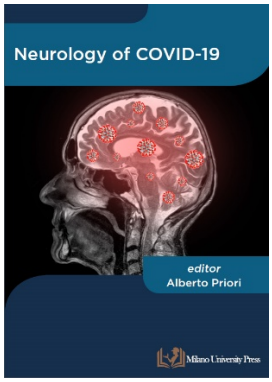

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Chapter 15. **Teleneurology in the COVID-19 era**

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Chapter 15. Teleneurology in the COVID-19 era

Elena Moro, Sara Meoni

Introduction

Telemedicine is defined as the delivery of medical care by electronic communication between a health care professional (i.e., a physician or advanced practice provider) and a patient, each at different locations[1]. It has the potential to overcome geographical, physical, and biological barriers to health care access. Telemedicine has been shown to be a safe, efficient, timely, and convenient procedure[1,2]. For decades, it has provided medical care to rural and underserved areas[3], but only more recently has this field undergone an accelerated development. This has been due to advances in technologies and a broader Internet access.

The application of telemedicine to neurology (teleneurology) allows delivery of or additional neurological care to remote locations. It reflects the gap existing between the growing demand of neurological expertise and the lack of neurologists[4,5].

Over the last decades, teleneurology has been successfully applied in acute care, mostly for stroke ("telestroke")[6], in outpatient evaluation and in teleconsultations for chronic diseases such as movement disorders[7], epilepsy[8], multiple sclerosis[9], dementia[10] and headache[11].

However, before the advent of COVID-19, there were considerable limitations to the use of telemedicine: technological, regulatory, political and clinical considerations, reimbursement issues, and social barriers.

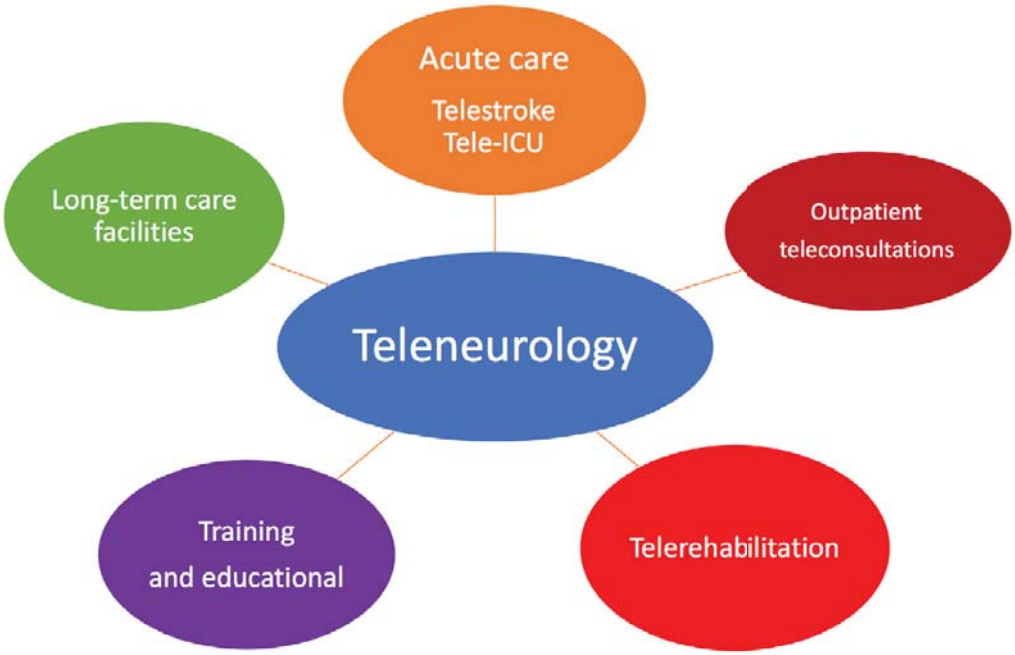
Since 2020, the COVID-19 pandemic and the new related challenges in health care have greatly pushed teleneurology forward[12].

