Impact of the corona virus (Covid 19)pandemic on stroke code activities and outcome. A retrospective observational study

Sheila Jala1, 4#*, RN, MHSS, MCN Neuroscience, PhD (Candidate)

Carin Bertmar1#, BSc (Econ), BA (Psych)

Miriam Wronski1, MBBS

Susan Day1, MPH

Jeanne Barr1, RN, MN

Ying Hu1, RN, MAdvN

Elizabeth O'Brien1, RN, Grad Dip Neuroscience Nursing, MNNP

Miriam Priglinger-Coorey1, 3, FRACP DMed

Iqra Aziz1, BMed, MD

Martin Krause1, 3, FRACP, DMed

Rosalind Elliot2, 4, RN, PhD

Margaret Fry2, 4, RN, PhD

1. Stroke Department, Royal North Shore Hospital, St Leonards, NSW, Australia.

2. Nursing and Midwifery Directorate, Northern Sydney Local Health District, Royal North Shore Hospital, St Leonards, NSW, Australia

3. University of Sydney, Northern Clinical School, St Leonards, NSW, Australia

4. University of Technology Sydney, Ultimo, NSW, Australia

# Equally contributing first author

*Corresponding author

Questions or comments about this article should be directed to Sheila Jala

Email address: sheila.jala@health.nsw.gov.au

DOI: 10.21307/ajon-2022-004

Abstract

Background: The Coronavirus 2019 (COVID-19) pandemic has affected the delivery of healthcare around the world. We assessed the impact of the COVID-19 pandemic on hospital presentations, reperfusion treatment and outcomes in a comprehensive stroke centre.

Methods: In this observational study seven months of retrospective data from February 2020 (at the beginning of the pandemic) were compared to data collected for the same time frame in 2019.

Results: There was a transient reduction in stroke presentation only at the beginning of the wave of COVID-19 community transmissions in Sydney. There were significantly more haemorrhagic strokes in the COVID-19 period (n = 66, 15.4 % vs n = 95, 21.5 %, *P* = 0.02) and baseline stroke severity was higher (NIHSS median 3 vs 4, *P* = 0.049). Similar proportions of ischaemic stroke patients received reperfusion therapy in the two time periods (IV thrombolysis [n = 51, 17.3% vs n = 52, 17.9%, *P* = 0.838]; and ECR [n = 38, 12.9% vs n = 46, 15.9%, *P* = 0.30]). The time from presentation to stroke bed admission was significantly shorter during the COVID-19 period (median 295 vs 260 minutes, *P* = 0.031). Three-month follow-up Modified Rankin Score was 2 (median) in both periods (P = 0.92).

Conclusion: There was no change in stroke presentations overall during the 2020 COVID 19 pandemic time period with the exception of the first phase of the pandemic. Baseline stroke severity scores were higher. There was no a difference in the degree of disability at three-month follow-up.

Key Words: COVID-19, stroke, stroke code, stroke admission, stroke outcome

INTRODUCTION

On 30 January 2020, the World Health Organisation (WHO) announced the coronavirus disease 2019 (COVID-19) outbreak in China to be a Public Health Emergency of International Concern and on 30 March 2020 a global pandemic was declared (WHO, 2020). In Australia in early 2020, the COVID-19 pandemic became the top priority for the health care system as presentations of the Severe Acute Respiratory Distress Syndrome Coronavirus-2 (SARS-COV-2) increased (Moss et al., 2020). In Sydney, the first COVID-19 related death was reported on 4 March 2020 and subsequently on 16 March 2020, the COVID 19-pandemic was declared a public health emergency by the Australian government (Storen & Corrigan, 2021).

Increased presentations of COVID-19, the high transmissibility (particularly in pre-symptomatic or asymptomatic patients) of the virus and its propensity to cause severe infection in some, and the emergence of new variants has and continues to pose significant challenges to global health systems (Gao et al., 2021; SARS-CoV, 2021). Lockdowns were implemented to help flatten the curve of the spread of COVID-19 (Verma et al., 2020). On 23 March 2020, Stage One restrictions were announced by the New South Wales (NSW) Premier in which non-essential activities and businesses in Sydney were shut down (Storen & Corrigan, 2021). This was followed by harsher Stage Two restrictions on 25 March 2020 including limits on numbers during social gatherings such as weddings and funerals (Storen & Corrigan, 2021). There is a suggestion that the COVID-19 pandemic caused disruption to people seeking emergency care for all healthcare conditions worldwide. Importantly delayed presentation has been recognised across a wide range of services including acute stroke services (Cadilhac et al., 2021; Markus & Brainin, 2020).

