ARTIGO ORIGINAL/ORIGINAL ARTICLE

Impact of the First Year of the COVID-19 Pandemic on Telestroke Network Performance: The Experience of a Portuguese "Drip-and-Ship" Model

Impacto do Primeiro Ano da Pandemia COVID-19 na Tele-Articulação Regional em Rede na Abordagem do AVC Isquémico Agudo: Experiência de um Modelo "Drip-and-Ship" Português

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Abstract

Introduction: Although scarce, regional telestroke networks have been developed worlwide in the last few decades. The COVID-19 pandemic put the healthcare system under exceptional pressure. We aimed to assess the impact of the first year of the COVID-19 pandemic on the telestroke network performance in the central region of mainland Portugal.

Methods: Retrospective multicenter cohort study including the eight hospitals of the regional stroke network. The first year of the COVID-19 pandemic (19/03/2020 to 18/03/2021) was compared with the period that preceded it, between 01/01/2018 and 18/03/2020. We analysed the number of telestroke consultations, the number of patients transferred for endovascular treatment, time metrics and functional outcome (measured using the modified Rankin Scale at three months).

Results: The number of consultations per day and patients transferred per day for endovascular therapy increased 8.2% and 12.9% during the COVID-19 period, respectively. The period between symptom onset/last known well (LKW) moment and admission to the primary hospital (LKW – Door 1 interval) increased by 95.8 minutes (159.5 vs 255.3, $p<0.01$), as well as the period between admission to the primary hospital and the tertiary hospital (Door1 – Door 2 interval): an increase in 18.5 minutes; 205.6 vs 224.1, $p=0.04$. The Door 2 - groin puncture interval decreased by 6.7 minutes (49.4 vs 42.7, $p=0.08$) and the Door 2 – reperfusion period decreased by 24.2 minutes (101.9 vs 77.7, $p<0.01$). The functional outcome of transferred patients

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was not affected by the pandemic (OR 0.66 [95%CI 0.7-1.3], *p*=0.79).

Conclusion: This study showed divergent results in different domains of the stroke care chain. Our results support the relevance of well-established telestroke networks in acute stroke care, especially during periods of high pressure on the public health systems.

Resumo

Introdução: Embora escassos, os modelos organizacionais regionais para abordagem do acidente vascular cerebral (AVC) agudo recorrendo à telemedicina têm vindo a ser implementados em diversos países nas décadas mais recentes. A pandemia COVID-19 colocou à prova a rede de prestação de cuidados de saúde. O objetivo deste estudo foi avaliar o impacto do primeiro ano da pandemia COVID-19 no desempenho da Rede da Via Verde do AVC na região Centro de Portugal.

Métodos: Estudo retrospetivo multicêntrico envolvendo os oito hospitais da Rede da Via Verde do AVC da região Centro de Portugal. O primeiro ano de pandemia COVID-19 (19/03/2020 a 18/03/2021) foi comparado com o período precedente, entre 01/01/2018 e 18/03/2020. Analisámos o número de teleconsultas, o número de doentes transferidos para tratamento endovascular, as métricas temporais de desempenho e o resultado funcional (avaliado através da *modified Rankin Scale* aos três meses).

Resultados: Observou-se um aumento de 8,2% no número de teleconsultas por dia na fase pandémica quando comparada com o período precedente e de 12,9% no número de doentes transferidos para trombectomia diariamente. Durante a pandemia, observou-se um aumento de 95,8 minutos no intervalo de tempo entre o início dos sintomas e a admissão no hospital primário (159,5 *vs* 255,3, *p*<0,01), de 18,5 minutos entre a admissão nos hospitais primário e terciário (205,6 *vs* 224,1, *p*=0,04). O intervalo entre a admissão no hospital terciário e a punção femoral reduziu 6,7 minutos (49,4 *vs* 42,7, *p*=0,08) e o intervalo entre a admissão no hospital terciário e a recanalização reduziu 24,2 minutos (101,9 *vs* 77,7, *p*<0,01). O resultado funcional aos 3 meses não foi afetado pela pandemia (OR 0,66 [95%CI 0,7-1,3], *p*=0,79).

