

ORIGINAL CONTRIBUTION

Acute Stroke Care Is at Risk in the Era of COVID-19

Experience at a Comprehensive Stroke Center in Barcelona

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BACKGROUND AND PURPOSE: The purpose of the study is to analyze how the coronavirus disease 2019 (COVID-19) pandemic affected acute stroke care in a Comprehensive Stroke Center.

METHODS: On February 28, 2020, contingency plans were implemented at Hospital Clinic of Barcelona to contain the COVID-19 pandemic. Among them, the decision to refrain from reallocating the Stroke Team and Stroke Unit to the care of patients with COVID-19. From March 1 to March 31, 2020, we measured the number of emergency calls to the Emergency Medical System in Catalonia (7.5 million inhabitants), and the Stroke Codes dispatched to Hospital Clinic of Barcelona. We recorded all stroke admissions, and the adequacy of acute care measures, including the number of thrombectomies, workflow metrics, angiographic results, and clinical outcomes. Data were compared with March 2019 using parametric or nonparametric methods as appropriate.

RESULTS: At Hospital Clinic of Barcelona, 1232 patients with COVID-19 were admitted in March 2020, demanding 60% of the hospital bed capacity. Relative to March 2019, the Emergency Medical System had a 330% mean increment in the number of calls (158 005 versus 679 569), but fewer Stroke Code activations (517 versus 426). Stroke admissions (108 versus 83) and the number of thrombectomies (21 versus 16) declined at Hospital Clinic of Barcelona, particularly after lockdown of the population. Younger age was found in stroke admissions during the pandemic (median [interquartile range] 69 [64–73] versus 75 [73–80] years, $P=0.009$). In-hospital, there were no differences in workflow metrics, angiographic results, complications, or outcomes at discharge.

CONCLUSIONS: The COVID-19 pandemic reduced by a quarter the stroke admissions and thrombectomies performed at a Comprehensive Stroke Center but did not affect the quality of care metrics. During the lockdown, there was an overload of emergency calls but fewer Stroke Code activations, particularly in elderly patients. Hospital contingency plans, patient transport systems, and population-targeted alerts must act concertedly to better protect the chain of stroke care in times of pandemic.

Key Words: COVID-19 ■ pandemic ■ Spain ■ thrombectomy ■ workflow

In December 2019, the emergence of a novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), in Wuhan, China, has evolved into a pandemic with reported cases in >200 countries.¹ The crisis is straining the healthcare system worldwide, and

depending on the local intensity of the crisis, there is a high risk of preventing the application of well-established therapies to patients with prevalent conditions, such as cancer,² acute myocardial infarction,³ or acute ischemic stroke.⁴

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Nonstandard Abbreviations and Acronyms

COVID-19	coronavirus disease 2019
ECASS II	European Cooperative Acute Stroke Study II
EMS	Emergency Medical System
HCB	Hospital Clinic of Barcelona

The coronavirus disease 2019 (COVID-19) pandemic challenges hospital leaders to make time-sensitive, critical decisions about clinical operations, and resource allocations.⁵ The impact of the ongoing crisis on acute stroke care is not settled, and it may not be dependent only on in-hospital decisions, but it may also depend on how efficient is the prehospital care system to provide optimized prehospital triage and equitable access to acute treatments.⁶ Here, we aimed to analyze the impact of the COVID-19 outbreak on the chain of acute stroke care in a Comprehensive Stroke Center in Barcelona, a city hard hit by the pandemic. The study paid special attention to the number of Stroke Code activations, stroke admissions, and the number of reperfusion therapies performed in eligible patients, highlighting the dependence of efficient prehospital care for maximization of the benefits of in-hospital care.

