



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



Contents lists available at ScienceDirect

Journal of the Neurological Sciences

journal homepage: www.elsevier.com/locate/jns

Lessons learned in stroke care during COVID-19 pandemic and preparing for future pandemics in the MENA+ region: A consensus statement from the MENA+-SINO

Amal Al Hashmi^{a,*}, Stephan von Bandemer^b, Ashfaq Shuaib^c, Ossama Yassin Mansour^d, Mohammed Wassy^e, Atilla Ozcan Ozdemir^f, Mehdi Farhoudi^g, Hosam Al Jehani^h, Adnan Khanⁱ, Seby John^j, Maher Saqqur^{k,1}, On the behalf of MENA-SINO Organization¹

^a Neuroscience Directorate, Khoula Hospital Ministry of Health of Oman, Muscat, Sultanate of Oman

^b Division of Health Service Research, Institute of Work and Technology, Gelsenkirchen, Germany

^c Medicine and Neurology, Director Stroke Program, University of Alberta, Edmonton, AB, Canada

^d Alexandria Faculty of Medicine, Department of Neurology, Alexandria University, Egypt

^e Department of Neurology, Aga Khan University, Pakistan

^f Interventional Neurology & Neurocritical Care Program, Eskisehir Osmangazi University, Turkey

^g Neuroscience Research Center, Tabriz University, Islamic Republic of Iran

^h Department of Neurosurgery and Interventional Radiology, King Fahad Hospital of the University, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia

ⁱ Department of Medicine, Research Division, Weill Cornell Medicine-Qatar, Doha, Qatar

^j Neurology and Neurointerventional Surgery, Neurological Institute, Cleveland Clinic Abu Dhabi, United Arab Emirates

^k University of Alberta Edmonton, Canada

¹ Trillium Hospital, University of Toronto at Mississauga, Mississauga, ON, Canada

ARTICLE INFO

Keywords:

Stroke care
 COVID-19 pandemic
 First wave
 Futures waves
 Lessons
 MENA + region

ABSTRACT

Background: COVID-19 pandemic has negatively impacted stroke care services at multiple levels. There was a decline in acute stroke admissions. Fewer interventions have been performed. Increased “door-to-needle times and “door-to-groin puncture” during this pandemic. These factors combined have led to declining in the favoured outcomes of stroke patients’ globally. Yet this pandemic permits an opportunity for higher preparedness for future pandemics.

Objectives and methods: This paper aims to shed light on the main lessons learned in the field of stroke care during the first wave of COVID-19 pandemic. Here we are presenting proposals and initiatives for better preparedness in future similar emergencies. These proposals are based primarily on literature review of COVID-19 publications, as well as the first-hand experience gained during the first wave at the regional level. In addition to the consensus and collective ride of stroke experts in the Middle East North Africa Stroke and Interventional Neurotherapies Organization (MENA+-SINO) and interaction and collaboration with international stroke specialists from the Stroke World Organization (WSO), European Stroke Organization (ESO) and stroke and COVID-19 papers authors.

Conclusion: Stroke care is very complex, particularly in the initial hours after onset of symptoms. A successful outcome requires very close collaboration between clinical personnel from multiple specialties. Preparedness for future pandemics requires the improvement of care plans that allow for rapid assessment of stroke patients and ensuring that regular ‘mock exercises’ familiarize quintessential services that care for the stroke patients.

* Corresponding author.

E-mail addresses: amalm.alhashmi@moh.gov.om, amalm.alhashmi@gmail.com (A. Al Hashmi), bandemer@iat.eu (S. von Bandemer), Ashfaq.shuaib@ualberta.ca (A. Shuaib), yassinossama@yahoo.com (O.Y. Mansour), mohammad.wassy@aku.edu (M. Wassy), atillaozcanozdemir@gmail.com (A.O. Ozdemir), farhoudi_m@yahoo.com (M. Farhoudi), hosam.aljehani@gmail.com (H. Al Jehani), adk2018@qatar-med.cornell.edu (A. Khan), Johns5@clevelandclinicabudhabi.ae (S. John), maher2000@ualberta.ca (M. Saqqur).

¹ Website: <http://mena-sino.org>

<https://doi.org/10.1016/j.jns.2021.120060>

Received 27 March 2021; Received in revised form 22 October 2021; Accepted 17 November 2021

Available online 27 November 2021

0022-510X/© 2021 Published by Elsevier B.V.

1. Background

On March 11, 2020, and after tracking the rising number of cases across several regions globally, the World Health Organization declared coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome corona virus-2 (SARSCoV-2) as a pandemic [1]. The number of people infected with COVID-19 has been steadily increasing since then. The internationally recognized John Hopkins University web site confirmed on September 18th, 2021 227,613,687 COVID-19 cases globally with 4,678,856 deaths and a total of 192 affected countries and regions [2]. The countries most seriously affected by this pandemic are the United States, India, and Brazil [2]. Countries in the MENA + region have also been severely affected with the largest reported cases in Turkey 6,794,670, Iran 5,396,013, Iraq 1,970,746 and Morocco 915,835 [2]. After an initial severe illness with rising numbers of cases worldwide, the pandemic appeared to be contained by the summer months of 2020 [1]. Unfortunately, the number of confirmed cases rose again in numerous countries bringing in the several waves of the pandemic. The emergence of new variants of COVID-19 [3,4], with potential for increased spread in the community and higher virulence, pose serious demand on health systems globally in the coming years [1]. Since the start of COVID-19 pandemic major complications on the care of a number of disorders including stroke have been witness [5–10]. COVID-19 also resulted in major vascular neurological complications. Ischemic stroke (IS), intracranial hemorrhage (ICH) and cerebral venous sinus thrombosis were all reported as complications of COVID-19 [11]. In order to avoid and properly treat all strokes sub types during this pandemic and future once. Health systems should ensure that acute stroke care does not get neglected or compromised during any pandemic not only in the Middle East and North Africa plus (MENA +) region but globally. Collaboration and exchange of experience and knowledge will allow us to be better prepared for any future pandemics or major regional emergencies that may affect us in the coming years.

MENA + region was one of the earliest region affected by COVID-19 pandemic. The number of confirmed cases in the very first few months of the pandemic has been estimated to exceed five million [12]. During the first wave of the pandemic, our regional health care systems were crushed just as they have been in other regions and countries of the world. The situation was even worse with the subsequent waves. The devastating effects on the fragile health system of politically and economically volatile region have made the situation extremely critical.