Stroke is the second leading cause of mortality and disability worldwide and people experiencing stroke signs and symptoms commonly present to their local Emergency Department (ED) for assessment (Carroll, 2019). The current gold standard of treatment varies depending on the type of stroke. For example, patients with acute ischaemic stroke may be administered intravenous (IV) thrombolysis alone or in combination with endovascular clot retrieval (ECR) in those with large vessel occlusions (LVOs). The efficacy of acute reperfusion therapies is time critical and declines rapidly within hours of symptom onset. Therefore, people with stroke symptoms rely on efficient pre-hospital

transport, early ED assessment and coordinated in-hospital stroke systems. Patients presenting to ED with stroke symptoms should be first assessed by a triage nurse. Upon completion of the assessment, the nurse will allocate an urgency code according to the Australian Triage Scale (ATS) (Hodge, Hugman, Varndell, & Howes, 2013; Vance & Sprivulis, 2005). The triage code determines how urgently the patient will be assessed by a treating clinician (Hodge et al., 2013). According to the ATS a person presenting with stroke like symptoms should be allocated a triage category 2, which means medical assessment needs to occur within ten minutes (Middleton et al., 2016; Vance & Sprivulis, 2005).

Studies have consistently shown that delays in treating patients with IV thrombolysis and/or ECR is associated with reduced functional outcomes (Emberson et al., 2014; Hacke, Donnan, & Fieschi, 2004; Lees et al., 2010; Muth, 2019). Additionally, the optimal care of acute stroke patients also includes the availability of specialised inpatient stroke unit care, which improves survival and reduces dependency (Stroke Unit Trialists, 2013). Therefore, the purpose of this study was to identify the impact of the COVID-19 pandemic on acute stroke admissions, acute treatments and patient outcomes in a tertiary hospital in Sydney, Australia.

METHODS

Study Design

In this single site, retrospective, observational study patient data were compared for the first seven months from the beginning of the COVID-19 pandemic (1 February to 31 August 2020) with data for the same time frame in 2019 (Pre-COVID-19).

Site

The study was conducted in a 634-bed, tertiary referral hospital in metropolitan Sydney, NSW, Australia. This hospital provides tertiary stroke care (IV thrombolysis, ECR and neurosurgery) to a population of approximately one million in Northern Sydney. Approximately 1200 emergency presentations are triaged to the stroke pathway per year; approximately 800 patients per year are diagnosed with a principal diagnosis of stroke or Transient Ischaemic Attack (TIA). Patient stroke care is provided in the acute stroke unit (ASU), neuroscience intensive care unit (NSICU) and neurosurgery step-down unit (NSDU).

Sample

The study sample inclusion criteria comprised: adults (³18 years) with signs and symptoms of acute stroke, who presented to the ED and were treated for acute stroke (commenced on the stroke pathway) and consequently were discharged from hospital with a confirmed diagnosis of stroke (either ischaemic or haemorrhagic) or TIA. Patients who were transferred to the hospital from other referring facilities and admitted directly into the stroke unit were also included. Classification of stroke was defined as acute episodes with a principal International Classification of Diseases 10th Revision (ICD-10) diagnosis of ischaemic or haemorrhagic stroke (I61.0-I61.9, I62.9, I63.0-I63.9 and I64) or TIA (G45.9).

Data were obtained, for the two time periods, from the Health Information Exchange (HIE) data set - a state-wide data repository in NSW Australia - and the hospital stroke service database. Baseline demographics, hospital length of stay, re-admission to the hospital and primary ICD-10 stroke coding were compiled from the HIE. Data examined included: stroke code activation (stroke pathway) and presentations; admission for stroke care; stroke assessment, imaging and reperfusion treatment; length of stay; in-hospital mortality, degree of disability on discharge and at three months post discharge. The Incident Information Management System (IIMS) database was also reviewed to gather adverse events and near miss incidents reported during the two time periods. The primary outcome measures were stroke presentation, admission to stroke care, and reperfusion treatments. Secondary outcome measures were pre-admission and discharge Modified Rankin Score (mRS) and stroke severity as assessed using the National Institutes of Health Stroke Scale (NIHSS) at the time of presentation. Assessment of mRS was conducted by nurses in the ASU, NSICU and NSDU at time of admission and discharge. NIHSS was assessed at the time of presentation by the neurology registrar (a senior neurology trainee). The electronic medical records were reviewed by members of the research team. Patients who experienced a stroke or TIA during their hospital stay (inpatients) were excluded from the study.