Conclusão: Na pandemia, observaram-se resultados divergentes em diferentes domínios da cadeia de cuidados. Os resultados deste estudo realçam a relevância da existência de redes regionais para abordagem do AVC agudo bem estabelecidas, especialmente durante períodos colocam à prova a rede de prestação de cuidados de saúde.

Introduction

Stroke is a leading cause of mortality and disability worldwide[1–5] The most recent available data in Portugal is from 2021 and places diseases of the circulatory system and among these, stroke as the main cause of death (7.7% of deaths corresponding to a crude mortality rate of 92.2 per 100 000 inhabitants).[5]

A rapid assessment and standardized management are essential in the acute phase to increase the chances of a good functional outcome. Faster treatment requires recognition of signs and symptoms of stroke by the community, prompt identification of stroke by pre-hospital care teams and swift transportation to the hospital for medical evaluation and imaging. When the patient meets the criteria for reperfusion therapy, intravenous thrombolysis and/or endovascular thrombectomy should start immediately.[6-9]

Regional telestroke networks were developed in the last decades.[10] The telestroke network in the central region of mainland Portugal was created in August 2015 and plays a key role in specialized coordination and support during the acute phase of stroke in this area of the country.

The COVID-19 pandemic disrupted the healthcare systems of many countries and put the healthcare net-

work under exceptional pressure.[11] The first cases of COVID-19 in Portugal were confirmed on the 2nd of March 2020 and the state of emergency was declared on the 19th of March. During the first year of the pandemic, 816 623 cases were confirmed resulting in 16 754 deaths.[12] The rapid increase in the number of COVID-19 patients led to extraordinary measures, such as social distancing, adjustment of emergency services, redistribution of human and material resources and establishment of hospital wards dedicated exclusively to COVID-19 patients. The population's perception of health problems was also significantly modified.[13,14]

A well-organized telemedicine network can offer advantages during periods of crisis.[15] We aimed to evaluate the impact of the first year of the COVID-19 pandemic on the regional telestroke model of the Centre of mainland Portugal, focusing on the number of telestroke consultations, number of patients transferred for endovascular treatment, time metrics and functional outcomes.

Material and Methods

Brief description of the regional telestroke network

The regional stroke network of the centre of mainland Portugal is based on a drip-and-ship model according to the recommendations for telestroke in Europe[16] and includes seven primary hospitals and one tertiary hospital (Stroke Center), as presented in **Fig. 1**.

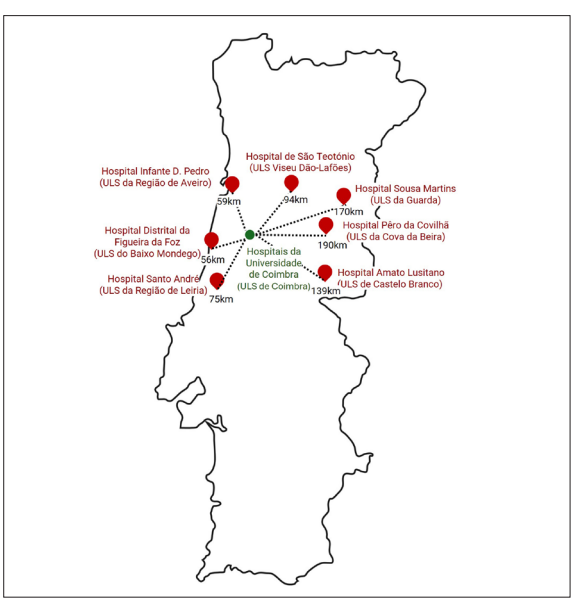

Figure 1. Regional stroke network of the centre of mainland Portugal that includes seven primary hospitals (in red) and one tertiary hospital (in green). The distance between each primary and the tertiary hospital is indicated in black.