The lack of preparedness of the medical systems, inadequate resources and perhaps most importantly, the denial of the seriousness of infection among the public, very likely contributed to the severity and spread of the pandemic in the region. Additionally the lack of formal and systematic data and dedicated attention to the impact of COVID-19 in the MENA +region resulted in unfavorable out come with the first COVID-19 wave of the pandemic.

Like European and North American countries, the governments in the MENA + region have imposed travel and gatherings restrictions to contain the spread of the pandemic [13]. Yet the rate of infection remained raising. The second and following waves of the COVID-19 infection had led to significant increase in the numbers of cases. This is at a time when the medical community has barely recovered from the first wave. Stroke management during the successive waves of this pandemic has faced unique challenges on multiple levels. Not up until the vaccination campaigns started; were some decline in the spread and severity of the pandemic was witnessed. However in the presence of the possibility of the emergence of new mutations the situation with this pandemic remains unpredictable. There is therefore an urgent need for better preparation and awareness in case there is an increase in the number of COVID-19 cases or any other pandemics in the region.

2. MENA+ SINO

The Middle East and North Africa plus Stroke and Interventional

Neurotherapies Organization (MENA +SINO) is the main regional stroke organization in the region with membership from several regional countries. Egypt, Sudan, Libya, Tunisia, Iran, Turkey, Jordan, Lebanon, Iraq, Saudi Arabia, Oman, United Arab Emirates, Qatar, Pakistan, Indonesia, Thailand, and Malaysia are all part of this organization. The (MENA+ -SINO) plays a major role in improving stroke care. MENA+-SINO organizes local, regional, and international conferences on stroke. Currently working on setting regional stroke protocols and is in the process of developing stroke certification programs for regional hospitals as well as stroke fellowship programs. Additionally it has a great net of international collaboration and cooperation with internationally recognized bodies like World Stroke Organization (WSO) and European Stroke Organizations (ESO).

3. Objectives and methods

The main aim of this communication is to present the obstacles, challenges, and lessons learned in stroke care and the COVID-19 pandemic. General consensus and collective settlement have been reached among stroke leaders and professionals in the MENA+ region through several virtual meetings and workshops. A large number of challenges faced by the region throughout the first and successive waves of the pandemic were identified.

There have also been numerous discussions and consultations between MENA+ SINO board members, WSO and ESO international stroke specialists, and lookup papers' authors. In addition, the literature review of COVID-19 and stroke publication and first-hand experience have extensively assisted in accomplishing a comprehensive grasp and strategy to this pandemic in relation to stroke care.

Before taking up the most important lessons learned. First, we will focus on the most important research on COVID-19 and stroke. This will be accompanied by examples of the constraints and challenges faced by the region and the remarkable response through a number of countries. Finally, some tips for initiatives at different ranges of stroke care will be addressed.

3.1. Stroke and COVID-19 land mark publications

Stroke is one of the most common medical emergencies causing severe disability and death worldwide [14,15]. The treatment of stroke requires immediate evaluation, imaging, and initiation of reperfusion therapies. Stroke services were not immune from this pandemic with multiple reports of delay in hospital admissions and delay to treatment that may have resulted in poor outcome [5–10,16–23]. Several stroke organizations and stroke specialists around the world have raised red flags [5–10,16–23]. Numerous research papers from around the world have discussed the most important challenges the world has faced in treating stroke patients in these difficult times and few provided recommendations and pathways for better management of stroke patients during this pandemic. [9,10]

Several studies have shown a decrease in stroke admissions to hospital and some were related to the fear of contracting the infection in the hospital [24,25]. Patients with milder stroke symptoms, e.g., transient ischemic attack (TIA) and stroke mimics are more likely to avoid hospitalizations than patients with more severe stroke symptoms [19]. In the MENA region, like other parts of the world, a decrease in hospital admissions of stroke patients has been observed. This was also accompanied by a decrease in mechanical thrombectomy and intravenous thrombolysis procedures [24–26].

A decrease in subarachnoid hemorrhage cases was also observed at a rate ranging from 24.7% to –87.7% regionally, with the exception of the United Arab Emirates and Tunisia, which witnessed a clear increase with a percentage ranging 6.5% -38.1%. [25]. In a retrospective study from Qatar, an increase in stroke due to large vessel occlusion (LVO) was found, despite the overall reduction in stroke admission as a result of decline in stroke mimics [26]. The increase in LVO can be explained in

part by an increased prothrombotic state as has been described in severe COVID-19 infections. Additionally a series of 21 patients with stroke related to COVID-19 from UAE had shown 90% of stroke victims are from south Asian origin with multiple risk factors [27]. Up to date the largest study of cerebral venous thrombosis patients in relation to COVID-19 infection published was conducted in the MENA+ region [28]. Furthermore an important paper suggesting a link between low stroke incidence and decreased air pollution during pandemic lock down was published from Pakistan [29].

Though the etiological relationship between COVID-19 and stroke remains unclear. There is a convincing data that COVID-19 may result in an increase in cerebrovascular disease in the community [30,31]. In stroke patients with severe infection, hypercoagulation and cardioembolic stroke are frequently evident [28]. COVID-19 virus may also play a direct role through injury to the human angiotensin converting enzyme, ACE2, expressed in epithelial cells throughout the body, including the central nervous system [30]. Other coronaviruses, including SARS-CoV-1 and MERS-Cove have been identified in the brains of patients (case reports) and heavily in the brains of mice that express human ACE2 [32–34].

COVID-19 infection affected all age categories, including the very young adults. Thomas et al. demonstrated the possible relation between COVID-19 and embolic stroke in the young in whom multiple emboli were seen in cervical and cranial vessels suggestive of a prothrombotic state [35].

3.2. *Reginal experience of obstacles, challenges and solutions during the pandemic*

3.2.1. *Egypt*

The first case of COVID-19 was announced on February 14, 2020 [36]. This was then followed by a significant rise in the number of cases registered in the country. The Egyptian Ministry of Health worked to develop a preparedness plan by transferring some medical services to serve COVID-19 cases. It also started multidisciplinary national coordination between different ministries [37]. In spite of the success of this step in dealing with the exacerbating increases in COVID-19 cases. This step, however, has negatively affected the ability of the medical system to deal with other emerging diseases, such as acute stroke. Therefore a significant reduction in intravenous thrombolysis and thrombectomy procedures compared to a comparable months from the pre-COVID-19 era was witnessed [38,39].