Data analysis and Statistics

Descriptive statistics were used to characterise and summarise the data using frequencies and percentages for categorical data and medians and interquartile ranges for continuous and ordinal data. The Mann-Whitney U-test was used to compare differences in continuous outcomes with skewed distributions and ordinal variables. Differences in

INTRODUCTION

On 30 January 2020, the World Health Organisation (WHO) announced the coronavirus disease 2019 (COVID-19) outbreak in China to be a Public Health Emergency of International Concern and on 30 March 2020 a global pandemic was declared (WHO, 2020). In Australia in early 2020, the COVID-19 pandemic became the top priority for the health care system as presentations of the Severe Acute Respiratory Distress Syndrome Coronavirus-2 (SARS-COV-2) increased (Moss et al., 2020). In Sydney, the first COVID-19 related death was reported on 4 March 2020 and subsequently on 16 March 2020, the COVID 19-pandemic was declared a public health emergency by the Australian government (Storen & Corrigan, 2021).

Increased presentations of COVID-19, the high transmissibility (particularly in pre-symptomatic or asymptomatic patients) of the virus and its propensity to cause severe infection in some, and the emergence of new variants has and continues to pose significant challenges to global health systems (Gao et al., 2021; SARS-CoV, 2021). Lockdowns were implemented to help flatten the curve of the spread of COVID-19 (Verma et al., 2020). On 23 March 2020, Stage One restrictions were announced by the New South Wales (NSW) Premier in which non-essential activities and businesses in Sydney were shut down (Storen & Corrigan, 2021). This was followed by harsher Stage Two restrictions on 25 March 2020 including limits on numbers during social gatherings such as weddings and funerals (Storen & Corrigan, 2021). There is a suggestion that the COVID-19 pandemic caused disruption to people seeking emergency care for all healthcare conditions worldwide. Importantly delayed presentation has been recognised across a wide range of services including acute stroke services (Cadilhac et al., 2021; Markus & Brainin, 2020).

Stroke is the second leading cause of mortality and disability worldwide and people experiencing stroke signs and symptoms commonly present to their local Emergency Department (ED) for assessment (Carroll, 2019). The current gold standard of treatment varies depending on the type of stroke. For example, patients with acute ischaemic stroke may be administered intravenous (IV) thrombolysis alone or in combination with endovascular clot retrieval (ECR) in those with large vessel occlusions (LVOs). The efficacy of acute reperfusion therapies is time critical and declines rapidly within hours of symptom onset. Therefore, people with stroke symptoms rely on efficient pre-hospital

transport, early ED assessment and coordinated in-hospital stroke systems. Patients presenting to ED with stroke symptoms should be first assessed by a triage nurse. Upon completion of the assessment, the nurse will allocate an urgency code according to the Australian Triage Scale (ATS) (Hodge, Hugman, Varndell, & Howes, 2013; Vance & Sprivulis, 2005). The triage code determines how urgently the patient will be assessed by a treating clinician (Hodge et al., 2013). According to the ATS a person presenting with stroke like symptoms should be allocated a triage category 2, which means medical assessment needs to occur within ten minutes (Middleton et al., 2016; Vance & Sprivulis, 2005).

Studies have consistently shown that delays in treating patients with IV thrombolysis and/or ECR is associated with reduced functional outcomes (Emberson et al., 2014; Hacke, Donnan, & Fieschi, 2004; Lees et al., 2010; Muth, 2019). Additionally, the optimal care of acute stroke patients also includes the availability of specialised inpatient stroke unit care, which improves survival and reduces dependency (Stroke Unit Trialists, 2013). Therefore, the purpose of this study was to identify the impact of the COVID-19 pandemic on acute stroke admissions, acute treatments and patient outcomes in a tertiary hospital in Sydney, Australia.

METHODS

Study Design

In this single site, retrospective, observational study patient data were compared for the first seven months from the beginning of the COVID-19 pandemic (1 February to 31 August 2020) with data for the same time frame in 2019 (Pre-COVID-19).

