Neurology Asia 2021; 26(2) : 215 – 221

ORIGINAL ARTICLES

Patterns of stroke management during the Covid – 19 pandemic: A systematic review

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Abstract

Background & Objective: The Covid-19 pandemic is an unpresented worldwide health emergency that has totally changed how the medical community treat patients with stroke. Deviation from the usual pathways on stroke management has become the collateral damage of this pandemic. This present review summarizes the impact of the Covid-19 pandemic on stroke care. *Methods:* The research question was answered with a systematic literature and results were summarized narratively. A literature search in the databases PubMed, Google Scholar, ProQuest, Cochrane Library, Embase, Web of Science, CIHNL, Open Grey, Grey Net and PROSPERO between 2019 to August 2020 was performed. Three authors reviewed the full texts of potentially relevant studies to determine their eligibility for inclusion. *Results:* Fourteen studies were included in this review. There was a delay in hospital presentation, door-to-needle time and door-to-imaging time in the process flow of stroke management during the pandemic. There was also a decrease in the number of admissions, rate of IV thrombolysis, mechanical thrombectomy and rehabilitation referrals.
Conclusions: The Covid-19 pandemic has totally changed how patients with acute stroke are managed. There is a need to devise ways to circumvent this problem to maximize patient recovery without compromising patient safety.

Keywords: Stroke, cerebrovascular accident, ischemic stroke, hemorrhagic stroke, Covid-19, SARS-Cov 2, Corona virus

INTRODUCTION

Stroke is a one of leading cause of morbidity, mortality and long-term disability worldwide.[1-3] The high rates of mortality, morbidity and disability associated with stroke, in addition to its prevalence, necessitate good, long-term preventive strategies. In 2021, the World Health Organization (WHO) estimated that the death from stroke among low-income and middle-income countries accounted for 85·5% of stroke deaths worldwide, and the disability- adjusted life years (DALYs) lost in these countries was almost seven times more compared to high-income countries. Studies from developed countries suggests that one in 20 adults is affected by stroke and currently exceeds the incidence of acute coronary heart disease.[4] There was a statistically significant trend in stroke incidence over the past four decades, with a 42% decrease in stroke incidence in high-income countries and a greater than 100% increase in stroke incidence in low to middle income countries.[4]

According to the American Heart Association, patients presenting with signs and symptoms of stroke must be brought to a stroke-ready hospital for further treatment. Upon arrival at a stroke-ready hospital, performance of plain cranial CT scan must be done to determine the etiology of stroke, and once deemed eligible for IV thrombolysis, door-to-needle time must be <60 mins. If the patient presents at a stroke-ready hospital >4 hrs but <24 hrs after onset of signs and symptoms of stroke, thrombectomy may be offered. Upon receiving acute care treatment, patient must be admitted to an acute stroke unit or neuro intensive care unit for further monitoring

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Date of Submission: 20 March 2021; Date of Acceptance: 22 March 2021

and management.[5]

For patients suspected with intracerebral hemorrhage (ICH), a patient must be transferred to a stroke-ready hospital with facility and personnel (neurologists, stroke specialist and neurosurgery) capable of managing the patient. Immediate neuroimaging must be done (CT or MRI), investigation of coagulopathy, blood pressure stabilization with anti-hypertensive medications, admission to the intensive care unit (ICU) or dedicated stroke unit with physician and nursing neuroscience acute care expertise and referral to neurosurgery for patients with cerebellar hemorrhage who are deteriorating or with brainstem compression and/or hydrocephalus with ventricular obstruction.[6]

Covid-19 has affected over 153,094,318 confirmed cases including 3,206,399 deaths reported to the World Health Organization (WHO) as of April 2021.[7] The WHO declared Covid-19 caused by severe acute respiratory syndrome corona virus-2 (SARS- CoV-2) as a pandemic on 11 March 2020.[8] Although Covid-19 is primarily a disease of the respiratory tract, studies have implicated that it may also lead to a hypercoagulability and thrombotic complications[7,9] which includes ischemic stroke.

Most of the elective procedures have been set aside, delayed or out-right postponed due to the escalating need for prevention of Covid-19 infection that spread among medical personnel and patients; this also includes reallocation of limited medical resources. For example, there has been reallocation of beds for neurology and stroke patients that includes ICU facilities to favor COVID-19 patients. Moreover, there has been a need to move stroke units to less optimal accommodation and redeployment of stroke physicians, nurses, and other stroke healthcare-related workers to look after COVID-19 patients.[8]

Emergency procedures like endovascular thrombectomy (EVT) for acute ischemic stroke (AIS) must be performed even during the pandemic, not only to save viable neural tissues but also to rescue important functions and save lives.[8,10,11]

To address this alarming situation, we aim to describe the patterns of stroke management during the Covid-19 pandemic. We plan to address the following study objectives: Determine the changes in current clinical practice of stroke care during the Covid-19 pandemic as to: Achievement of the door-to-needle time; achievement of the door-to-imaging time; utilization of acute stroke units; performance of thrombectomy; referral to rehabilitation medicine; performance of decompressive craniotomy; and performance of aneurysm clipping or stenting

METHODS

The present review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA).[12] This review covered 1 research question that was answered from one systematic search strategy.

Studies were selected according to the criterion outlined below. We selected retrospective and prospective studies. These studies were written in any language that will be translated into the English pending approval from the authors.