On the other hand, the imposition of a pandemic curfew in March 2020 resulted in stroke patients being reluctant to seek medical help due to fear of infection. This has affected both pre- and post-stroke care significantly [40]. Therefore, the Egyptian Ministry of Health launched a public campaign in the media to urge people to seek medical services as soon as symptoms of stroke appear or any other medical emergencies.

Additionally, the ministry of health announced a tele-medical communication initiative to help lower the magnitude of this impact. Yet the mortality rate from all diseases jumped with extra ~80 thousand casualties in May, June, and July 2020 compared to the rate of the previous year [40]. This could be on one hand due to a decrease in the number of patients with acute medical emergencies (including stroke patients) seeking medical services. On the other hand, due to increased deaths due to COVID-19 infection-related deaths [41]. All these have urged the Egyptian Ministry of Health to communicate with the private medical sectors to find a solution. Both Worked to classify some of these hospitals for non-COVID-19 emergencies. In this context, the official emergency triage protocol (using rapid testing, CT scan of the chest, and laboratory) has been used to keep these hospitals ready for non-COVID-19 emergencies.

3.2.2. *Oman*

On February 24, 2020; The Omani Ministry of Health (OMH) announced the first two confirmed cases of COVID-19 infection [42].

Both cases contracted the disease through travel to Iran [42]. By March 12, 2020, the rate of COVID-19 cases had increased to a total of 19 cases. Of which, 17 cases related to travel to Iran and one to Italy and another one was under epidemiological investigations [43]. Since then MOH called upon all to adhere to quarantine procedures and avoid public and worship places and obey all preventive measures such as social distancing, hand hygiene, and mask-wearing. One of the main challenges, especially at the beginning of the pandemic was that Oman is one of the countries where a large pool of multinational foreigners operates. This necessitated that the teaching aids be in multiple languages to ensure that all information related to the pandemic reached all residents. The Ministry of Health and in collaboration with the Ministry of Information has created awareness and guidance materials in multiple languages. With the continuous increase in the number of COVID-19 cases recorded in the country. In March 2020; the government announced the formation of a higher national committee. This committee aimed to discuss the mechanism of dealing with developments resulting from the spread of COVID-19 infections. It also aimed to provide appropriate suggestions and recommendations based on the results of the general health assessment.

3.2.3. *Pakistan*

The government of Pakistan has established a COVID-19 infection coordination center for daily reporting of all PCR tests throughout the country, positive cases, hospitalized cases, patients on ventilators [44]. In addition, to lockdown, many field hospitals were established to treat COVID-19 patients to accommodate the increasing number of confirmed cases. The medical community was not well prepared initially, unfortunately, this has led to significant COVID-19 related mortality among doctors and health care workers in the first few months.

The Neurology training programs were affected due to the relocation of neurology residents to serve medical wards. Additionally, there was a decrement in the teaching sessions and minimal activity of neurophysiology labs. In order to compensate for that, the Pakistan Society of Neurology and Pakistan Stroke Society (PSS) started webinars and zoom sessions for residents and trainees.

A multi-center study was conducted in Pakistan evaluating preparedness and the impact of COVID-19 of the neurological / stroke care and training of residents and fellows [45]. Both societies organized many public awareness and media awareness activities related to COVID-19 neurological manifestations and stroke care in COVID-19 patients. (PSS) started COVID-19 and cerebral venous thrombosis and COVID-19 stroke registries.

A few months after the pandemic hits, neurological care shifted to tele neurology and tail stroke at large academic centers. Lastly, during the last six months, the country has observed a strong and effective drive for COVID-19 vaccination leading to the vaccination of almost half of the eligible population in the country [44].

3.3. *Lessons learned in stroke care during first and successive waves of COVID-19 pandemic*

3.3.1. *Public awareness initiatives*

The pandemic was an unexpected global event with no previous experience available on how best to prepare for it. The response on how to deal with the first wave of the COVID-19 pandemic varied across the world. In some countries (for example, Taiwan, New Zealand) the governmental response to the pandemic was comprehensive resulting in very successful control of the disease while in others (for example, USA, Russia, India), lack of a comprehensive response likely resulted in a high number of cases and fatalities [2].

Most successful strategies at the public level included universal mandates to wear masks, social distancing, closing of schools, restaurants, gyms, and other public spaces. In addition to applying travel ban and lock down, successful implementation of these programs varied across countries leading to variable extent in stopping the exponential

spread of infections. An unexpected halting effect of these programs was due to the fear of contracting the COVID-19 infection. Simultaneously there was a significant decline in emergency presentations of patients with potentially serious diseases (for example, acute coronary syndrome and stroke) [45–47]. While there is no clear evidence that this decrease in hospital admissions of patients with acute vascular syndromes may have resulted in serious effects, the realization that patients may not come to the hospital requires active public efforts to promote the safety of care in such situations. Such efforts may be particularly important in the Middle East where there is a very high incidence of diabetes and other factors that may adversely affect prognosis of COVID-19 infection. Additionally presence of different nationalities living and working in MENA+ region.

Pandemic preparedness poses special problems in the MENA + region. Public perceptions of the seriousness of the illness may be lacking, especially in the expatriate population. It must be emphasized clearly that staying at home is not the right decision with suspected stroke symptoms and that hospitals are managed professionally and there is no increased risk of infection. The information must be available in multiple languages that reflect the needs of the local communities. Communication about COVID-19 therefore also requires not making the wrong choices and to report to hospitals in case of emergencies. This implies adopting new strategies for stroke campaigns (for example, “strokedonotstay@home” campaign). Combined local, regional and international efforts are necessary to communicate experience from the first wave and subsequent waves (making use of stroke angels’ platform, exchange in networks like MENA+/SINO or ESO/WSO). With the increasing use of social media, optimizing it may help with communication of important messages. Additionally advocating for safety of vaccinations especially the one approved by WHO.

On the public level therefore, it is crucial to communicate:

- Stroke is an emergency that has to be treated in a stroke-unit as quickly as possible (time is brain).
- Stroke treatment is safe for patients with COVID-19 infection.
- Adherence to all protective measures such as social distancing, wearing masks, hand hygiene etc. and creating comprehensive regional/international protocols with general instructions in regards to preventions
- Availability of COVID -19 preventive measure in multiple languages
- Medical staffs should not hesitate to treat infected patients with stroke symptoms due to fear of risk of infection.
- Timely evaluation is important for patients with stroke even when they are suspected to have COVID-19 infection.
- Medical staffs must adhere to PPE all the time for their own and patients safety
- Restrict hospital visitations to secure safety of the patients and medical staffs.
- Advocate and encourage public on the important of getting vaccinated through vaccination campaign

3.3.2. Health institution initiatives

COVID-19 is a highly communicable disease. Similarly, any newer pandemic may also carry the risk of spread via contact. To ensure the safety of patients and the health care professionals, several important initiatives require urgent attention for smooth transition of patients with suspected acute stroke that may require admission to the hospital. These will likely require very close cooperation and guidance of the regional health boards/ministries and the hospitals’ administration.