Site

The study was conducted in a 634-bed, tertiary referral hospital in metropolitan Sydney, NSW, Australia. This hospital provides tertiary stroke care (IV thrombolysis, ECR and neurosurgery) to a population of approximately one million in Northern Sydney. Approximately 1200 emergency presentations are triaged to the stroke pathway per year; approximately 800 patients per year are diagnosed with a principal diagnosis of stroke or Transient Ischaemic Attack (TIA). Patient stroke care is provided in the acute stroke unit (ASU), neuroscience intensive care unit (NSICU) and neurosurgery step-down unit (NSDU).

Sample

The study sample inclusion criteria comprised: adults (³18 years) with signs and symptoms of acute stroke, who presented to the ED and were treated for acute stroke (commenced on the stroke pathway) and consequently were discharged from hospital with a confirmed diagnosis of stroke (either ischaemic or haemorrhagic) or TIA. Patients who were transferred to the hospital from other referring facilities and admitted directly into the stroke unit were also included. Classification of stroke was defined as acute episodes with a principal International Classification of Diseases 10th Revision (ICD-10) diagnosis of ischaemic or haemorrhagic stroke (I61.0-I61.9, I62.9, I63.0-I63.9 and I64) or TIA (G45.9).

Data were obtained, for the two time periods, from the Health Information Exchange (HIE) data set - a state-wide data repository in NSW Australia - and the hospital stroke service database. Baseline demographics, hospital length of stay, re-admission to the hospital and primary ICD-10 stroke coding were compiled from the HIE. Data examined included: stroke code activation (stroke pathway) and presentations; admission for stroke care; stroke assessment, imaging and reperfusion treatment; length of stay; in-hospital mortality, degree of disability on discharge and at three months post discharge. The Incident Information Management System (IIMS) database was also reviewed to gather adverse events and near miss incidents reported during the two time periods. The primary outcome measures were stroke presentation, admission to stroke care, and reperfusion treatments. Secondary outcome measures were pre-admission and discharge Modified Rankin Score (mRS) and stroke severity as assessed using the National Institutes of Health Stroke Scale (NIHSS) at the time of presentation. Assessment of mRS was conducted by nurses in the ASU, NSICU and NSDU at time of admission and discharge. NIHSS was assessed at the time of presentation by the neurology registrar (a senior neurology trainee). The electronic medical records were reviewed by members of the research team. Patients who experienced a stroke or TIA during their hospital stay (inpatients) were excluded from the study.

Data analysis and Statistics

Descriptive statistics were used to characterise and summarise the data using frequencies and percentages for categorical data and medians and interquartile ranges for continuous and ordinal data. The Mann-Whitney U-test was used to compare differences in continuous outcomes with skewed distributions and ordinal variables. Differences in

categorical variables were assessed using the Pearson's chi-square test or Fisher's Exact Test. A value of P<0.05 was considered statistically significant (2-sided). All analyses were conducted using IBM SPSS Statistics v.27.

Ethical considerations

The study was determined as adhering to the National Health and Medical Research Council definition of quality assurance and evaluation and approved by the Northern Sydney Local Health District Human Research and Ethics Committee. Only de-identified patient data were collected after extraction from the hospital databases and no identifiable data were reported.

Results

The number of adult presentations in the ED decreased from 38,576 in 2019 to 35,172 during the COVID-19 period (seven months study period). There was also a non-significant trend for less stroke presentations in 2020 compared to 2019 (712 vs 742). However, the percentage of stroke patients for all adult ED presentations were similar (P = 0.32) indicating that stroke presentation frequency was impacted less by COVID-19 than non-stroke presentations. Only when comparing the month of April was there a statistically significant difference (P = 0.02) of fewer stroke code activations (- 31.1%) in the COVID-19 period (n = 73) versus the pre-COVID period (n = 106).

Of the 742 stroke codes activated during the pre-COVID-19 period, 428 (57.7%) patients were diagnosed with a stroke or TIA at discharge. This compared to 441 out of 712 (61.9%) in the COVID-19 group (P = 0.10). Patient baseline characteristics were similar for age and gender. Patients with ischaemic strokes constituted approximately two thirds of all strokes and TIAs (P = 0.32). There was a significantly higher proportion of patients with a haemorrhagic stroke in the COVID-19 period throughout May to August (n = 66, 15.4 % vs n =95, 21.5 %, P = 0.02) compared to the Pre-COVID-19 period (Table 1).