METHODS

Acute Stroke Care in Catalonia

In Catalonia (total population of 7.5 million inhabitants), acute stroke care is provided through a network of 26 acute hospitals, including 6 Comprehensive Stroke Center.⁷ The Emergency Medical System (EMS) is the main activator of the Stroke Code and the patient transport system that guarantees the urgent and priority transfer of a patient with suspected acute stroke to the nearest hospital with the appropriate diagnostic and therapeutic capacity. All Stroke Codes in Catalonia are prospectively recorded by EMS personnel and stored in the regionwide *Codi Ictus Catalunya* Register.⁸

Hospital Clinic of Barcelona (HCB) is a public University Hospital with 713 hospital beds, including 48 intensive care beds, serving as a community hospital to a population of 540 000 inhabitants and providing tertiary acute stroke care to a population of 2 200 000. The Stroke Service at HCB has a Stroke Unit with 8 semi-intensive care beds and 10 conventional hospital beds managed by a multidisciplinary team of vascular neurologists, neurosurgeons, neurointerventionalists, anesthesiologists, and emergency physicians. On average, 1000 Stroke Codes are dispatched to our center every year, where roughly 300 acute reperfusion treatments are performed, of which 200 are thrombectomies.

On February 15, 2020, the first patient with COVID-19 was admitted at HCB (and in Catalonia). On February 28, HCB implemented contingency plans to contain the pandemic, including suspension of all nonessential visits and adjustment of clinical

out-patient and in-patient services and the progressive opening of quarantine wards according to changing needs. As part of its general planning, HCB refrained from limiting the full capacity and personnel of the Stroke Team and the Stroke Unit, including in-patient speech therapy and rehabilitation. The 24/7 availability of multimodal brain imaging, computed tomography–angiography, and endovascular treatment for eligible patients was guaranteed. The availability of brain magnetic resonance imaging was maintained during hospitalization, although the use of ultrasonography was replaced by vessel imaging studies. To further limit the risk of infection among the stroke personnel, we also abbreviated the neurological exam to minimize physical contact with the patient, and we limited the performance of transthoracic echocardiography by stroke neurologists or petitions of transesophageal echocardiography to the Cardiology Department. Other performance quality indicators were maintained mostly unchanged, including swallowing assessment, and in-hospital rehabilitation. Symptomatic severe carotid stenosis requiring urgent revascularization was treated with stenting, whereas carotid endarterectomy was put on hold during the study period. Stable outpatients awaiting elective revascularization or other procedures to reduce stroke or hemorrhagic risk (eg, incidental aneurysms) were deferred. Out-patient services as discharge to rehabilitation centers were maintained, whereas out-patient visits were performed only by telephone contact. All the ongoing randomized clinical trials that the Comprehensive Stroke Center was participating were also put on hold, with the exception of the CHOICE trial (Chemical Optimization of Cerebral Embolectomy).⁹

Exceptionally, 2 stroke neurologists were relocated to the care of patients with COVID-19 during some days of March, and in-patient rehabilitation was not available during a week for a sick leave. The admission of new patients into the Stroke Unit was sectorized to limit contamination. Thus, patients with fever or pulmonary symptoms were first admitted into an isolated bed and were transferred to the clean Stroke Unit only once a positive COVID-19 test was excluded. A chest computed tomography scan to rule out findings suggesting COVID-19 was performed to patients before thrombectomy. It was only on April 1, 2020, that COVID-19 testing was available and mandatory before any new stroke admission. Early at the onset of the crisis, the hyperacute assessment and management of patients was delivered under a Protected Stroke Code,¹⁰ which included the use of full personal protective equipment. A lockdown of Catalonia was started on March 15, and still it is maintained as on April 30.

Outcomes

The primary outcome of the study was the Stroke Code activations, stroke admissions, and reperfusion therapies (intravenous thrombolysis or thrombectomy) performed in eligible patients at HCB¹¹ in March 2020. Other outcome measures included workflow metrics, such as time from symptom onset to hospital arrival, and time from hospital arrival to brain imaging, onset of intravenous thrombolysis, or groin puncture. Efficacy and safety outcomes included the severity of stroke National Institutes of Health Stroke Scale at day 5 or hospital discharge, functional status (modified Rankin Scale score) at day 5 or hospital discharge, and rates of successful recanalization (modified Thrombolysis in Cerebral Infarction perfusion score 2b-3), and symptomatic hemorrhagic transformation (ECASS II [European Cooperative Acute Stroke Study II] criteria). All outcome variables were compared

with data of March 2019 and were prospectively collected into local databases and in the regionwide *Codi Ictus Catalunya* Registry. Data that support the findings of this study are available from the corresponding author on reasonable request.