We recommend that an amendment to the regular “Stroke Protocol” be developed and implemented in practice. This amended protocol shall be comprehensive and will include pre-hospital, hospital, and post-hospital recommendations. The recommendations suggested are pertinent to the local MENA+/SINO region and incorporates several initiatives that have been adopted in many other countries, i.e. Canada [46]. In order to avoid the risk of exposure, medical staffs that come in contact

with the patients during prehospital evaluation and hospitalization should all be provided with appropriate PPE and be trained in implementing general hygienic standards. In some Middle Eastern countries, the medical staffs from the stroke program were redeployed to a special COVID-19 hospital leading to a critical shortage of the personnel managing the stroke units. Of note, it is important to re-emphasize that the stroke unit staff are highly specialized medical personnel and are universally of limited numbers and therefore should not be redeployed. Additionally.

The recommendations for preparedness for the anticipated future waves require attention in the following levels of care, and each will be reviewed separately:

- Prehospital care
- Hospital admission in the emergency department and stroke ward
- Post-acute care
- Coordination between primary and accredited stroke centers
- Leadership and administrative support

a. Pre-hospital care of suspected stroke patients

It is a universal consensus that stroke is a time-sensitive medical emergency and requires activation of the emergency medical service (EMS). In most countries, including most of the MENA + countries, the first contact between the patient and the medical community is the ambulance and paramedics. The paramedics therefore require the necessary training to screen patients for COVID-19 risk and recognize patients with suspected stroke. The experience from the first wave of COVID-19 has been very helpful for the EMS to rapidly screen stroke patients while on-route to the hospital. This prescreening is very useful and saves valuable time for patients requiring reperfusion therapies. Infection screening may include inquiring for a history of infection, contact with an infected person or travel history by paramedics as far as possible. When there is suspicion of COVID-19 infection, prenotification to the stroke team, emergency department and the stroke unit can save valuable time and lower risk of infection. In order to ensure that the information is readily available, the protocols require regular updates and should be essential learning for paramedics that are very frequently the first contacts with patients with suspected stroke.

All protocols that have regionally been developed for stroke patients, including pre -notification, bypass and diversion to tertiary care centers do not require any changes during the pandemic.

b. Hospital care of stroke patients

The assessment and treatment of patients with acute stroke is a demanding process. Following an initial quick clinical examination, blood is drawn, and the patient is transferred for brain and vascular imaging. The involvement of several medical personnel at triage, nursing trauma bay, stroke physicians and radiology technologists are essential to ensure that the ‘door to CT’ time is kept at a minimum. Delays in time to CT imaging and thrombolysis were noted in many stroke studies published in the first wave of COVID-19 [5,6]. As time to treatment can make major differences in outcome, all efforts should be made to avoid delays as the number of cases of COVID-19 increase. The experience from the first wave had revealed that there was a decrease in emergency department (ED) visits for all sorts of medical emergencies [47]. This 25% decrease [48] in hospital ED visits may also be anticipated with the future waves of this pandemic. The lower level of activity in the ED can allow for resources to focus on stroke patients that require thrombolysis to ensure that there are no delays in initiation of treatment.

It is essential that safety measures be implemented in all areas that the stroke patients will require evaluation and treatment, including the emergency room, the CT room, the angiography suite, and the stroke unit. In the emergency room, systematic screening and testing for COVID-19 rapid if available to be implanted (travel or contact history,

presence of fever, cough, chest pain, dyspnea, headache, myalgia, gastrointestinal symptoms or any others). In the CT room a protocol with dedicated CT scanner for COVID-19 patients or suspects is necessary. In the event of positive pulmonary symptoms, a chest CT should be performed at the same time as a head CT. CTA should substitute the carotid Doppler unless it is contraindicated to prevent unnecessary exposure of the radiographer due to proximity during the procedure. An MRI should only be done with extreme necessity, otherwise a CT head should remain the first option to avoid and minimize time of exposure.

In the angiography suite, measures must be taken to ensure minimal exposure of staff including low threshold for intubation and avoiding conversion of cases from conscious sedation to intubation. The transfer to ICU or stroke unit has to be done by the same team to avoid exposure of other staff. The stroke unit must be split into COVID-19 and non-COVID-19 areas. The same staff will have to be dedicated to one of the areas while following and monitoring patients to minimize exposure.

In a recent study, COVID-19 patients with large vessel occlusion experienced more complex thrombectomy procedures, early re-occlusions leading to high-hospital mortality (60%) rates [49]. Moreover, COVID-19 related ischemic strokes were associated with higher mortality and worse functional outcome [50]. There is a clinical benefit for patients with intracerebral hemorrhage, ischemic stroke, subarachnoid hemorrhage, and traumatic brain injury when NCCU is established [51,52]. Therefore, there is a need for a dedicated neurocritical care unit (NCCU) in the era of pandemics. On the other hand, in some centers, dedicated NCCU was repurposed to manage non-neurological COVID-19 patients. In terms of environment, NCCU should be set up as a separated, isolated ICU that consists of negative pressure airborne infectious isolation rooms (AIIRS) [53].

Establishing a dedicated, advanced and well-designed neurocritical care training program will help COVID-19 both neurocritical care and general ICU care for patients with COVID-19. Similar to the pre-hospital preparedness program, there is need for regular reviews of the protocols in place for acute care that will be helpful in ensuring that the patients and medical staff remain safe as 'time-sensitive' treatments are being offered.

c. Post-acute care in rehabilitation and at home

Rehabilitation sessions should be provided while the patient is on the stroke unit when possible to minimize exposure to COVID-19 infection. Efforts should be made for the rehabilitation sessions with the same personnel to allow for a decreased risk. All equipment for COVID-19 patients will require frequent sterilization.