The time from ED arrival to ASU, NSICU or NSU admission was significantly shorter during the COVID-19 period (295 vs 260 median minutes, P = 0.03). The proportion of patients admitted to an inpatient stroke bed was similar (P = 0.86). There was no statistical difference between stroke symptom onset and arrival time in hospital (P = 0.53). There was no significant difference in the "door to imaging time" (P = 0.57) (Table 1).

Ischaemic stroke reperfusion treatments involving IV thrombolysis were similar for the

Table 1. Demographics and key performance measures

	Pre-COVID-19 (n=428)	COVID-19 (n=441)	P value
ED adult presentations	38,576	35,172	
Number of stroke code activations, n (%)	742 (1.9)	712 (2.0)	0.33
Diagnosis of stroke / TIA, n (%)	428 (57.7)	441 (61.9)	0.10
Age, median (IQR)	77 (66-86)	77 (67-85)	0.89
Gender, female n (%)	209 (48.8)	225 (51.0)	0.54
Type of stroke diagnosis at discharge, n (%)			
Ischaemic[1]	295 (68.9)	290 (65.8)	0.32
Intracranial haemorrhage (ICH)	66 (15.4)	95 (21.5)	0.02
TIA	67 (15.7)	56 (12.7)	0.21
Known symptom onset, n (%)	235 (54.9)	243 (55.1)	1.00
Time from known onset to ED presentation, minutes median (IQR)	134 (71-251)	134 (77-238)	0.53
ASU or NSICU or NSDU admission[2], n (%)	365 (85.3)	378 (85.7)	0.86
Time from ED presentation to ASU or NSICU or NSDU[3], minutes median (IQR)	295 (188-555)	260 (183-448)	0.03
Time from presentation to first CT brain imaging[4], minutes median (IQR)	32 (19-85)	30 (20-63)	0.57
Reperfusion therapy, ischemic strokes			
IV thrombolysis, n (%)	51 (17.3)	52 (17.9)	0.84
ECR, n (%)	38 (12.9)	46 (15.9)	0.30
Time from presentation to IVtPA infusion, minutes median (IQR)	60 (43-90)	65 (45-96)	0.53
Time of onset of stroke to IVtPA infusion, minutes median (IQR)	166 (117–218)	186 (136–239)	0.18

[1] Patients with ICD code I64 (Stroke, not specified) are included in Ischaemic strokes as they were clinically diagnosed as ischaemic strokes (9 vs 3).
[2] Includes patients who were admitted to ASU or NSICU or NSDU as first ward after presentation to the ED.
[3] Includes patients who were admitted to ASU or NSICU or NSDU after presentation to the ED; excludes direct admissions (no ED) (29 vs 20), patients admitted to other types of wards (24 vs 32), patients only admitted to the ED short stay unit (6 vs 7), and patients who transferred from the ED to other hospitals for clot retrieval and then were repatriated back to the hospital (6 vs 6).
[4] Excluded: CT brain performed at referring hospitals: 69 vs 85

ASU = acute stroke unit, CT = computed tomography, ED = emergency department, ECR = endovascular clot retrieval, ICH = intracranial heamorrhage, IQR = interquartile range, NSICU =neuroscience intensive care unit, NSDU = neurosurgical surgical dependency unit, IVtPA = intravenous tissue plasminogen activator, TIA = transient ischaemic attack

two time periods (P = 0.84) and likewise for patients with ischaemic strokes who received ECR (P = 0.30). The median door to needle time was shorter pre-COVID-19 compared to COVID-19 period (60 minutes vs 65 minutes, P = 0.53), although, it was not statistically significant. There was no statistical difference in stroke onset time to administration of IV thrombolysis (P = 0.18).

The percentage of complications during hospital admission was similar (P = 0.95); in-hospital mortality was 9.3% (n =40) [pre-COVID-19] compared to 12.5% (n = 55) in the COVID-19 period (P = 0.16). There were three incidents (one patient with complications resulting from a fall, one with skin graft issue, and one patient with respiration pneumonia) with a Severity Assessment Code (SAC) of 2 (moderate harm attributed to health care provision) reported in the pre-COVID-19 time period and five (three patients with peripheral intravenous cannula site infections, and two complications from a fall) in the COVID-19 time period.

Length of stay was comparable for the patients' hospital stay (median 6 vs 6 days, P = 0.61). The median pre-admission mRS was zero. At the time of presentation to hospital during the COVID-19 period, patients had a higher stroke severity than before the pandemic (median NIHSS 3 vs 4, P = 0.049). There were no differences in stroke outcomes (degree of disability) measured by the mRS on discharge from hospital or at three-month follow-up (Table 2).