The patients are initially evaluated in the nearest hospital. If a patient is admitted directly to the tertiary hospital, he is immediately assessed by the stroke team. If the patient is admitted to a primary hospital, the stroke neurologist in charge at the stroke centre is contacted. Brain computed tomography (CT) scan (and cervical-cerebral angio-CT, if needed), are performed and analysed by the stroke team through a specific National Health System (NHS) software. Immediately after, the patient starts thrombolysis, when indicated, and/or is transferred for endovascular treatment. The transport is ensured by the National Institute of Medical Emergency (Instituto Nacional de Emergência Médica, INEM).

Procedures

We performed a multicenter observational and retrospective study including the eight hospitals of the regional stroke network.

We obtained demographic, clinical and imaging data, as well as time measures from all adult patients admitted in the seven primary hospitals with signs and symptoms suggestive of acute stroke and evaluated by teleconsultation between 01/01/2018 and 18/03/2021. The data was obtained through the review of digital clinical records and imaging exams. Patients younger than 18 years old were excluded.

If symptoms onset was witnessed the precise time was used, otherwise last known well (LKW) moment was considered. Time of admission to the primary hospital was recorded as Door 1 and time of admission to the tertiary hospital as Door 2.

The intervals between symptoms onset/LKW and admission to the primary hospital, Door 1 to Door 2, Door 2 to arterial punction and Door 2 to reperfusion time were designated LKW - Door 1 interval, Door 1 - Door 2, Door 2 - groin puncture and Door 2 - reperfusion, respectively. All intervals (LKW - Door 1; Door 1 - Door 2; Door 2 - groin puncture; Door 2 - reperfusion) were expressed in minutes.

We recorded patient functional outcome (assessed by the modified Rankin Scale score at three months) for those transferred for endovascular treatment. The assessment was obtained through in-person or telephonic evaluation by the attending physician.

The first year of the COVID-19 pandemic (19/03/2020 to 18/03/2021) was compared with a period between 01/01/2018 and 18/03/2020. March 19th was chosen as

the cut-off date for the analysis because it corresponds to the date of the declaration of the state of emergency in Portugal.

The data was collected anonymously, and the study protocol was approved by our Institution's ethics committee (OBS.SF.075/2023).

Statistical Analysis

Categorial variables are presented as frequencies and percentages, and continuous variables as means and standard deviation. Univariate analysis and ordinal regression adjusted for potential confounding variables were used. All reported p-values are two-tailed, and statistical significance was set for *p*-values <0.05.

Results

Population and telestroke consultations

Between January 1st 2018, and March 18th 2021, 3082 patients were evaluated in telestroke consultations with a mean age of 73.3±14.0 years, 50.2% females; 1073 telestroke consultations occurred during the first 12 months COVID-19 period. The number of consultations per day increased by 8.2% during the COVID-19 period (2.7 vs 2.9 consultations per day) compared to the control period.

In total, 721 patients were transferred to the tertiary hospital for endovascular therapy, 256 of which during the pandemic (**Fig. 2**). Of those, six patients tested positive for SARS-CoV-2, and three of them were symptomatic. The number of patients transferred per day increased 12.9% during the COVID-19 period (0.59 vs 0.68 patients per day). The percentage of patients submitted to telestroke consultation who were then transferred for endovascular treatment slightly decreased (from 23.6% to 22.9%) during the pandemic.