It is important that while in hospital the patients be offered information sessions on COVID-19 risk. The patients should be informed that patients with stroke or other vascular diseases, especially those with diabetes, are at an increased risk of complications if they are exposed to COVID-19 infections. The patients should avoid unnecessary contact with family members and friends.

d. Coordination between primary and accredited stroke centers

Many large stroke programs have interactions with smaller primary stroke care programs. This allows for appropriate care for acutely ill stroke patients and prevents transfer of patients to the comprehensive centers unless it is necessary. Patients requiring less intensive care or in the chronic stages of the illness may stay at the primary centers and are followed remotely by the experts from the tertiary stroke programs. Telestroke is increasingly used for such consultations [54]. One of the surprising effects of the COVID-19 pandemic is the exponential increase in the usage of telemedicine for care of the stroke patients. This has been particularly useful for follow-up appointments where programs such as Zoom allow for unprecedented access to the patients within the safety of their homes [54]. Such communications are the future of health care and need to be enhanced between the primary and tertiary stroke centers.

The use of tele-technology will be particularly useful in the MENA + region where the telemedicine technology is currently not widely available. Local seminars organized by the stroke faculty with experience in telemedicine will be very useful. Telestroke is also very useful for assessment of patients for thrombolysis and thrombectomy of acute stroke and has been shown to be very safe and as effective as "in-person" consultation. Consultations require specialized equipment that fortunately is not very expensive and very easy to use.

Preparedness for future pandemic should consider the use of tele-technology as an essential component of care to avoid the risk of infection to the patient and health care personal.

e. Leadership and administrative support:

The implementation of these measures requires commitment by the leadership at the ministries of health and hospital administration. Their full support is required for successful implementation of these measures. Information and proactive collaboration between the stroke team leadership and the administration at the Ministry of Health and hospitals will be very useful in the event of number of COVID-19 cases begin to increase again or in case of any future pandemic .

The preparedness for future increases in COVID-19 or new pandemics require readiness and an action plan. The plan will require regular reviews and updating as new information becomes available. The board membership of the MENA+-SENO organization recommends the following measures in the event:

1. Adoptions of the measures proposed in the consensus statement by participating members of the MENA+-SINO organization
2. Development of a core-group with membership of representatives from the Ministry of Health, hospital administration and the stroke program that will review the recommendations at local levels
3. Periodic mock-up meetings of the core-group to review and update plans on implementation of public awareness campaigns, provision of institutional measures as described and training of staff. This should include administration, paramedics, ER staff, radiology, and stroke team.
4. Action plan for the MENA+-SINO region in the event of future waves of COVID-19 or other pandemics. The board members/scientific committee will convince and review the severity of the illness offer timely advice as mentioned above (also see Fig. 1).
5. Encouraging stroke research initiatives at local and regional level including national COVID-19 stroke registries (UAE, Pakistan, Oman and Qatar), Stroke and Cerebral venous thrombosis registry, Covid vaccine and stroke/ CVT registry. These registries help to improve the understanding of the disease , and its burden at the regional level. Faculty from this region is involved in many COVID-19 stroke related guidelines, statements, review articles. [55,56]

4. Conclusion

Treating acute stroke patients during the initial waves of the pandemic have shown that:

- If adequate protocols are followed, patients and employees are safe. It's critical to get this information out to the public so that all acute stroke patients seek medical help. It's also worth mentioning that successful strokes treatment is time-dependent.
- Hospital stroke preparedness necessitates concerted efforts to ensure that protocols are followed at all levels of care for patients with suspected stroke in the event of a future crisis. Stroke patients should be managed according to general guidelines, which must be supplemented by COVID-19-related interventions.
- Stroke treatment is complicated, especially in the first several hours after symptoms appear. A successful outcome necessitates close collaboration among medical professionals from many disciplines.

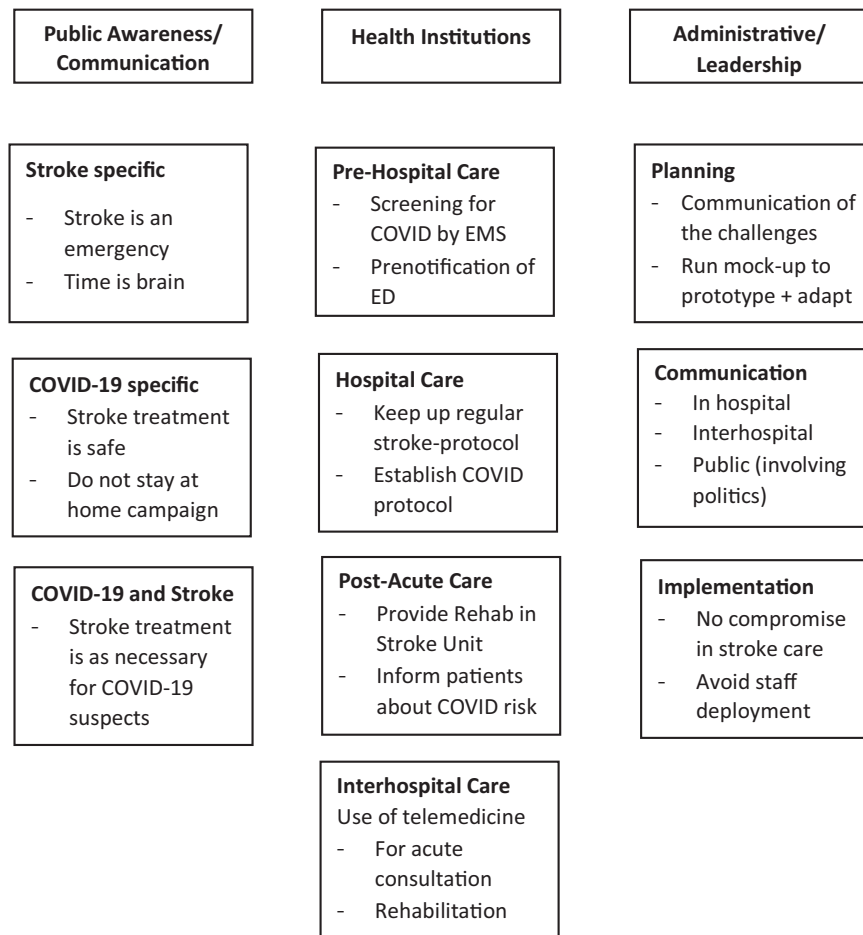


Fig. 1. Levels and means of intervention - COVID-19 and stroke management.

The nursing team on the stroke unit is critical for preventing problems and improving rehabilitation. Staff from the stroke unit should not be transferred to other locations.

- A mock-up can be used to prepare for the implementation of a COVID-19 ready stroke service, ensuring that communication, processes, and structures are in place.
- A ready-to-implement action plan that is reviewed and updated on a regular basis will ensure timely preparedness in future crises.