Discussion

This retrospective study shows that only at the beginning of COVID-19 community transmissions in Sydney during 2020, was there a

Table 2. Length of stay, stroke severity and outcomes

	Pre-COVID-19 (n=428)	COVID-19 (n=441)	P value
Episode LOS, days, median (IQR)	4.0 (2-7)	4.7 (3-8)	0.06
Hospital LOS, days, median (IQR)	6.0 (3-10)	6.0 (3.5-10)	0.61
Pre mRS[1], median (IQR)	0 (0-2)	0 (0-2)	0.92
NIHSS baseline[2], median (IQR)	3 (1-9)	4 (1-11)	0.049
Discharge mRS[3], median (IQR)	3 (0-4)	3 (0-4)	0.18
Severe events, n (%)	54 (12.6)	55 (12.5)	0.95
In-hospital Mortality, n (%)	40 (9.3)	55 (12.5)	0.16
Readmission within 28 days, n (%)	32 (7.5)	22 (5.0)	0.16
3 months mRS[4], median (IQR)	2 (1-3)	2 (1-3)	0.92

[1] Missing data: 10 vs 5, [2] Missing data: 25 vs 28, [3] Missing data: 39 vs 11, [4] Missing data: 213 vs 166
IQR = interquartile range, LOS = length of stay, mRS = modified Rankin Score

transient period of fewer stroke presentations. This finding is similar to the reported healthcare activity in NSW (Sutherland et al.). During April and the first half of May 2020, restrictions on community movement and interactions were strictly implemented in Sydney. These measures may have helped reduce community transmissions however, they may have caused patients with acute stroke symptoms to avoid calling an ambulance or presenting to ED for fear of contracting the infection in hospital.

With regard to the type of stroke, more patients presented to the ED with haemorrhagic stroke during the COVID-19 pandemic than the year before the pandemic. This might explain the higher baseline stroke severity scores during the COVID-19 pandemic period as well as the marginal longer hospital length of stay. However, there was no significant change in the total number of confirmed stroke or TIA presentations, rate of reperfusion therapy, time to present to hospital or receive therapy or any other measured clinical outcome. This reflects the strength of the organisation and commitment of the ED and stroke teams who continue to focus on providing the best care possible to stroke patients during the pandemic.

In addition, while there was no statistically significant difference in overall access to stroke unit care, the median time to acute stroke unit admission was significantly shorter during the pandemic. The reported changes in the delivery of acute stroke services as a result of the COVID-19 pandemic has differed significantly worldwide. While some hospital systems have been significantly restructured (including the redeployment of senior clinicians to other areas, the realloca-

tion of acute stroke units to care for COVID-19 patients, modified stroke pathways and changes to triage and transportation protocols), other hospitals have not undergone those changes (Bersano et al., 2020; Cadilhac et al., 2021; Hoyer et al., 2020; Markus & Brainin, 2020). Stroke services in our organisation were not reallocated so continuation of usual clinical care was possible.

Internationally, there have been reports of delays in hyperacute stroke treatment delivery due to changes in workflow processes of the emergency and radiology departments in order to prioritise infection preventative strategies (Cadilhac et al., 2021; Hoyer et al., 2020; Markus & Brainin, 2020). In contrast, our study demonstrated that the provision of reperfusion therapy was not adversely impacted for ED stroke presentations. This may be attributable to the lower case numbers of COVID-19 reported in Australia in 2020.

There was a significantly shorter transfer time to the acute stroke unit /stroke bed during the COVID-19 period. A possible explanation is that during COVID-19 transfer from ED to inpatient beds was expedited to minimise possible exposure to COVID 19 in ED. Additionally, there may have been a decrease in workload in the stroke unit relative to the ED workload given new COVID-19 workflow modifications. Of concern was the higher number of haemorrhagic stroke presentations during the pandemic and this remains unexplained. Further investigation of confounding patient variables such as risk factor profiles and/or medication control and compliance is needed.

Limitation

We acknowledge that the data from one single centre on Australia's east coast is not representative of true population-based data in a global pandemic and that the numbers were too small to detect minor but potentially important clinical differences reliably. An additional limitation is the lack of complete data for some of the variables (the COVID-19 time period contained more complete data for all measures), which may have introduced sample bias. Finally, the omission of time-based metrics for ECR (onset-to-groin or door-to-groin time) was also a limitation, as it is well known that timeliness of ECR improves functional outcomes (Bersano et al., 2020).