Studies that included adults (≥ 18 years), both genders, across all socio-economic strata and all races with a diagnosis of stroke based on clinical presentation and imaging, either by magnetic resonance imaging or computed tomography with the following definitions: Transient ischemic attack (TIA) – acute occurrence of focal neurological deficit that resolved within <24 hrs with no evidence of stroke on neuroimaging; Ischemic infarct – stroke that is caused by blockage of an artery either from a thrombus or emboli; ICH – rupture of an intracranial artery into the brain parenchyma; or Subarachnoid hemorrhage – rupture of an aneurysm into the subarachnoid space. An average stroke onset <7 days who sought consult for the first time in a hospital setting will be included.

All studies on the current practice of stroke medicine during the Covid-19 pandemic were included. This include studies on stroke care related to: Emergency room care (door-to-needle and door-to-imaging time); Admission to acute stroke units; Performance of thrombectomy; Availability of stroke-dedicated room or units; Availability of stroke practitioners (stroke doctors and nurses) and Referral to rehabilitation medicine.

Information sources and search strategies

A search for both full text published and unpublished articles and study protocols with preliminary results in the English language was performed. If only the abstract is available during the search, the author was contacted to provide a full-text version of the article. If a study is written in language other than English, the author was contacted to provide the English translation of the article. The search was done by the primary researcher (JRE). The first step

was searching electronic data bases using both subject and headings/terms and free keywords. Databases that were included was the following: PubMed, Google Scholar, ProQuest, Cochrane Library, Embase, Web of Science, CIHNL, Open Grey, Grey Net and PROSPERO. The search was done using in advance identified and fixed search terms from each databases (Appendix Table 1-3). There were no restrictions on date of publication status applied to the searches. The second step was a hand search of the reference lists and bibliographies of all identified reports and articles (backward search) that were included in the review. Additionally, a citation search was conducted on the Web of Science to identify articles which included publications that have been cited (forward search).

Data management

Literature search was uploaded to Mendeley, a software program that facilitates collaboration among reviewers during the study selection process. The team developed and tested screening questions and forms for level 1 and 2 assessment based on inclusion and exclusion criteria. Citation abstracts and full text articles were uploaded with screening questions to Mendeley. Prior to the formal screening process, calibration exercise was undertaken to pilot and refine the screening questions. Further, we provided training to members of the review team not familiar with Mendeley. All articles were organized into folders that would indicate the process of screening. They were: All articles; Screened through titles; Screened through abstracts; Screened through full text; and Removal of duplicates.

Study selection process

First sensitive study selection was done by the primary researcher (JE) by screening title yielded by the databases. Next, abstracts and full texts of the articles selected in the first step was restricted in terms of the aforementioned eligibility criteria. Abstracts and full text analysis was done by one independent researcher (MLC). Disagreements between the researchers were resolved through discussion or adjudication of a third independent researcher (JAC). Reference lists of finally included articles were screened in the same way. To illustrate the study selection process and reasons for exclusion, a PRISMA flow chart is provided (Figure 1).

Data collection process

Data was extracted from studies eligible for inclusion using the JBI extraction form. The coding was done by two independent researchers (JE & MLC) and an inter-rater reliability was calculated – interclass correlations for continuous variables and Cohen's Kappa for categorical variables. If there are disagreements concerning the coding was resolved through discussion or adjudication of a third reviewer (JAC).

Reference lists of final articles were screened for articles that tackled stroke management during the Covid-19 pandemic period.

Data Items

The following variables were extracted from the each study: a. Study identification: first author, year of publication, country where recruitment took place; b. Study design: sample size, control group, design type, assessment tool used to determine the presence of stroke (CT, MRI, other. Taking into consideration the door-to-CT time); c. Intervention: thrombolysis (taking into consideration door-to-needle time, thrombectomy, acute stroke unit), decompressive hemicraniectomy, clipping or stenting? Or Coiling of an aneurysm; d. Others: stroke-dedicated beds, stroke doctors, stroke nurses

Outcomes and Prioritization

The primary outcome of interest was the change in acute stroke care, in terms of: a. Emergency room care (door-to-needle and door-to-imaging time); b. Admission to acute stroke units or neuro ICU; c. Performance of thrombectomy d. performance of thrombolysis; Availability of stroke-dedicated room f. availability of stroke practitioners (stroke doctors and nurses); Referral to rehabilitation medicine h. Decompressive hemicraniectomy and clipping & stenting? Or coiling of an aneurysm.

The diagnosis of stroke was done through clinical examination and confirmed by neuroimaging either computed tomography (CT) scan or magnetic resonance imaging (MRI).

Stroke timelines would include: a. Door-to-CT time, which is defined as the time the patient went in the emergency room to the time the patient was brought to imaging; b. Door-to-needle time which is defined as time the patient went in the emergency room to the time patient was given IV thrombolysis. These were measured in minutes and were assessed as achieved or not achieved depending on the recommendation of the American Heart Association/American Stroke