Statement of ethics

The article reports non interventional organisational experience.

Funding

No funding was received for this work.

Declaration of Competing Interest

There are no conflicts of interest.

Acknowledgements

None.

References

- [1] <https://www.who.int/emergency/diseases/novel-coronavirus-2019>.
- [2] <https://coronavirus.jhu.edu/map.html> (September 18th 2021).

- [3] <https://www.mayoclinic.org/diseases-conditions/coronavirus/expert-answers/covid-variant/faq-20505779>.
- [4] Elisabeth Mahase, Covid-19: how many variants are there, and what do we know about them? Eight notable variants of SARS-CoV-2 have been found since September 2020, *BMJ* 374 (2021), n1971, <https://doi.org/10.1136/bmj.n1971> Published: 19 August 2021.
- [5] Salvatore Rudilosso, Carlos Laredo, Víctor Vera, et al., Acute Stroke Care Is at Risk in the Era of COVID-19; Experience at a Comprehensive Stroke Center in Barcelona *Stroke* 51, 2020, pp. 1991–1995.
- [6] Shagi Yaghi, Koto Ishida, Jose Torres, Brain Mac Grory, et al., SARS-CoV-2 and stroke in a New Yourk Healthcare System, *Stroke* 51 (2020) 2002–2011 (May 20, 2020).
- [7] M.D. Basile Kerleroux, M.D. Thibaut Fabacher, M.D. Nicolase Bricout, M.D. Martin Moise, et al., Mechanical Thrombectomy for Acute Ischemic Stroke Amid the COVID -19 Outbreak; Decreased Activity and Increased Care Delays *Stroke* 51, 2020, p. 2012. May 20,2020.
- [8] Houman Khosravani MD, PhD, Phavalan Rajendram MD, Lowyl Notario MSc, Martin G Chapman MD, Bijoy K Menon MD, MSc, Hyperacute Stroke Management During the Coronavirus Disease 2019 (COVID-19) Pandemic, *STROKEAHA*, 2020.
- [9] Amal M. Al Hashmi, Atilla Ozcan Ozdemir, Ashfaq Shuaib, Hosam Al-Jehani, Ossama Yassin Mansour, Adel Al Hazzani, Farid Aladham, Mehdi Farhoudi, Seby John, Maher Saqqur, Current recommendations for the management of stroke patients in the middle east in the era of COVID-19 pandemic; statement from the MENA SINO, *J Stroke Cerebrovasc. Dis.* 29 (11) (2020 Nov) 105181.
- [10] Hosam Al-Jehani, Seby John, Syed Irteza Hussain, Amal Al Hashmi, May Adel Alhamid, Dareen Amr, Atilla Ozcan Ozdemir, Farid Aladham, Ossama Mansour, Ossama Yassin Mansour, Ashfaq Shuaib, Maher Saqqur, Consensus statement of the MENA-SINO on implementing care pathway for acute neurovascular emergencies during the COVID-19 pandemic, *Front. Neurol.* 11 (2020 Aug 25) 928, <https://doi.org/10.3389/fneu.2020.00928>.
- [11] Georgios Tsvigoulis, Lina Palaiodimou, Ramin Zand, Vasileios Arsenios Lioutas, Christos Krogias, Aristeidis H. Katsanos, Ashkan Shoamanesh, Vijay K. Sharma, Shima Shahjouei, Claudio Baracchini, Charalambos Vlachopoulos, Rossetos Gournellis, Petros P. Sfikakis, Else Charlotte Sandset, Andrei V. Alexandrov, Sotirios Tsiodras, COVID-19 and cerebrovascular diseases: a comprehensive overview, *Ther. Adv. Neurol. Disord.* 13 (2020) 1–18 (DOI: 10.1177).