The study protocol was approved by the local Clinical Research Ethics Committee from HCB under the requirements of Spanish legislation in the field of biomedical research, the protection of personal data, and the standards of Good Clinical Practice, as well as with the Helsinki Declaration (Reg. HCB/2020/0390). The board waived the need for patients' consent.

Statistical Methods

Continuous variables were reported as mean and SD or as median and interquartile range and were compared with the Student *t* or Mann-Whitney tests. Categorical variables were reported as proportions and compared with the χ^2 and Fisher exact test. The analysis was performed using SPSS Version 25.0, and the level of significance was established at a 0.05 level (2-sided).

RESULTS

From March 1 to March 31, 2020, 1232 patients with COVID-19 were admitted at HCB, and this overflow of admissions required a gradual opening of 31 quarantine areas in the hospital with 300 conventional beds, and 120 intensive care beds. As shown in Table 1, the EMS Coordination Center received in Catalonia 158.005 emergency calls in March 2019 and 679.569 in March 2020 (overall 330% increment). The number of daily emergency phone calls increased from 5.056 in March 2019 to 23.266 in March 2020 (360% increment; Table 1). Paradoxically, there was an 18% reduction in the number of Stroke Codes activated in Catalonia (517 in 2019 and 426 in 2020), and a similar 18% reduction in the Stroke Codes dispatched to HCB (83 in 2019 and 68 in 2020). In agreement with these declines, the number of stroke admissions at HCB also showed in March 2020 a 23% decline compared with March 2019 (83 and 108). The number of stroke admissions was further reduced in the second fortnight of March 2020, after the lockdown of Catalonia on March 15 (50 and 33 admissions); the reduction of stroke admissions was most noticeable during the higher peaks of emergency calls (Figure). Indeed, there was not a single stroke admission

Table 1. Effects of the Pandemic on the Number of Emergency Calls, Stroke Code Activations, and Stroke Admissions in Catalonia and at Hospital Clinic

	March 2019	March 2020	P Value
EMS Coordination Center			
Monthly calls	158.005	679.569	<0.0001
Daily calls	5.056	23.266	<0.0001
Stroke Codes			
Catalonia	517	426	<0.01
Hospital Clinic	83	68	0.22
Stroke admissions at HCB			
All admissions	108 (100)	83 (82)	0.07
Before lockdown*	...	50 (60)	
After lockdown*	...	33 (40)	
Notification modality			0.53
EMS notifications	73 (68)	57 (69)	
Intramural notifications	10 (9)	11 (13)	
No notifications	25 (23)	15 (18)	

Numbers are n (%) or median (IQR) as appropriate. EMS indicates Emergency Medical System; HCB, Hospital Clinic of Barcelona; and IQR, interquartile range. *March 15, 2020.

at our center between March 15 and 17, although there was an average of 30 to 40 thousand emergency calls during these 3 days in Catalonia. There was a slight fall in the number of stroke admissions without previous notification compared with March 2019 (15 and 25; Table 1).

Stroke admissions in 2020 were significantly younger than in 2019, also in the subgroup of patients dispatched by the EMS, but these patents did not have other differential traits, including the sex, initial severity of stroke, stroke subtype, wake-up strokes, or stroke mimics (Table 2). Fewer intravenous thrombolysis and fewer thrombectomies were performed in eligible patients compared with March 2019, although there were no differences in pre-hospital or in-hospital workflow metrics, including the delay of arrival to hospital after symptom onset, the time delay in performing a diagnostic brain computed tomography scan, the delay in implementing intravenous thrombolysis or in performing thrombectomy (Table 2). The rates of successful recanalization, hemorrhagic complications, and neurological impairment, and functional status at day