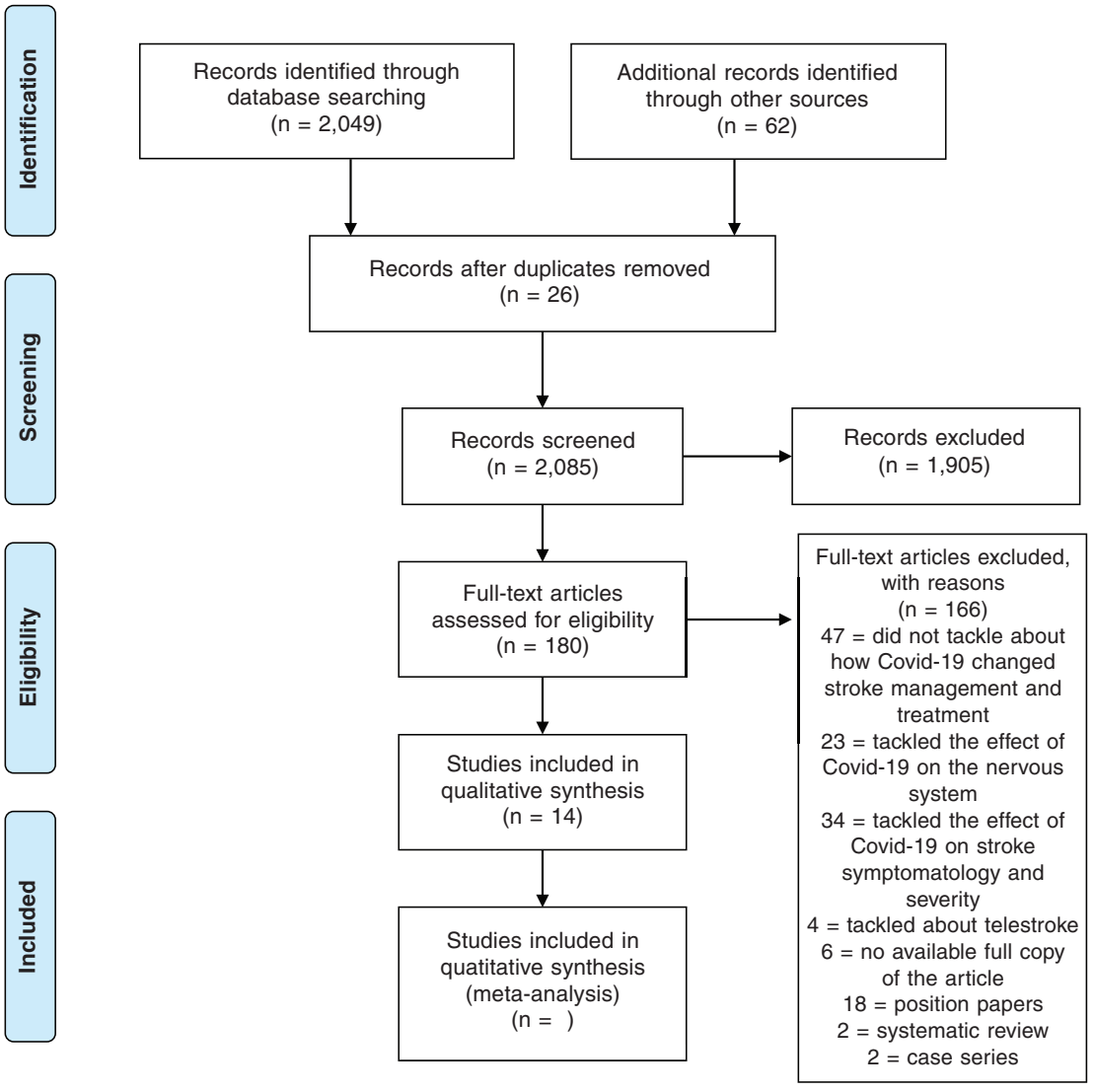

Figure 1. Flowchart for selection of evaluation of screening approaches.

Association guidelines for the management of acute ischemic stroke eligible for thrombolysis.

Intervention for acute stroke included the following: a. Thrombolysis which involves giving of IV recombinant tissue plasminogen activator for patients with acute ischemic stroke; b. Thrombectomy which is an intravascular intervention either to retrieve the blood clot or stent placement.

Quality assessment

Critical appraisal was done by using the Critical Appraisal Skills Program (CASP) check list. Two reviewers (JE & MLC) independently assessed the quality of the included studies. For each included study, the description of risk was be provided as "yes", "can't tell" and "no" for each domain, depending on the type of study that was included in the review.

Data synthesis

A narrative synthesis was performed to synthesize the findings of the different studies. Because of the range of very different studies that are included in the eligibility criteria (type of studies), we have decided that a narrative synthesis constitutes the best instrument to synthesize the findings of the study. First, a preliminary analysis that involved searching of studies, listing and presenting the results in a tabular form. Then the results were discussed again and will be structured into themes. Afterwards, summarizing the studies in a narrative

synthesis within a framework was performed by the primary author (JRE). The framework consisted of the following factors: a. Diagnostic procedures (CT, MRI, door-to-needle time); b. Treatment (thrombolysis taking into consideration door-to-needle time, thrombectomy, acute stroke unit, decompressive hemicraniectomy, clipping or stenting? of aneurysm); c. Hospital resources (acute stroke unit stroke dedicated beds) and d. Personnel (stroke doctors, and stroke nurses).

