.043; p=0.650) was revealed between the two groups. Early improvement in neurological outcomes was not significantly different between the two groups, with no obvious change in NIHSS score at 24 hours in both groups (table 2). The safety outcome was also not significantly different in the pre-pandemic group versus the pandemic group (35.3% (n=12) vs 28.6% (n=6); OR 0.810, 95%CI 0.68 to 2.10; p=0.606). One patient (2.9%) of the pre-pandemic group died due to ICH within 24 hours post-procedure (table 2).

**DISCUSSION**

In this retrospective study during the COVID-19 pandemic, we evaluated the impact of the PCS algorithm (figure 1) on EVT for AIS patients by comparing its process and clinical outcomes between the pre-pandemic period and the pandemic period. The results showed: (1) hospital arrival to puncture time and hospital arrival to reperfusion time were significantly prolonged during the pandemic compared with the pre-pandemic period (table 2); (2) puncture to reperfusion time decreased by an average of 10 min but without statistical significance (table 2); (3) rate of successful reperfusion and other clinical outcomes were all comparable between the two groups (table 2 and figure 2).
Table 2  Procedural details and clinical outcomes of EVT for AIS patients in pre-pandemic and pandemic groups

<table>
<thead>
<tr>
<th></th>
<th>Pre-pandemic group</th>
<th>Pandemic group</th>
<th>OR (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>mTICI 2b–3, n (%)</td>
<td>30 (88.2)</td>
<td>18 (85.7)</td>
<td>0.971 (0.785 to 1.203)</td>
<td>1.000</td>
</tr>
<tr>
<td>Local anesthesia, n (%)</td>
<td>23 (67.6)</td>
<td>18 (85.7)</td>
<td>1.267 (0.947 to 1.695)</td>
<td>0.240</td>
</tr>
<tr>
<td>ADAPT as the first choice, n (%)</td>
<td>10 (29.4)</td>
<td>9 (42.9)</td>
<td>1.457 (0.711 to 2.987)</td>
<td>0.308</td>
</tr>
<tr>
<td>Solubra as the first choice, n (%)</td>
<td>18 (52.9)</td>
<td>10 (47.6)</td>
<td>0.899 (0.519 to 1.558)</td>
<td>0.701</td>
</tr>
<tr>
<td>Stent retriever as the first choice, n (%)</td>
<td>3 (8.8)</td>
<td>0</td>
<td>NA</td>
<td>0.279</td>
</tr>
<tr>
<td>Rescue treatment, n (%)</td>
<td>10 (29.4)</td>
<td>5 (23.8)</td>
<td>0.810 (0.321 to 2.043)</td>
<td>0.650</td>
</tr>
<tr>
<td>Balloon angioplasty, n (%)</td>
<td>4 (11.8)</td>
<td>4 (19.0)</td>
<td>1.619 (0.453 to 5.792)</td>
<td>0.464</td>
</tr>
<tr>
<td>Stent placement, n (%)</td>
<td>8 (23.5)</td>
<td>1 (4.8)</td>
<td>0.202 (0.027 to 1.505)</td>
<td>0.146</td>
</tr>
<tr>
<td>Hospital arrival to puncture time, median (IQR), min</td>
<td>125.5 (113–153)</td>
<td>174 (139–204)</td>
<td>NA</td>
<td>0.002</td>
</tr>
<tr>
<td>Puncture to reperfusion time, median (IQR), min</td>
<td>40.5 (28.5–55.5)</td>
<td>32 (28–43)</td>
<td>NA</td>
<td>0.231</td>
</tr>
<tr>
<td>Hospital arrival to reperfusion time, median (IQR), min</td>
<td>172 (148–218.5)</td>
<td>213 (177–256)</td>
<td>NA</td>
<td>0.047</td>
</tr>
<tr>
<td>Onset to reperfusion time, median ±SD, min</td>
<td>478.28±160.6</td>
<td>511.68±213.54</td>
<td>NA</td>
<td>0.529</td>
</tr>
<tr>
<td>24 hours NIHSS score, median (IQR)</td>
<td>14 (6–40)</td>
<td>10 (6–40)</td>
<td>NA</td>
<td>0.380</td>
</tr>
<tr>
<td>72 hours NIHSS score, median (IQR)</td>
<td>8 (5–14)</td>
<td>8 (4–21)</td>
<td>NA</td>
<td>0.675</td>
</tr>
<tr>
<td>Overall adverse events, n (%)</td>
<td>12 (35.3)</td>
<td>6 (28.6)</td>
<td>0.810 (0.358 to 1.829)</td>
<td>0.606</td>
</tr>
<tr>
<td>Subarachnoid hemorrhage, n (%)</td>
<td>3 (8.8)</td>
<td>4 (19.0)</td>
<td>2.159 (0.535 to 8.707)</td>
<td>0.408</td>
</tr>
<tr>
<td>All intracranial hemorrhage, n (%)</td>
<td>9 (26.5)</td>
<td>3 (14.3)</td>
<td>0.540 (0.165 to 1.770)</td>
<td>0.467</td>
</tr>
<tr>
<td>Hemorrhagic transformation, n (%)</td>
<td>7 (20.6)</td>
<td>2 (9.5)</td>
<td>0.463 (0.106 to 2.021)</td>
<td>0.482</td>
</tr>
</tbody>
</table>

ADAPT, a direct aspiration first pass technique; AIS, acute ischemic stroke; EVT, endovascular thrombectomy; IQR, interquartile range (25–75%); mTICI, modified Thrombolysis In Cerebral Infarction; NA, not applicable.