Of concern to all health professionals was that the COVID-19 pandemic may delay presentations to ED. It remains unclear if the pandemic altered behaviour so that people chose not to present to ED despite significant symptomatology. In this study while overall adult presentations were lower, stroke

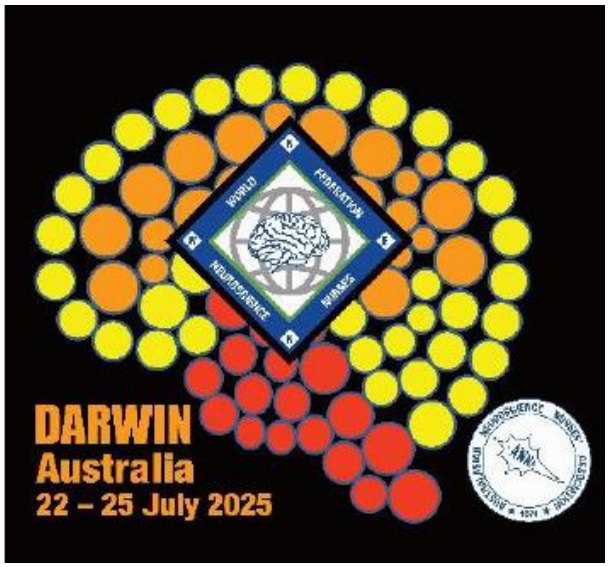
presentations remained unchanged. While stroke severity on presentation was marginally higher in the COVID-19 time period (median NIHSS of 4 in COVID-19 group compared with NIHSS of 3 pre-pandemic group), this may be related to the severity of haemorrhagic strokes as reported in an earlier study (Andersen, Olsen, Dehlendorff, & Kammersgaard, 2009).

Future studies could involve a larger cohort and include all patients who present to hospital with stroke symptoms, not just those who were admitted following ED stroke code activation (for stroke treatment) as presented in this study. Further COVID-19 studies could examine the long-term outcomes of patients presenting during the pandemic. Of specific importance is the outcome of stroke patients with COVID-19 infection, as early data indicates an increased risk of ischaemic stroke in people with COVID-19, as a result of SARS-COV-2 associated hypercoagulability and thrombo-inflammation (Connors & Levy, 2020).

CONCLUSIONS

This study demonstrated that there was no difference in stroke presentations overall during the 2020 COVID-19 pandemic time period with the exception of the first phase of the pandemic. There were no significant differences in the timely provision of reperfusion therapies, time-based metrics or patient outcomes. Although this study has demonstrated few differences between the two time periods (pre and during COVID-19 pandemic) there was an unexplained higher haemorrhagic stroke rate and stroke severity at ED presentation.

These results highlight the importance of ongoing analysis of the impact of the COVID-19 pandemic on stroke presentations, management and of the potential factors that might inhibit the routine care of and best outcomes for these patients. It is imperative to inform the community that even during a pandemic it is vital to present to hospital rapidly if signs and symptoms of stroke are evident to optimise patient outcomes and deliver best practice treatments in a timely manner.



REFERENCES

Andersen, K. K., Olsen, T. S., Dehlendorff, C., & Kammersgaard, L. P. (2009). Hemorrhagic and ischemic strokes compared: stroke severity, mortality, and risk factors. Stroke, 40(6), 2068-2072.

Bersano, A., Kraemer, M., Touzé, E., Weber, R., Alamowitch, S., Sibon, I., & Pantoni, L. (2020). Stroke care during the COVID□19 pandemic: experience from three large European countries. European journal of neurology, 27(9), 1794-1800.

Cadilhac, D. A., Kim, J., Tod, E. K., Morrison, J. L., Breen, S. J., Jaques, K., Kleinig, T. et al. (2021). COVID-19 Pandemic Impact on Care for Stroke in Australia: Emerging Evidence From the Australian Stroke Clinical Registry. Frontiers in neurology, 12, 230.

Carroll, W. M. (2019). The global burden of neurological disorders. The Lancet Neurology, 18(5), 418-419.

Connors, J. M., & Levy, J. H. (2020). Thromboinflammation and the hypercoagulability of COVID-19. J Thromb Haemost, 18(7), 1559-1561.