RESULTS

The bibliographic search yielded 2,111 hits; 2,085 hits without duplicates were screened; 180 were potentially relevant and obtained full text. (Figure 1) Subsequent full paper-based screening excluded an additional 166 references, as they did not address how Covid-19 changed stroke management (n=47), as they addressed the effects of Covid-19 in the Central nervous system (n=23), as they addressed the effects of Covid-19 on stroke symptomatology and severity (n=34), as they addressed telestroke (n=4), no available full article (n=60), position papers (n=18), systematic reviews (n=2) and case series (n=2). We ultimately included 14 studies: Salavatore[13], Hadju[14], Hoyer[15], Montaner[16], Diegoli[17], Havenon[18], Teo[19], Meza[20], Yang[10], Yaeger[21], Kasab[22], Naccarato[23], and Kerleroux.[24] Overall quality of the articles was found to be acceptable, with clearly stated research questions and appropriately used methods, recruitment strategies and data analyses.

The characteristics of the 14 studies are presented in Appendix Table 4. There were 4 studies that discussed about stroke code activation, 4 studies discussed door-to-needle time, 1 study discussed door-to-imaging time, 8 studies talked about stroke admission, 11 studies talked about thrombolysis, 11 studies talked about mechanical thrombectomy and only 1 study talked about rehabilitation. Most of these were conducted in Western countries with only 2 studies done in Asia (China and Hong Kong). Most were conducted in stroke-capable hospitals. 11 studies were retrospective and 3 were prospective studies.

Stroke code activation

There was a decrease in stroke code activation[13,23] comparing the pre-pandemic and pandemic period . This was accompanied by a delay from symptom onset to arrival to the hospital time by half an hour[16] to an hour.[19] There were also lower proportion of patient that arrived at the hospital within 4.5 hours.[19]

Door-to-imaging time

There was an increase in the door-to-imaging time from 21 mins to 22 mins (p=0.61), although it was not statistically significant.[13]

Door-to-needle time

There was an increase in the door-to-needle time, although it was not statistically significant except for the study by Monataner[16] which showed a significant delay in the administration of Iv rTPA (59 mins vs 75 mins, p<0.001) and Yang (174 mins vs 125.5 mins, p=0.002).

Acute stroke unit admission

There was a decrease in stroke admission across all studies. Looking into the type of stroke per admission, there was a decrease in admission rates of patients with TIA, ischemic stroke and subarachnoid hemorrhage. On the other hand, ICH remained to be similar to those in 2019.[17]

IV thrombolysis

There was a decrease in the rate of giving IV rTPA across all the studies. If we are to compare high Covid-19 burden countries and low Covid-19 burden countries, thrombolysis rate were lower in high Covid-19 burden countries as well as, lesser Covid-19 (+) patients received IV rTPA.[22] Despite these small numbers, the rate of successful recanalization, hemorrhagic transformation & neurological and functional status were similar with 2019[13] or not statistically significant.[10]

Mechanical thrombectomy

There was a drop in the number of patients who underwent mechanical thrombectomy. For those who underwent mechanical thrombectomy, there was a faster procedural time.[13,22] There were also delays in the stroke onset-to-groin puncture time[14,10,21,22,24], except in the study of Montaner which showed an improvement in the doo-to-puncture times (141 mins vs 119 mins, p<0.001). Comparing the low Covid-19 burden countries vs high Covid-19 burden countries, there was a trend towards a longer door-to-groin time in the low Covid-19 burden countries.[22] Despite this events, the rate of successful recanalization were similar as of 2019[13,24], as well as the rate of hemorrhagic transformation and neurological impairment and functional status.[13]

Physical rehabilitation

There were less stroke patients referred for physical rehabilitation as compared to the period before the pandemic.[23]

DISCUSSION

The Covid-19 started in Wuhan, China in December 2019 and caused a pandemic that change the way medical care was given to patients. It caused a significant change in stroke management, whether it is transient ischemic attack, ischemic stroke, intracerebral hemorrhage or subarachnoid hemorrhage.

Most of the elective procedures have been put aside or not pushed through because of the escalating need for prevention of Covid-19 infection and spread among medical personal and patients: also includes reallocation of limited medical resources. For example, there has been reallocation of beds for neurology and stroke patients which also includes ICU facilities to COVID-19 patients. There is also the need to move of stroke units to less optimal accommodation and redeployment of stroke physicians, nurses, and other stroke healthcare-related workers to look after COVID-19 patients.[8]

During the Covid-19 pandemic, there was a reduction in stroke code activations and stroke admission.[13,17] This could be due to an overload of emergency calls that could have saturated the patient transport system and fewer stroke code activations, particularly with elderly patients who may feel more threatened by the spread of Covid-19 infection.[13] This posed a huge collateral damage in acute stroke patients with lesser emergency treatments or missing the therapeutic window due to delays in hospital admissions or referrals or patients not entering the hospital at all.[16]

Decreased public mobility[15] and business activities[18] due to imposed lock-downs in certain areas around the world may reflect the effectiveness of stay-at-home orders as one constituent measure of social distancing. As indicated by the positive correlation of lower admission rates for stroke/TIA with decreased public mobility during the pandemic, such measures may influence patients' willingness to seek medical help for acute symptoms. On a similar note, medical workers from all around the world have been joining campaigns urging people to stay home. Such campaigns may have contributed to the reduced admissions for acute stroke, if not balanced by raising and sustaining public awareness for stroke. WE CAN REMOVE this - in particular regarding the importance of timely diagnosis and treatment of acute neurological symptoms, for example, through social media or respective information on-site. To resolve this, patients should be encouraged to seek medical care and be assured that hospitals make every effort to provide the necessary precautions and employ appropriate protocols in preventing contact/exposure to potentially infectious Covid-19 patients. All of these are paramount in avoiding serious healthcare and economic consequences resulting from undiagnosed and untreated strokes.[15]