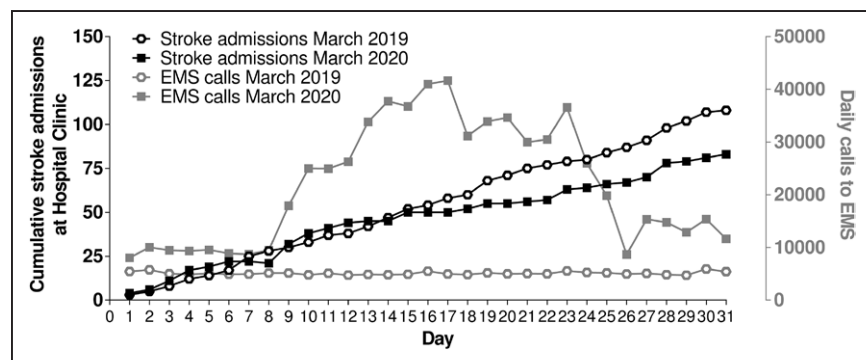


Figure. Superposition of data in the period between March 1 and March 31, 2019 and 2020.

On the left axis, the cumulative stroke admissions at Hospital Clinic during March 2019 (empty circles) and March 2020 (black squares) are shown. On the right axis, daily calls to Emergency Medical System (EMS) during March 2019 (gray dots) and March 2020 (gray squares) are shown.

Table 2. Main Characteristics of the Patients Admitted Through Stroke Code Activation and Quality Measures of the Acute Care Provided During the Pandemic in Relation to the Previous Year

	March 2019; N=83	March 2020; N=68	P Value
Baseline traits			
Age, y			
All stroke codes	75 (73–80)	69 (64–73)	0.009
EMS stroke codes	77 (74–81)	70 (64–75)	0.03
Males	46 (55)	38 (56)	0.95
Baseline NIHSS	9 (8–14)	6 (4–10)	0.41
Wake-up strokes	20 (24)	17 (25)	0.85
Diagnosis			
Ischemic stroke	53 (64)	42 (62)	0.44
Hemorrhagic stroke	11 (13)	7 (9)	
Stroke mimics	19 (23)	19 (28)	
Reperfusion therapy in eligible patients*			
IV thrombolysis	9 (17)	3 (7)	0.57
Thrombectomy	21 (40)	16 (38)	0.87
None	23 (43)	23 (55)	0.27
Time delay (min) workflow			
Stroke onset to hospital arrival	126 (95–216)	135 (86–217)	0.64
Hospital arrival to imaging	21 (19–26)	22 (20–27)	0.61
Hospital arrival to thrombolysis	28 (22–33)	23 (21–48)	0.92
Hospital arrival to puncture	61 (58–90)	56 (48–72)	0.35
Length of stay, days	5 (5–7)	4 (3–6)	0.92
Angiographic and early clinical course			
Thrombectomy procedural time	55 (37–65)	36 (30–66)	0.31
mTICI score 2b/3	14 (67)	13 (81)	0.32
NIHSS score day 5	4 (2–2)	6 (3–4)	0.22
mRS score 0–2, day 5	40 (48)	41 (60)	0.13
Death, day 5	6 (9.2)	8 (11.8)	0.33
Symptomatic hemorrhagic transformation	1 (3)	0	1.00

Numbers are n (%), median (IQR) as appropriate. EMS indicates Emergency Medical System; IQR, interquartile range; IV, intravenous; mRS, modified Rankin Scale; mTICI, modified Thrombolysis in Cerebral Infarction; and NIHSS, National Institutes of Health Stroke Scale.

*Patients with acute ischemic stroke and excluding from the numerator stroke mimics or hemorrhagic strokes.

5 or at hospital discharge, were similar to those found in 2019. During the study period, none of the patients who were awaiting an elective procedure were admitted at our center with an impending acute stroke.

Mandatory COVID-19 testing for all acute stroke patients was implemented at HCB on April 1. Thus, only 8 of 83 (10%) patients were tested in March 2020, of which 4 (5%) patients were COVID-19+ on admission. Of the latter, 2 patients had a final diagnosis of confusional state, one had encephalitis, and only one patient with atrial fibrillation that presented with central facial palsy and respiratory symptoms had an ischemic stroke.