Figure 2  (A) The mTICI grade distribution. No significant difference was revealed between the pre-pandemic and pandemic groups. (B) The time intervals from onset to successful reperfusion. Compared with the pre-pandemic group, the time from hospital arrival to puncture time (174 vs 125.5 min, p=0.002) and hospital arrival to reperfusion time (213 vs 172 min, p=0.047) in the pandemic group was prolonged significantly. HTP, hospital arrival to puncture; mTICI, modified Thrombolysis In Cerebral Infarction; OTH, onset to hospital arrival; PTR, puncture to reperfusion.
The prolonged hospital arrival to puncture time (by 48.5 min, \(p=0.002\)) and hospital arrival to reperfusion time (by 41 min, \(p=0.047\)) mainly reflected the delay caused by the COVID-19 screening process. In accordance with guidelines of the National Health Commission, all hospitals need to conduct strict COVID-19 screening for all newly admitted patients, including emergency cases. The screening included taking a travel history, chest CT scanning, complete blood count test, body temperature measurement and the ensuing multidisciplinary consultation. Although this screening was started simultaneously with the screening for AIS, and patient transfer among different departments within the hospital was facilitated, it still delayed the subsequent treatment. Another reason was perhaps the launch of PCS. A middle-aged patient was diagnosed as a clinically suspected case of COVID-19 by the multidisciplinary consultation based on fever, abnormal lymphocyte count and signs of inflammation in the chest CT; thus PCS was triggered and EVT was performed under the highest level of protection. Postoperative mTICI 2b recanalization was achieved. Hospital arrival to puncture time was 287 min, 46 min longer than the average hospital arrival to reperfusion time (241 min). On the other hand, our results showed the lengthy increases of hospital arrival to puncture time and hospital arrival to reperfusion time did not impact the short-term outcomes. The currently available data in this study were not enough to explain the above situation. Although there was no significant difference in relation to short-term outcomes, we did not have the long-term follow-ups (eg, 90 day mRS scores) to evaluate the long-term efficacy. Whether the delayed window time for treatment had an impact on the long-term outcomes is thus still unclear. Both situations need further studies.

Puncture to reperfusion time was shown to have a tendency to decrease (from 40.5 min to 32 min) without evidence of any influence on patient safety and successful recanalization rates during the pandemic. A series of attempts were adopted to minimize the time of the EVT procedure, including performing the entire procedure by an experienced neurointerventional specialist and reducing angiography processes based on good CT angiography images. Other reasons may be more frequent use of local anesthesia and first-line ADAPT strategy (42.9% vs 29.4%; OR 1.457, 95%CI 0.711 to 2.987; \(p=0.308\)).

Although hospital arrival to puncture time and hospital arrival to reperfusion time have been prolonged during the pandemic, all clinical outcomes including rate of successful recanalization and procedure-related serious adverse events have remained unchanged during the pandemic. Expert consensus from the Chinese Federation of Interventional and Therapeutic Neuroradiology recommended that all patients, including those receiving emergency cerebrovascular interventional therapy, should undergo preoperative chest CT scanning and multidisciplinary consultations to exclude COVID-19, and the PCS algorithm was established to deal with confirmed or suspected COVID-19 patients. The results of the present study show that this recommendation could potentially reduce the spread of SARS-CoV-2 without threatening patient safety and clinical outcomes.

One of the major limitations of this study is the retrospective, observational design which is prone to inherited selection bias. In addition, the sample size of this single center study was relatively small. Third, the limited follow-up due to the influence of the pandemic does not allow the evaluation of long-term efficacy (eg, 90 day mRS scores). Future prospective multicenter studies with large sample sizes are needed to confirm the above results.

In conclusion, the PCS algorithm which combines COVID-19 screening and protection measures could decrease the impact of the disease on the clinical outcome of EVT for AIS patients to the lowest extent possible during the pandemic. This needs to be confirmed by future well-designed studies.

**Acknowledgements** The authors thank Mr Kun Yang (Department of Evidence-Based Medicine, Xuanwu Hospital, Capital Medical University, Beijing, China) for helping us with statistical analysis.

**Contributors** All authors of this work met the International Committee of Medical Journal Editors criteria for authorship and made substantial contributions to the conception and design, acquisition of data, analysis and interpretation of data, drafting, critical revising, and final approval of this manuscript.

**Funding** This work was supported by the National Key Research and Development Project (2016YFC1301703) and the Beijing Scientific and Technologic Project (D161100003816002).

**Competing interests** None declared.

**Patient consent for publication** Not required.

**Ethics approval** Approved by the Ethics Committee of Xuanwu Hospital ([2020]005).

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** The data used to support the findings of this study are available from the corresponding author upon request.

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**REFERENCES**