Aside from the substantial change in the conduction of mechanical thrombectomy since the start of the Covid-19 pandemic, neurointensive specialists were reassigned to a Covid-19 focused intensive care unit, thus the endovascular team member assumed the role of the neurointensivist.[21]

Across all studies, there was a decline in the rate of giving IV thrombolysis amongst Caucasian and Asian countries. This may be due to the delay in hospital-arrival time, beyond the therapeutic window for thrombolysis.[19]

Despite the delays in hospital arrival, delivery of IV thrombolysis and mechanical thrombectomy, all clinical outcomes including rate of successful reperfusion, hemorrhagic conversion, procedure - related adverse events, neurological impairment and functional status were similar with that of the pre-pandemic period in 2019.[10,13,24]

In Asia, where the Covid-19 originated, there were also significant changes in stroke management during the pandemic. Although Hong Kong was able to maintain most of their stroke services[19]; in Wuhan China for example, the Chinese Federation of Interventional and Therapeutic Neuroradiology recommended that all patients, including those receiving emergency cerebrovascular interventional therapy, should undergo pre-operative chest CT scan and multi-disciplinary consultations to exclude Covid-19 to potentially reduce the spread of Covid-19 without threatening patient safety and clinical outcomes.[10]

In conclusion, the Covid-19 pandemic has totally changed the way we manage emergency cases like acute stroke. Acute stroke management has been recognized as one of the collateral damages during this pandemic. It is not known how long this pandemic will continue, but early implementation of protective measures to secure the patient's safety must be taken into consideration. In addition to in-hospital contingency plans, patient transport system and public education must be coordinated to better protect the patients with acute stroke. Solutions

in this unpresented global public health scourge may vary locally and regionally but considering alternate or dedicated emergency medical system pathways for neurovascular emergencies may help maintain case volumes and continuity of care. Public education about the importance of seeking medical assistance in case of symptoms of stroke, even if the presentation is mild or transient is of utmost importance. It must be emphasized that emergent care for acute stroke should not be postponed during a pandemic due to its high morbidity and mortality.

There were several limitations of this review, most importantly would be the novelty of the disease, that is Covid-19. The studies included in this review only look into patients with stroke from December 2019 up till mid-2020. We might still not see the full extent of this pandemic and its effect in our current health care system. As such, there is paucity of studies regarding surgical management in stroke, that is decompressive hemicraniectomy and aneurysmal clipping and coiling. Moreover, there is also paucity of studies regarding cerebral venous thrombosis. It is therefore recommended for those who will undertake future studies or reviews similar to this topic/s to extend the time frame, in the premise that the pandemic is still ongoing with subsequent and consequent adjustments to improve on how the medical community handle medical emergencies in the midst this pandemic.

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APPENDIX

Table 1: Initial logic grid aligned with the PEO elements of the review question

Population	Exposure	Outcome
Stroke patients	Covid-19	Current stroke medicine practice

Table 2: Logic grid with identified keyword added

Population	Exposure	Outcome
Population Stroke patients Cerebrovascular disease* CVA Isch!mic stroke Thrombotic stroke Embolic stroke Hemorrhagic stroke H!morrhagic stroke Intracerebral hemorrhage Intracerebral h!morrhage Subarachnoid hemorrhage Subarachnoid h!morrhage Cerebral venous thrombosis Cerebral sinus venous thrombosis	Covid-19 SARS-Cov 2 Corona Virus Severe acute respiratory syndrome corona virus 2 SARS 2	Current stroke medicine practice Stroke care Current stroke practice Stroke timeline Emergency room Door-to-CT time Door-to-needle time Thrombolysis Thrombectomy Acute stroke unit Stroke bed Stroke specialists Stroke rehabilitation Decompressive hemi craniotomy Aneurysmal clipping Aneusrysmal stenting