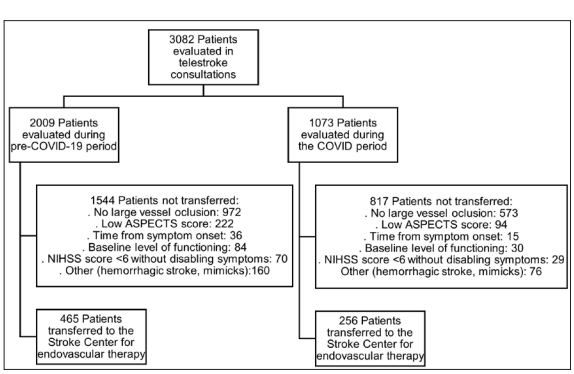

Figure 2. Study population. Pre-COVID 19 period: 01/01/2018 to 18/03/2020 (808 days).
COVID period: 19/03/2020 to 18/03/2021 (365 days).

A total of 3082 patients were not transferred to the Stroke Center, 1073 of whom were during the COVID-19 period (**Fig. 2**). The decision not to transfer was due to alternative diagnoses (other than acute ischemic stroke), absence of large vessel occlusion, low Alberta Stroke Program Early CT Score (ASPECTS), time from symptom onset (outside the time window), baseline functional status and NIHSS score.

Demographic characteristics and vascular risk factors of transferred patients (**Table 1**) did not differ between the pre-pandemic and pandemic periods. There was a statistically significant difference ($p<0.01$) in the baseline degree of functional disability evaluated with the modified Rankin scale, which was lower in patients transferred during the pandemic period.

Time metrics

The LKW - Door 1 interval increased by 95.8 minutes during the COVID-19 period (159.5 vs 255.3, $p<0.01$), as well as the Door 1 - Door 2 period (18.5 minutes increase; 205.6 vs 224.1, $p=0.04$). Door 2 - groin puncture interval decreased by 6.7 minutes (49.4 vs 42.7, $p=0.08$) and Door 2 - reperfusion period decreased by 24.2 minutes (101.9 vs 77.7, $p<0.01$). All time measures are summarized in **Table 2**.

Functional outcome

The functional outcome of transferred patients evaluated with modified Rankin scale at 3 months (**Fig. 3**) was not affected by the pandemic (OR 0.66 [95%CI 0.7-1.3], $p=0.79$). There was an increase in the percentage of patients with functional status 0 and 1 at the expense of a reduction in 4 and 5, along with a slight increase in mortality (2%).

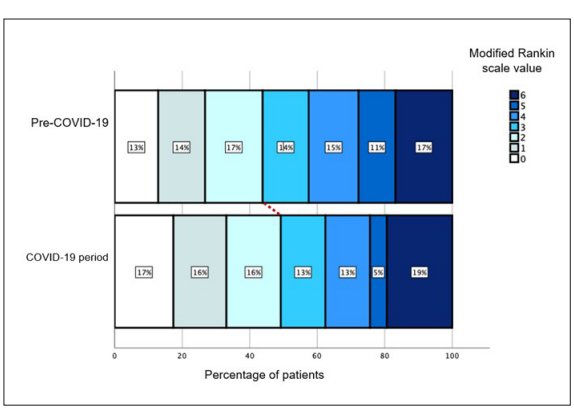

Figure 3. Functional outcome of patients with acute stroke transferred for endovascular treatment.

Table 1. Demographic and clinical characteristics of transferred patients.

	Pre-COVID-19 (n= 475)	COVID-19 period (n= 246)	*p* value
Demographic characteristics			
Age (years)	75.0 ± 11.7	75.2 ± 12.4	0.844
Female, n(%)	246 (51.8)	126 (51.2)	0.885
Vascular risk factors, n (%)			
Hypertension	346 (72.8)	173 (70.3)	0.476
Diabetes	88 (18.5)	54 (22.0)	0.273
Dyslipidaemia	251 (52.8)	114 (46.3)	0.098
Atrial fibrillation	191 (40.2)	95 (38.6)	0.679
Active smoking	40 (8.4)	21 (8.5)	0.958
Alcoholism	20 (4.2)	12 (4.9)	0.680
Coronary artery disease	28 (5.9)	18 (7.3)	0.459
Peripheral arterial disease	6 (1.3)	6 (2.4)	0.242
Previous stroke	33 (6.9)	16 (6.5)	0.823
Hypocoagulation, n (%)	113 (23.7)	50 (20.3)	0.211
Vitamin K antagonist	33 (29.2)	13 (26.0)	
Direct thrombin inhibitor	10 (8.8)	3 (6.0)	
Direct factor Xa inhibitors	70 (61.9)	34 (68.0)	
Baseline modified Rankin scale value, n (%)			
0	336 (70.7)	215 (87.4)	<0.01
1	65 (13.7)	14 (5.7)	
2	24 (5.1)	12 (4.9)	
3	17 (3.6)	4 (1.6)	
4	3 (0.6)	1 (0.4)	