- [12] Mohammad Karamounzian, Navid Madani, COVID-19 response in the Middle East and North Africa: challenges and path forward, *Lancet Glob. Health* 8 (7) (2020 Jul) e886–e887, [https://doi.org/10.1016/S2214-109X\(20\)30233-3](https://doi.org/10.1016/S2214-109X(20)30233-3).
- [13] <https://www.dohaneews.co/covid-cases-double-in-less-than-a-month-as-qatar-brac-es-for-possible-second-wave/>.
- [14] Emelia J. Benjamin, Paul Muntner, Alvaro Alonso, Marcio S. Bittencourt, et al., Heart disease and stroke statistics: 2019 update, *Circulation* 139 (2019) e56–e528, <https://doi.org/10.1161/CIR.0000000000000659>.
- [15] S. Claiborne Johnston, Shanthi Mendis, Colin D. Mathers, Global variation in the stroke burden and mortality: estimates from monitoring surveillance and modelling, *Lancet Neurol.* 8 (2009) 345–354.
- [16] A.P. Kansagra, M.S. Goyal, S. Hamilton, G.W. Albers, Collateral effect of Covid-19 on stroke evaluation in the United States, *N. Engl. J. Med.* 383 (4) (2020 Jul 23) 400–401, <https://doi.org/10.1056/NEJMc2014816> (Epub 2020 May 8. PMID: 32383831; PMCID: PMC7233187).
- [17] S. Masroor, Collateral damage of COVID-19 pandemic: delayed medical care, *J. Card. Surg.* 35 (6) (2020 Jun) 1345–1347, <https://doi.org/10.1111/jocs.14638> (Epub 2020 May 17. PMID: 32419177; PMCID: PMC7276840).
- [18] J. Montaner, A. Barragán-Prieto, S. Pérez-Sánchez, I. Escudero-Martínez, F. Moniche, J.A. Sánchez-Miura, L. Ruiz-Bayo, A. González, Break in the stroke chain of survival due to COVID-19, *Stroke* 51 (8) (2020 Aug) 2307–2314, <https://doi.org/10.1161/STROKEAHA.120.030106> (Epub 2020 May 29. PMID: 32466738; PMCID: PMC7282408).
- [19] H. Diegoli, P.S.C. Magalhães, S.C.O. Martins, C.H.C. Moro, P.H.C. França, J. Safanelli, V. Nagel, V.G. Venancio, R.B. Liberato, A.L. Longo, Decrease in hospital admissions for transient ischemic attack, mild, and moderate stroke during the COVID-19 era, *Stroke* 51 (8) (2020 Aug) 2315–2321, <https://doi.org/10.1161/STROKEAHA.120.030481> (Epub 2020 Jun 12. PMID: 32530738; PMCID: PMC7302100).
- [20] D.Z. Rose, W.S. Burgin, S. Renati, Untreated stroke as collateral damage of COVID-19: “time is brain” versus “stay at home”, *Neurohospitalist* 10 (4) (2020 Oct) 291–292, <https://doi.org/10.1177/1941874420929199> (Epub 2020 May 26. PMID: 32973965; PMCID: PMC7495700).
- [21] P.P. Bójtí, R. Stang, B. Gunda, I. Sipos, D. Bereczki, A COVID-19-pandémia hatása az akut ischaemiás stroke ellátásra. A járulékos egészségügyi veszteségek retrospektív, egycentrumos felmérése (A COVID-19-pandémia orvosszakmai kérdései) [Effects of COVID-19 pandemic on acute ischemic stroke care. A single-center retrospective analysis of medical collateral damage], *Orv. Hetil.* 161 (34) (2020 Aug) 1395–1399. Hungarian, <https://doi.org/10.1556/650.2020.31936> (PMID: 32804669).
- [22] G.E. Zovovich, A. Alves De Lima, M. Fosco, L.M. Burgos, R. Martínez, R. Dupuy De Lôme, A. Torn, J. Sala Mercado, Daño colateral de la pandemia por COVID-19 en centros privados de salud de Argentina [Collateral damage of COVID-19 pandemic in private healthcare centers of Argentina], *Medicina (B Aires)* 80 (Suppl. 3) (2020) 37–41 (Spanish. PMID: 32658846).
- [23] Raul G. Nogueira, Muhammed Qureshi, Mohammed Abdalkder, Sheila Quriques Martins, et al., Global impact of COVID-19 on stroke care and intravenous thrombolysis, *Int. J. Stroke* 16 (5) (2021 Jul) 573–584, <https://doi.org/10.1177/1747493021991652>.
- [24] Raul G. Nogueira, Mohammed Abdalkder, Muhammed Qureshi, M.R. Frankel, et al., Global impact of the COVID-19 pandemic on stroke hospitalizations and mechanical thrombectomy volumes, *Int. J. Stroke* 16 (5) (2021) 573–584, <https://doi.org/10.1177/1747493021991652>.
- [25] Thanh N. Nguyen, Diogo C. Haussen, Muhammad M. Qureshi, Hiroshi Yamagami, Toshiyuki Fujinaka, Ossama Y. Mansour, et al., Decline in subarachnoid hemorrhage volumes associated with the first wave of the COVID-19 pandemic, *Stroke Vasc. Neurol.* (2021), <https://doi.org/10.1136/svn-2020-000695>, 0.
- [26] Naveed Akhtar, Slam Al Jerdi, Ziyad Mahfoud, Yahia Imam, et al., Impact of COVID-19 pandemic on stroke admissions in Qatar, *BMJ Neurol. Open* 3 (2021).
- [27] M. Khan, R.H. Ibrahim, S.A. Siddiqi, Y. Kerolos, M.M. Al-Kaylani, S.A. AlRukn, D. W. Krieger, COVID-19 and acute ischemic stroke - a case series from Dubai, UAE, *Int. J. Stroke* 15 (6) (2020 Aug) 699–700, <https://doi.org/10.1177/1747493020938285> (Epub 2020 Jun 26. PMID: 32525467).
- [28] S. Hameed, M. Wasay, B.A. Soomro, O. Mansour, F. Abd-Allah, T. Tu, R. Farhat, N. Shahbaz, H. Hashim, W. Alamgir, A. Iqbal, M. Khan, Cerebral venous thrombosis associated with COVID-19 infection: an observational, multicenter study, *Cerebrovasc. Dis. Extra* 11 (2) (2021 May 11) 55–60, <https://doi.org/10.1159/000516641>.
- [29] S. Hameed, M. Khan, Z. Fatmi, M.J. Wasay, Exploring the relationship between Air Quality and Ischemic Stroke Admissions during the COVID-19 pandemic, *Stroke Cerebrovasc. Dis.* 30 (8) (2021 Aug) 105860, <https://doi.org/10.1016/j.jstrokecerebrovasdis.2021.105860> (Epub 2021 May 9).
- [30] S.M. Desai, F.X. Guyette, C. Martin-Gill, A.P. Jadhav, Collateral damage - impact of a pandemic on stroke emergency services, *J. Stroke Cerebrovasc. Dis.* 29 (8) (2020 Aug), 104988, <https://doi.org/10.1016/j.jstrokecerebrovasdis.2020.104988> (Epub 2020 Jun 10. PMID: 32689650; PMCID: PMC7284271).
- [31] Yanan Li, Man Li, Mengdie Wang, Yifan Zhou, David Wang, Mao Ling, Huijuan Jin, Bo Hu, et al., Acute cerebrovascular disease following COVID-19: a single center, retrospective, *Stroke Vasc Neurol* 5 (3) (2020 Sep) 279–284, <https://doi.org/10.1136/svn-2020-000431>.
- [32] T. Guo, Y. Fan, M. Chen, X. Wu, L. Zhang, T. He, et al., Cardiovascular implications of fatal outcomes of patients with coronavirus disease 2019 (COVID-19), *JAMA Cardiol.* (2020), <https://doi.org/10.1001/jamcardio.2020.1017>.