Table 3: Search strings for the different databases

Suche		Pubmed	Cochrane Library	Google Scholar	Web of science	Open Grey	Grey net	Proquest	Prospero
1	Stroke	12,755	4,471	90,000	15	1334	0	30548	5479
2	Cerebrovascular Disease*	11,559	643	23,800	821	42	0	7,569	388
3	CVA	12,713	36	16,000	0	15	0	843	194
4	Isch!mic stroke	5,246	835	40,000	15	98	0	11,372	14
5	Thrombotic stroke	759	835	16,800	15	3	0	1,476	2
6	Embolic stroke	838	800	13,500	15	5	0	916	656
7	Hemorrhagic stroke	2,208	140	17,600	16	11	0	630	240
8	Intracerebral Hemorrhage	1,657	170	17,300	1	1	0	602	152
9	Intracerebral H!morrhage	1,657	170				0		
10	Subarachnoid Hemorrhage	859	130	17,000	1	15	0	606	175
11	Subarachnoid H!morrhage	859	130				0		
12	Cere venous thrombosis	225	27	16,200	1	16	0	1,043	15
13	Cerebral sinus venous thrombosis	93	13	12,300	1	4	0	384	0
14	1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13	16,990	5,101	7,140	269	1405	0	34,910	
15	Covid-19	5,609	1,317	85,400	0	0	4	31,206	2165
16	SARS-C0v 2	4,760	83	22,400	4	2	0	12,774	1138
17	Corona virus	112	737	45,400	0	70	1	28,735	1444
18	Severe acute respiratory syndrome corona virus 2	94	40	42,800	81	0	0	1,636	3
19	SARS 2	1,958	588	34,500	4	0	0	14,717	10
20	15 OR 16 OR 17 OR 18 OR 19	5,616	1,409	16,900	72	81	4	37,239	2217
21	Current stroke medicine practice	106	98	36,900	2,398	14	0	7,244	0
22	Stroke care	2,798	1,031	89,100	224	2	0	17,680	53
23	Current stroke practice	162	202	51,800	1,210	19	0	10,377	0
24	Stroke timeline	8	8	12,100	1,210	0	0	711	0
25	Emergency room stroke	221	20	18,100	2,960	4	0	1,592	0
26	Door – CT - time	0	26	1,200	3	1	0	2,263	0
27	Door – to Needle time	49	14	16,900	2	1	0	622	9
28	Thrombolysis	1,081	312	17,200	1	62	00	2,268	262
29	Thrombectomy	1,074	180	15,200	0	6	0	1,151	137
30	Acute stroke unit	1,682	174	25,400	24	15	0	6,211	8
31	Stroke bed	54	53	18,300	9	6	0	2,594	0
32	Stroke specialist	118	118	17,900	9	8	0	2,315	3
33	Stroke rehabilitation	1,869	1,017	21,600	59	112	0	4,502	182
34	Decompressive hemi craniotomy	2	0	1,120	0	0	0	6	2
35	Aneurysmal clipping	285	12	5,220	1	0	0	219	1
36	Aneurysmal stenting	995	1	16,400	1	0	0	132	0
37	21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30 OR 31 OR 32 OR 33 OR 34 OR 35 OR 36	7,781	2,343	12,900	4.042	365	0	24,462	533
38	14 AND 20 AND 37	85	18	210	548	0	0	1,185	3

Table 4: Characteristics of the studies Included in the review

AUTHOR	DATE	JOURNAL	METHODOLOGY	PHENOMENON OF INTEREST							
				STROKE CODE	DTN TIME	DTI TIME	ASU	rTPA	MT	RM	DH
Salvatore R *et al*.	July 2020	Stroke AHA	Retrospective, observational	Decrease in activation by 18% (P<0.01)	Increase DTN from 28 (22-23) mins to 23 (21-48 mins (p= 0.64)	Increase DTI time from 21 (19-26) mins to 22 (20-27) mins (P=0.61)	Decrease stroke admissions by 23% (P=0.07)	Decrease in thrombolysis By 23% (P=0.57) Rates of successful recanalization, hemorrhagic complications & neurological impairment and functional status is similar as of 2019	Decrease in Thrombectomy Performed by 24% (P=0.87) Decrease procedural time from 55 (37-65) mins to 36 (30-66) mins P=0.31 Rates of successful recanalization, hemorrhagic complications & neurological impairment and functional status is similar as of 2019	-	-
Hadju S. *et al*.	August 2020	Stroke AHA	Retroscpective, observational						Decrease in mean number of EVTs performed (9.0 (95% CI, 7.8010.1)) and after covid-19 confiement (6.1 (95% CI, 4.5 -7.7)), (P<0.001) significant increase in mean stroke onset-to-groin puncture time (P<0.001), between before COVID- 19 confinement (300.3 minutes [95% CI, 285.3–315.4]) and after COVID-19 confinement (354.5 minutes [95% CI, 316.2–392.7]		
Hoyer C *et al*.	July 2020	Stroke AHA	Retrospective, multi-center study				There was a significant decrease in stroke admissions (Center A: 85%, BC: 43%, D:46%) 95% CI A 0.38-0.99 B 0.83-1.63 C 0.74 – 1.49 D 0.35 – 0.83 P value A 0.046 B 0.377 C 0.799 D 0.005	Center A: significant drop in thrombolysis rate by 60% 95% CI A 0.19- 0.86 B 0.34 – 2.43 C 0.48 – 2.1 D 0.29 – 2.13 P value A 0.019 B 0.838 C 0.995 D 0.629	Center A: decrease thrombectomy rate by 61% 95% CI A 0.17 – 0.87 B 0.87 – 4.04 C 0.48 – 2.99 D 0.31 – 1.67 P value A 0.022 B 0.108 C 0.685 D 0.436		
Montaner J *et al*.	August 2020	Stroke AHA	Descriptive study	Mean times of arrival to hospital from symptoms onset was delayed almost half an hour (93 mins pre-covid vs 119 mins post-covid, P<0.001	Delayed by 16 mins than usual (59 mins vs 75 mins, pre and post covid, P<0.001)		Decrease in admission by 25% (P<0.001)	Decrease thrombolysis (28 vs 23, pre and post-covid, P<0.001)	Mean global number of thrombectomies was reduced from a man of 24 cases to 17 cases (P<0.001) Mean times of arrival to thrombectomy from symptom onset improved during the pandemic (316 mins vs 293 mins, pre and post covid, P<0.001) Door-to puncture times improved accordingly (141 mins vs 119 mins, pre and post-covid, P<0.001		