ASPECTS: Alberta stroke program early CT score; NIHSS: National Institutes of Health Stroke Scale.

Table 2. Time measures.in stroke protocol procedures.

	Pre-COVID-19 (n= 475)	COVID-19 period (n= 246)	*p* value
Time measures, minutes			
LKW - *Door 1*	159.5	255.3	*p*<0.01
Door 1 - Door 2	205.6	224.1	*p*=0.04
Door 2 - groin puncture	49.4	42.7	*p*=0.08
Door 2 - reperfusion	101.9	77.9	*p*<0.01

LKW - *Door 1*: interval between symptoms onset or last known well and admission to the primary hospital; *Door 1 - Door 2*: period between admission to the primary hospital and tertiary hospital; *Door 2* - groin puncture: interval between admission to the tertiary hospital and the start of thrombectomy; *Door 2* - reperfusion: time that elapses between admission to the primary hospital and recanalization.

Discussion

This study showed divergent results in different domains of the stroke care chain.

Despite the complexity of this unexpected pandemic period, there was an increase in the number of telestroke consultations as well as in the number of patients being transferred for endovascular treatment. Nonetheless, the percentage of patients submitted to telestroke consultation who were subsequently transferred for endovascular treatment slightly decreased.

The baseline level of functional disability, as assessed by the modified Rankin Scale, was lower in patients transferred during the pandemic period. However, there was no significant increase in the number of pa-

tients who were not transferred to the tertiary hospital due to their baseline level of functioning during this period. Therefore, this difference is unlikely to be attributed to different selection criteria. It is possible that more vulnerable patients and their families were hesitant to seek healthcare during the pandemic.

A meta-analysis of twenty-nine studies addressing ischemic stroke admissions, treatment, and time metrics across the COVID-19 pandemic published between June 2nd 2019 and October 9th 2020[13] demonstrated a significant reduction in stroke admission rates, with higher relative presentation of large vessel occlusions; the proportion of patients receiving reperfusion therapy was not inferior to control periods. Our study did not aim to evaluate the incidence of stroke nor the total number of patients presenting to the emergency department with signs or symptoms of stroke. We can speculate that in COVID-19 pandemic there was an additional need for expertise support but also that, for unclarified reasons, there was also an increase in ischemic strokes with large vessel occlusion.

Comparisons with meta-analysis[13] are also limited due to different study periods. The included studies focused only on the initial months of the pandemic, ranging from January to May 2020, rather than the entire first year. This discrepancy may account for some of the observed differences.

There was an increase in the interval between symptoms onset/LWK and admission to the primary hospital (Door 1), possibly due to changes in the perception of health problems, delays in the identification of the signs of stroke (because of social distancing and/or lack of awareness), hesitancy and fear of seeking medical care or constrains in pre-hospital emergency care. It is worth noting that none of the hospitals included in the telestroke network was redeployed exclusively to the care of COVID-19 patients. This increase was also reported in drip-and-ship models in the previously referred meta-analysis; however, it was less significant (32 minutes) and lacked statistical significance.[13]

The Door 1 - Door 2 interval, that depends on the performance of both, the primary hospital (timely recognition of acute stroke signs and symptoms and CT availability) and the organization for patient transfer, has also increased. Abnormal pressure in the emergency departments during the pandemic, implementation of new protocols for patient triage, and an increase in the time required to perform personal protection measures, with consequent delays in symptom identification, neurological assessment, imaging and transportation may explain this result.