Emberson, J., Lees, K. R., Lyden, P., Blackwell, L., Albers, G., Bluhmki, E., et al. Stroke Thrombolysis Trialists' Collaborative, G. (2014). Effect of treatment delay, age, and stroke severity on the effects of intravenous thrombolysis with alteplase for acute ischaemic stroke: a meta-analysis of individual patient data from randomised trials. Lancet (London, England), 384(9958), 1929-1935. doi:10.1016/S0140-6736(14)60584-5

Gao, Z., Xu, Y., Sun, C., Wang, X., Guo, Y., Qiu, S., & Ma, K. (2021). A systematic review of asymptomatic infections with COVID-19. Journal of Microbiology, Immunology and Infection, 54(1), 12-16.

Hacke, W., Donnan, G., & Fieschi, C. (2004). Association of outcome with early stroke treatment: pooled analysis of ATLANTIS, ECASS, and NINDS rt-PA stroke trials. The Lancet, 363(9411), 768-774. doi:https://doi.org/10.1016/S0140-6736(04)15692-4

Hodge, A., Hugman, A., Varndell, W., & Howes, K. (2013). A review of the quality assurance processes for the Australasian Triage Scale (ATS) and implications for future practice. Australasian Emergency Nursing Journal, 16(1), 21-29.

Hoyer, C., Ebert, A., Huttner, H. B., Puetz, V., Kallmünzer, B., Barlinn, K., Platten, M., et al. (2020). Acute stroke in times of the COVID-19 pandemic: a multicenter study. Stroke, 51 (7), 2224-2227.

Lees, K. R., Bluhmki, E., von Kummer, R., Brott, T. G., Toni, D., Grotta, J. C., Byrnes, G., et al. (2010). Time to treatment with intravenous alteplase and outcome in stroke: an updated pooled analysis of ECASS, ATLAN-

TIS, NINDS, and EPITHET trials. Lancet (London, England), 375(9727), 1695-1703. doi:10.1016/s0140-6736(10)60491-6

Markus, H. S., & Brainin, M. (2020). COVID-19 and stroke—A global World Stroke Organization perspective. International journal of stroke, 15(4), 361-364.

Middleton, S., Levi, C., Dale, S., Cheung, N. W., McInnes, E., Considine, J., Gerraty, R., et al. (2016). Triage, treatment and transfer of patients with stroke in emergency department trial (the T 3 Trial): a cluster randomised trial protocol. Implementation Science, 11(1), 1-9.

Moss, R., Wood, J., Brown, D., Shearer, F. M., Black, A. J., Glass, K., McVernon, J., et al. (2020). Coronavirus Disease Model to Inform Transmission-Reducing Measures and Health System Preparedness, Australia. Emerging infectious diseases, 26(12), 2844.

Muth, C. C. (2019). Endovascular Therapy for Acute Ischemic Stroke Treated in Clinical Practice. JAMA, 322(3), 263-263. doi:10.1001/jama.2019.8289

Organization, W. H. (2020). COVID 19 Public Health Emergency of International Concern (PHEIC). Global research and innovation forum: towards a research roadmap.

SARS-CoV, C. (2021). Variant Classifications and Definitions. Centers for Disease Control and Prevention https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/variant-surveillance/variant-info. html.

Storen, R., & Corrigan, N. (2021). COVID-19: a chronology of state and territory government announcements (up until 30 June 2020). Parliamentary Library Research Paper Series Parliamentary Library.

Stroke Unit Trialists, C. (2013). Organised inpatient (stroke unit) care for stroke. The Cochrane database of systematic reviews, 2013(9), CD000197-CD000197. doi:10.1002/14651858.CD000197.pub3

Sutherland, K., Chessman, J., Zhao, J., Sara, G., Shetty, A., Smith, S., Levesque, J.F., et al. Impact of COVID-19 on healthcare activity in NSW, Australia. Public Health Research & Practice. Retrieved from https://www.phrp.com.au/issues/december-2020-volume-30-issue-4/impact-of-covid-19-on-healthcare-activity-in-nsw-australia/

Vance, J., & Sprivulis, P. (2005). Triage nurses validly and reliably estimate emergency department patient complexity. Emergency Medicine Australasia, 17(4), 382-386.

Verma, B. K., Verma, M., Verma, V. K., Abdullah, R. B., Nath, D. C., Khan, H. T., Verma, V., et al. (2020). Global lockdown: An effective safeguard in responding to the threat of COVID□19. Journal of evaluation in clinical practice, 26(6), 1592-1598.