RM	DHM	ANEURYSM TX	SETTING	GEOGRAPHICAL	CULTURAL	PARTICIPANTS	DATA ANALYSIS	CONCLUSION
	-	-	Hospital clinic	Barcelona, Spain	Caucasian	Patients with stroke	Continuous variables were reported as mean and SD and were compared with the Mann-Whitney tests. Categorical variables were reported as proportions and compared to with the X^2 and Fisher exact test	Moderate reductions of stroke code activations, stroke admissions and thrombectomies, particularly among elderly patients who may feel more threatened by the infection.
			Stroke centers	Switzerland, France, Spain, Portugal, Germany, Canada, USA	Causasians	Patients with ischemic stroke	Mean of number of EVT performed	There was decreased in the number of EVT performed as well as an increased in the mean stroke onset-to-groin puncture time.
			Academic stroke centers	Germany	Caucasians	Patients with ischemic stroke and TIA	Poission regression was used for the rate of events, covariance for possible overdisposition, rank correlations between moblity and stroke admissions. P<0.05 indicates statistical significance.	Decreased public mobility reflect effectiveness of public measure for the pandemic but it also cause a decrease in stroke admissions.
			Provincial hospital	Southern Europe	Caucasian	Patients with ischemic stroke	All categorical data presented as numbers and frequency, continuous data as mean and SD. In bivariate analysis the X2 text, Fisher Exact test, Student test and Mann-Whitney U test. P<0.05 as significant.	There was a huge collateral damage to acute stroke patients during the pandemic. There fewer emergency treatments and missing the therapeutic window due to delays in hospital admissions or referrals or patients preferring not to enter the hospital at all.

Diegoli H *et al*.	August 2020	Stroke AHA	Prospective Observational				Thee was a decreased in TIA admission from 2.28 cases/100,000 per month (SD0.8) to 0,51, P=0.0049 Admission of ICH remained similar to those in 2019 (0.8 (SD 0.4)in 2019 and 0,5 after covid) P=0.3645 Reduced SAH admission (0.4 in 2019 (SD 0.2) and 00.s post-covid. P=0.4453 Reduced admission for ischemic stroke from 9.4 in 2019 (SD1.4) to 6.3 post-covid) P=0.0195	There was decreased reperfusion therapies from a range or 0.51 to 1.35 /1000,000 per month (SD 0.29) to only 0.34/100,000 per month, but there was no statistical difference from 2019 (P=0.1024)			
Havenon A *et al*.	May 2020		Retrospective, observational				Decrease in stroke admission by 18.5% Decreased by 36.8% for ischemic stroke, 15.&% for ICH	Decreased in rTPA by 3.3%	There was an increased in MT by 18%		
Teo KC *et al*	July 2020	Stroke AHA	Retrospective, observational	Median onset stroke onset-to- door time delayed by 60 mins (154 (60-618) vs 95 (58-291), P=0.12) post and pre-covid There was a significant lower proportion of individuals with onset-to-door time within 4.5 hrs (40/73 (54.8%) vs 64/89 (71.9%), P=0.024)	No significant different in DNT P=0.12		Decreased in stroke admission from 89 to 73, pre and post-covid. Decreased TIA admission (14/89 vs 3/73, P=0.016)	No significant difference in rTPA P=0.95	No significant difference in MT P=0.43		
Meza H *et al*.	July 2020	International Journal of Stroke	Multicenter retrospective, observation s				there was a decline in admission from weekly average or 178 to 124, pre and post-covid, but it did not occurred homogenously in each hospital, the reduction was onlys significan in 6 out of 126 centers.	No statisifacly significance (17.3% vs 16.1%, P=0.405	No statistically sgnficance (22% vs 23%, P=0.504)		

			Local hospitals	Joinville, Brazil	Caucasians	Patients with TIA, mild and moderate stroke	Shapiro-Wik test for normality for the monthly incidence and number of IVT and MT per month and the distributions were presented in histograms. Data were compared by univariate analysis using Wlcoxon-Mann-Whitney test fro time to onset to admission.	The onset of COVID-19 was correlated with a reduction in hospital admissions for stroke in patients with less severe presentations. Particular attention should be given in reassuring the population about the importance of seeking medical assistance in case of symptoms of stroke, even if the presentation is mild or transient.
			Academic and community hospitals	USA	Caucasians	Patients with stroke and ACS	Descriptive analysis	Due to the rise on Covid cases, there was a corresponding interventions at hospitals across the country declined.. Because the most likely explanation is that some patients with stroke and ACS were not seeking medical care, public health messaging should include reminders that emergent care for acute cardiovascular and neurologic symptoms should not be postponed during a pandemic.
			hospital	Hong Kong	Asians	Patients with stroke and TIA	Baseline demographics, vascular risk factors, stroke sub- types and severity, stroke onset-to-door time, and critical time points in inpatient acute stroke care between COVID-19 vs pre–COVID-19 were compared using t test, $\chi 2$, and Mann-Whitney U test where appropriate. All analyses were done with Stata version 14, and a P value of <0.05 was considered sta- tistically significant.	HK's stroke service appears to have mostly maintained. Centralized diversion to pro- tected stroke centers that remain fully operational, and informing the public of such system is vital to prevent tragedies of potentially treatable patients with stroke being denied appropriate treatment during this pandemic
			Tertiary hospitals in the NORDICTS network	North-west Spain	Caucasians	Patients with ischemic stroke	Descriptive statistics to compare the incidence. Qualitative variables are described using counts and per- centages, and continuous quantitative variables as means with standard deviation and medians with interquartile ranges when necessary. Comparisons were made using chi-square tests for comparing categorical variables and the Student test or Mann- Whitney U test for continuous variables; p values<0.05 were considered statistically significant.	There was a decrease in the number of ischemic stroke admissions. Healthcare systems should be rapidly adapted to implement systems for COVID-19 care, but also to ensure the usual and effective stroke care despite system reorganizations. Since stroke is a life-threaten- ing condition, it is important not to neglect the usual level of stroke care regardless of the difficult situation derived from the COVID-19 pandemic.