All these patients were transferred to a specific COVID ward. None of the COVID-19 negative patients on admission had to be transferred to a quarantine zone for developing COVID-19 symptoms at follow-up.

DISCUSSION

There are little data informing how the COVID-19 pandemic is affecting the care provided to patients with acute stroke. At HCB, with 1232 COVID-19 admissions occurring in one month, the pandemic resulted in the occupation of 60% of the hospital bed capacity and 150% increment in the number of intensive care beds. Meanwhile, the study also found declines in the number of Stroke Code activations, stroke admissions, and thrombectomies performed at our center of 18%, 23%, and 24%, respectively. Nevertheless, during the pandemic it was possible to maintain, when not improve, prehospital time delays, and in-hospital workflow metrics compared with 2019. The length of hospital stay, the rate of successful reperfusion after thrombectomy, and the rate of good clinical outcome at hospital discharge were similar to those attained in 2019. However, although the outcome at hospital discharge did not worsen during the pandemic period, we cannot exclude that limitations in the availability of a thorough etiological workup in all admitted patients and the reduction in out-patient services could have influenced the long-term outcome or the stroke recurrence rate.

The decline of Stroke Codes observed at our center was similar to the general reduction of Stroke Codes in Catalonia. As we had protected the in-hospital chain of stroke, the decline in stroke admissions during the pandemic resulted in the unusual finding of having several Stroke Unit beds available most days of the month. The underutilization of the Stroke Unit beds when there was an overload of hospital admissions was an undesirable result that should be prevented in future crises. Readaptation of the protocols of the patient transport systems, giving preference to the dispatch of patients to centers willing to protect the chain of acute stroke care, would facilitate the access to stroke care to many patients who may remain untreated under strained healthcare conditions. Therefore, we concur with recent claims supporting the need of establishing centralized stroke treatment centers where sufficient stroke care resource can be secured, particularly at times of medical crisis, and to have stroke services that can continue to function.¹²

Arguably, the overload of emergency calls during the pandemic in Catalonia, with peaks of >41.000 emergency calls at a single day, could have caused difficulty in the correct activation of the Stroke Code at an overloaded EMS Coordination Center. For the stroke admissions at HCB were significantly younger during the pandemic, it is also possible that fewer Stroke Codes were activated because

older patients were more reluctant to demand emergency assistance for the fear of COVID-19, as it carries a higher risk of severe infection and death rates in older patients.¹³ Certainly, we cannot either exclude that isolation among the elderly could have played a role in the relatively younger age of the admitted patients. The lockdown of Catalonia on March 15 was also associated with a rocketing increment of emergency calls and a more marked decline of stroke admissions. In anticipation of the decline in acute stroke care in future crises, it is advisable to activate early during the crisis media reminders to the population of the importance of acting quickly and calling the EMS in the face of suspicion of a stroke. Interventions and activities aimed at reducing social isolation and loneliness particularly of older adults are also required.¹⁴

Only 5% of the patients in this series were found to be COVID-19+ on admission, and no patient developed the disease at follow-up, but only 10% of the patients were properly screened. Therefore, we cannot exclude the under-detection of milder cases, and future studies will be required to establish the magnitude of the relationship between COVID-19 and the incidence of stroke.¹⁵

In summary, the study identified moderate reductions of Stroke Code activations, stroke admissions, and thrombectomies performed at a Comprehensive Stroke Center during the COVID-19 pandemic. An overload of emergency calls could have led to saturation of the patient transport system, and fewer Stroke Code activations, particularly of elderly patients who may also feel more threatened by the infection. It is not known for how long this pandemic has arrived, but anticipation of potential new waves of the disease justify early implementation of protective measures to secure the patients' safety. In addition to in-hospital contingency plans, patient transport systems and public education reminders must be intertwined to better protect the patients with acute stroke in these uncertain times.

ARTICLE INFORMATION

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Disclosures

None.

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