- [33] L. Bao, W. Deng, B. Huang, H. Gao, J. Liu, L. Ren, et al., The pathogenicity of SARS-CoV-2 in hACE2 transgenic mice, *Nature.* 583 (7818) (2020 Jul) 830–833, <https://doi.org/10.1038/s41586-020-2312>.
- [34] N. Arbour, R. Day, J. Newcombe, P.J. Talbot, Neuroinvasion by human respiratory coronaviruses, *J. Virol.* 74 (2000) 8913–8921.
- [35] Thomas J. Oxley, J. Mocco, Shahram Majidi, Christopher P. Kellner, Hazem Shorrah, Paul Singh, Reade A. De Leacy, Tomoyoshi Shigematsu, Travis R. Ladner, Kurt A. Yaeger, Maryna Skliut, Jesse Weinberger, Neha S. Dangayach, Joshua B. Bederson, Stanley Tuhim, Johanna T. Fifi, *NEJ of Medicine.* *NEJM.org*, April 28, 2020.
- [36] H.K. Ramadan, M.A. Mahmoud, M.Z. Aburahma, A.A. Elkhawaga, M.A. El-Mokhtar, I.M. Sayed, et al., Predictors of severity and co-infection resistance profile in covid-19 patients: first report from upper Egypt, *Infect. Drug Resist.* 13 (2020) 3409–3422.
- [37] M.A. Medhat, M. El Kassas, Covid-19 in Egypt: uncovered figures or a different situation? *J. Glob. Health* 10 (2020), 010368.
- [38] J.E. Siegler, P. Cardona, J.F. Arenillas, B. Talavera, A.N. Guillen, A. Chavarria-Miranda, et al., Cerebrovascular events and outcomes in hospitalized patients with covid-19: the svn covid-19 multinational registry, *Int. J. Stroke* 16 (2021) 437–447.
- [39] R.G. Nogueira, M. Abdalkader, M.M. Qureshi, M.R. Frankel, O.Y. Mansour, H. Yamagami, et al., Global impact of covid-19 on stroke care, *Int. J. Stroke* 16 (2021) 573–584.
- [40] M. Abdelghani, M.G. Hamed, A. Said, E. Fouad, Evaluation of perceived fears of covid-19 virus infection and its relationship to health-related quality of life among patients with diabetes mellitus in Egypt during pandemic: a developing country single-center study, *Diabetol. Int.* (2021) 1–9.
- [41] CNN A, Egypt: An Increase in the Death Rate During the First Half of 2021.. The Population is 102 Million, 2021.
- [42] <http://www.moh.gov.om> statement No. (3) Registration of COVID-19 Cases.
- [43] <http://www.moh.gov.om> statement No. (14) Registration of COVID-19 Cases.
- [44] <http://www.nccoc.gov.pk>.
- [45] D. Kanwar, S. Awan, A. Sajjad, A. Farooq, L. Chand, A.B. Larak, A. Malik, M. Wazir, A. Aslam, H. Hashim, F. Niazi, M.F. Rasheed, F. Khan, M. Hamdani, F. Saleem, A. Iqbal, A. Asif, N. Shahbaz, H. Majid, M.J. Wasay, Preparedness and impact of COVID 19 infection at tertiary care neurology centers in Pakistan, *Neurol. Sci.* (425) (2021 Jun 15), 117462, <https://doi.org/10.1016/j.jns.2021.117462> (Epub 2021 Apr 17).
- [46] Houman Khosravani, Phavaln Rajendram, Bijoy K. Menon, Protected code stroke : hyperacute Stroke Management During the Coronavirus Disease 2019 (Covid 19) Pandemic, *Stroke* 51 (2020) e156–e157.
- [47] Ken Uchino, Murali K. Kolikonda, Dena Brown, Shivakrishna Kovi, Dana Collins, Zeshau Khawaja, A. Blake Buletko, Andrew N. Russman, M. Shazam Hussain, Decline in stroke presentations during COVID-19 surge, *Stroke* 51 (2020) 2544–2547, <https://doi.org/10.1161/STROKEAHA.120.030331>.
- [48] Jacqui Thornton, Covid –19:A&E visits in England fall by 25% in week after lockdown, *BMJ* (2020) 369, m1401, <https://doi.org/10.1136/bmj.m1401> (Published 6 April 2020).
- [49] S. Escalard, B. Maier, H. Redjem, F. Delvoe, et al., Treatment of acute ischemic stroke due to large vessel occlusion with COVID-19. Experience from Paris, *Stroke* 51 (2020) 2540–2543.
- [50] G. Ntaios, P. Michel, G. Georgiopoulos, Y. Guo, W. Li, J. Xiong, P. Calleja, et al., Characteristics and outcomes in patients with COVID-19 and acute ischemic stroke. The global COVID-19 stroke registry, *Stroke* 51 (2020) 3254–e258.
- [51] M.N. Diringer, D.F. Edwards, Admission to a neurologic/neurosurgical intensive care unit is associated with reduced mortality rate after intracerebral hemorrhage, *Crit. Care Med.* 29 (3) (2001) 635–640.
- [52] P.N. Varelas, L. Schultz, M. Conti, et al., The impact of a neuro-intensivist on patients with stroke admitted to a neurosciences intensive care unit, *Neurocrit. Care.* 9 (3) (2008) 293–299.
- [53] E.P. Raith, A.M.V. Luoma, M. Earl, M. Dalal, S. Failey, F. Fox, K. Hunt, C. Willett, U. Reddy, Repurposing a neurocritical care unit for the management of severely ill patients with COVID-19: A retrospective evaluation, *J. Neurosurg. Anesthesiol.* 33 (11) (2021) 77–81.
- [54] G.J. Hubert, F. Corea, F. Schlachetzki, The role of telemedicine in acute stroke treatment in times of pandemic, *Curr. Opin. Neurol.* 34 (1) (2021 Feb 1) 22–26, <https://doi.org/10.1097/WCO.0000000000000887> (PMID: 33230037).
- [55] N. Venketasubramanian, C. Anderson, H. Ay, S. Aybek, W. Brinjikji, G.R. de Freitas, O.H. Del Brutto, K. Fassbender, M. Fujimura, L.B. Goldstein, R.L. Haberl, G. J. Hankey, W.D. Heiss, I. Lestro Henriques, C.S. Kase, J.S. Kim, M. Koga, Y. Kokubo, S. Kuroda, K. Lee, T.H. Lee, D.S. Liebeskind, G.Y.H. Lip, S. Meairs, R. Medvedev, M. M. Mehdiratta, J.P. Mohr, M. Nagayama, L. Pantoni, P. Papanagiotou, G. Parrilla, D. Pastori, S.T. Pendlebury, L.C. Pettigrew, P.N. Renjen, T. Rundek, U. Schminke, Y. Shinohara, W.K. Tang, K. Toyoda, K.E. Wartenberg, M. Wasay, M.G. Hennericci, Stroke care during the COVID-19 pandemic: international expert panel review, *Cerebrovasc. Dis.* 50 (3) (2021) 245–261, <https://doi.org/10.1159/000514155> (Epub 2021 Mar 23. PMID: 33756459).
- [56] A.I. Qureshi, F. Abd-Allah, F. Al-Senani, E. Aytac, A. Borhani-Haghighi, A. Ciccone, C.R. Gomez, E. Gurkas, C.Y. Hsu, V. Jani, L. Jiao, A. Kobayashi, J. Lee, J. Liaquat, M. Mazighi, R. Parthasarathy, T. Steiner, M.F.K. Suri, K. Toyoda, M. Ribo, F. Gongora-Rivera, J. Oliveira-Filho, G. Uzun, Wang management, *Int. J. Stroke* 15 (5) (2020 Jul) 540–554, <https://doi.org/10.1177/1747493020923234> (Epub 2020 May 3. PMID: 32362244).