Yang B *et al*.	July 2020	Journal NeurolInter-ventional Surgery	Retrospective, observational		Compared with pre-covid, DNT time (174 vs 125.5 mins, P=0.002) Hospital arrival time to reperfu-sion time (213 vs 172 mins, p=0.047)		There was a decrease admission from 34 (61.8%) pre to 21 (38.2% post covid.	Decrease in rTPA from 12 to 11 (95% CI 1.484 (0.806 – 2.734) P=0.212) Rate of successful reperfusion was not statistically signifi-cant in the pre-covid vs posr-covid grp (88.2% vs 85.7%, OR 0.971, 95% CI 0.785 to 1.203, P=1.0000) Decreased in hemor-rhagic transformation from 7 (20.6%) to 2 (9,5%) p=0.482	Increase hospital arrival to puncture time, me-dian of 125.5 (113-153) mins to 174 (139-104) p=0.002		
Yaeger KA *et al*	August 2020	American journal of neuroradiol-ogy	Retrospective study						Median time to EVt consultation to vascular access was 65 mins.		
Kasab S *et al*.	July 2020	Journal or NeuroInter-ventional surgery	Prospective inter-national study		Longer DTN time of covid (+) as compared to non-covid (82 mins vs 56 mins, p=0.315)			More patients received tPA in the low covid burden countries (29 (27.9%) vs 155 (43.8%), P=0.004) vs high co-vid burden countries A decrease in rTPA in covid (+) px as com-pared to non-covid (30.8% vs 40.4%, p=0.576)	Trend toward longer door to groin time in the Low covid burden countries (85(45-127) vs 68 (360123) mins, P=0.054) vs high covid burden countries Faster procedural time I covid (+) as compared to non-covid (04 mins vs 45 mins, p=0.455)		
Naccarato M *et al*.	May 2020	Journal of Neurological Science	Retrospective study	Low absolute stroke code activations post and pre-covid (9 vs 17) (56% vs 59%)	Decrease DTN time post and pre-covid (51 mins vs 57 mins)		Decreased stroke admission, 16 in 2020 patients as compared to 29 at the same period in 2019 (decreased by 45%)	Low absolute tPA treatments (6 vs 12)		Lesser px re-ferred to rehab post and pre-covid (44% vs 52%)	
Kerleroux B *et al*.	July 2020	Stroke AHA	prospective					Decreased in IVT from 51% to 43.5%, prre and post-covic, p=0.029	A drop of an overall 20.9% stroke patients recieving MT. (0.79 (95% CI, 0.76 – 0.82, P<0.001) Slight delays between imaging and groin puncture (mean 144.9 +/- SD 86.8 mins vs 126.2 +/- SD in 2019, P<0.001) Similar rates of suc-cessful reperfusion (82.3% vs 82%, p=0.932)		

			Comprehensive stroke center	Wuhan, China	Asians	Patients with ischemic stroke	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 $\chi 2$ 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	Despote the delays in the stroke time line, all clinical outcomes including rate of successful reperfusion and procedure-related serious adverse events have remained unchanged during the pandemic.
				New York	Caucasians	Patients with ischemic stroke due to ELVO		Post-thrombectomy care has changed substantially since the study period began. With neurointensive care faculty reassigned to a COVID-19-focused intensive care unit, an endovascular team member has assumed the role of neurointensivist
			All centers included in the Strokes Thrombectomy Registry (STAR) and Endovascular Neurosurgery Research Groups (ENGR)	North America, South America, Europe	Caucasians	Patients with stroke	descriptive statistics for demographics and clinical characteristics using median and IQR for continuous variables and percentages for categorical variables. Comparison using the Wilcoxon rank- sum (Mann–Whitney U) test, Fisher's exact test, and chi- square as appropriate.	In this prospective, multicenter, international study, we found a low number of confirmed COVID-19 infections among stroke patients with LVO undergoing MT in LCC.
esser re- rred nab ost d e- vid 4% %)			University hospitals	Italy	Caucasians	Patients with stroke	Subgroup analysis and data presentation was proposed for 2019 and 2020 patients, continuous variables were presented as medians (25th–75th percentile) and non-continuous variables as percentages. Differences between the two groups were tested with the appropriate nonparametric tests (namely, Mann-Whitney U test) and chi-square. A level of $p < .05$ was regarded as statistically significant	In conclusion, the adopted strategies for stroke management during the COVID-19 emergency have suggested being effective, while suffering a reduced and delayed reporting of symptoms. Therefore, we recommend raising awareness among the population against possible stroke symptoms onset.
			Thrombectomy capable stroke centers	France	Caucasians	Patients with acute ischemic. Stroke due to LVO	Categorical variables are expressed as numbers (%) and con- tinuous data as medians (interquartile range) as appropriate. To test the impact of the outbreak, they analyzed the data in the following ways. Poisson regression model, the Pearson correlation coefficient, the $\chi 2$ or Fisher exact test Student t test or the Wilcoxon rank-sum test. The threshold for statistical significance was set at 0.05	There was significant decrease in patients treated with MTs during the first steps of the COVID epidemic in France and alarming indicators of lengthened care delays.