There was a slight reduction in the Door 2 - groin puncture interval and a significant decrease in the Door 2 - reperfusion, probably reflecting the progressive improvement in the thrombectomy devices and interventionalists expertise. Additionally, routine activities were reduced during the pandemic period and thus specialized personnel were readily available for emergency stroke interventions. In the already mentioned meta-analysis,[13] Door - needle (interval between admission and intravenous thrombolysis) and Door - groin puncture times were similar during COVID and control periods. However, the analysis of Door - groin puncture interval excluded drip-and-ship models.

Despite all the impact of the pandemic on health care, the functional outcome of patients with acute stroke and large vessel occlusion transferred for endovascular treatment was not affected. This study provides evidence of the potential benefit of telestroke networks not only in normal periods but also, and importantly, in extreme public health circumstances.

This study presented several limitations: first, it was an observational and a retrospective study, the information was collected from clinical records and some patients were excluded due to inability to obtain complete data. Despite being an important metric for evaluating the performance of the primary hospital, the Door in - Door out interval was not included due to difficulty in obtaining the exact time of departure from the primary hospital. Modified Rankin Scale score was recorded by experienced professionals, but not all of them had formal certification. For all these reasons, our results may not be generalizable to other regions with different protocols for stroke care and different healthcare responses to the COVID-19 pandemic.

Conclusion

The impact of the COVID-19 pandemic on the healthcare system was undeniable at all levels, including in the acute stroke care setting. This study adds additional evidence supporting the relevance of well-established telestroke networks in the acute stroke care, especially during periods of high pressure over the public health systems. ■

Prémios e Apresentações Prévias / Awards and Previews

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Contributorship Statement / Declaração de Contribuição

IC, FB: Data curation; methodology; formal analysis; writing - original draft.

CS: Conceptualization; data curation; methodology.

JS, AR, PF, EM, DD, CB, CT, CM, RR, CM, HQ, EV, FC, IP, LB, AG, FC, JF, AC: Data curation.

CN, CM, BR, LA, FS, CN, RV, DS, EQ, EA, FP, JC, AG, AG, JS, EM: Supervision; validation.

GS: Conceptualization; data curation; methodology; supervision; validation, Writing - review & editing.

All authors approved the final version to be published.

IC, FB: Curadoria de dados; metodologia; análise formal; redação - rascunho original.

CS: Conceptualização; curadoria de dados; metodologia.

JS, AR, PF, EM, DD, CB, CT, CM, RR, CM, HQ, EV, FC, IP, LB, AG, FC, JF, AC: Curadoria de dados.

CN, CM, BR, LA, FS, CN, RV, DS, EQ, EA, FP, JC, AG, AG, JS, EM: Supervisão; validação.

GS: Conceptualização; curadoria de dados; metodologia; supervisão; validação, Escrita - revisão e edição.

Todos autores aprovaram a versão final a ser publicada.

Responsabilidades Éticas

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Confidencialidade dos Dados: Os autores declaram ter seguido os protocolos da sua instituição acerca da publicação dos dados de doentes.

Proteção de Pessoas e Animais: Os autores declaram que os procedimentos seguidos estavam de acordo com os regulamentos estabelecidos pela Comissão de Ética responsável e de acordo com a Declaração de Helsínquia revista em 2013 e da Associação Médica Mundial.

Proveniência e Revisão por Pares: Não comissionado; revisão externa por pares.

Ethical Disclosures

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Protection of Human and Animal Subjects: The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research ethics committee and with those of the Code of Ethics of the World Medical Association (Declaration of Helsinki as revised in 2013).

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