Most of the hospitals and health systems around the world have modified their standard practices in telemedicine in order to assure care management of non-COVID neurological disorders[13]. The main objective of the adoption of telehealth during the pandemic is the safety of all the participants in their clinical encounters, including patients, family members, caregivers and health care teams. Several reimbursement and licenses issues which had limited teleneurology in the pre-COVID era, have been suspended or removed in order to deal with the worldwide health emergency. Most of the hospital consultations have

been replaced by teleconsultations using tablets, smartphones, mobile telehealth carts or cameras at patients' homes. New telemedicine tools have emerged to reduce the exposure to COVID-19 infection[13,14].

All the pandemic-related changes in neurology clinical practice have happened very quickly, in days or weeks, requiring the availability of adequate equipment and the rapid development of technology infrastructure to support the large expansion in the use of teleneurology. For example, at the epicenter of the pandemic, at NYU Langone Health, teleconsultations grew from a typical 50 visits per day to >7,000 daily visits within 10 days[15]. At the University of Pennsylvania Health System, nearly 400,000 telemedicine meetings across thousands of providers occurred in less than three months, requiring implementation of videoconferencing platforms, training, and development of new procedures for outpatient and inpatient management[16].

Figure 15.1: Teleneurology applications in the COVID-19 era



ICU: Intensive Care Unit.

Moreover, the pandemic has greatly impacted the scientific community and academic activities, as all the congresses, and educational training and teaching courses have been turned into virtual conferences and webinars, requiring a huge effort to change the routine practices in place up to the pre-COVID era.

In this chapter, we provide a summary of the available literature on teleneurology during the COVID-19 pandemic, its advantages and limitations, clinical implications, and future challenges.

Telestroke

Since the earliest stages of the pandemic, the risk of underestimating and undertreating several potentially treatable strokes emerged, leading health authorities to generate an appeal to the general population not to stay at home in case of onset of acute neurological symptoms[17]. However, studies in European countries[18,19], China[20] and the USA[21] reported a significant global reduction in admissions to the emergency department or stroke units for acute ischemic stroke in the first period of the emergency. This contraction has likely been secondary to policies minimizing provider-patient interactions as well as patients' reticence to come to the emergency departments during the pandemic.

At the same time, the COVID-19 crisis has required implementation of the use of telemedicine in the field of stroke at all treatment stages[22,23], and it could be the starting point for its large-scale use[24,25].

The continuum of care via telestroke has broadened to include prehospital, inter-facility and intra-facility hospital-based services, stroke telerehabilitation, and ambulatory telestroke[26].

Alternative stroke care models have been developed including protected stroke codes and streamlined triage for endovascular therapy[27-29] in order to maintain patient care in this pandemic setting.

Prehospital telestroke offers many advantages for acute stroke care in this context, such as the use of mobile systems limiting person-to-person contact in the prehospital stroke assessment, and ambulance-based telestroke. Emergency service providers can focus on personal protective equipment (PPE) and respiratory management, in parallel with a remote emergency provider or stroke specialist, who can assist with screening during ambulance transport[30]. The prehospital evaluation by the remote provider potentially reduces PPE usage limiting the need for multiple re-evaluations prior to acute treatment decisions. Prehospital triage with telestroke could further limit unnecessary exposures and PPE usage by identifying the appropriate hospital for the patient's needs. However, additional research is needed in order to optimize tele-triage protocols.

Inter-facility telestroke may also help during the pandemic, in order to limit unnecessary transfers of patients with mild stroke syndromes or stroke mimics in their local facilities and to reduce potential exposure to the patient and treatment teams. This is a key point, considering the higher risk of infection in stroke patients[31]. This model can also preserve bed availability at the hub for patients needing a higher level of care. Moreover, ambulance-based mobile systems can be used to support long distance transfers, particularly for "drip-and-ship" post-thrombolysis management, and for critically ill stroke patients[32].

During the COVID-19 crisis, several hospitals and stroke centers have developed intra-facility telestroke to help reduce provider and patient exposure and

PPE usage, and to cover workforce shortages due to COVID-19 related illness and quarantining of staff[13,14]. A new framework for COVID-19 screening and proper usage of PPE incorporated with stroke assessment, called "protected stroke code"[28] has emerged during the pandemic, which has also been applied at an intra-facility level. This model allows several team members to participate in the patient evaluation remotely, while preserving PPE and limiting staff-patient interactions. Moreover, some academic centers have also switched to virtual rounds using a teleconferencing platform[13], with table rounds first completed via teleconferencing, and with only one team member moving the workstation to each patient's room to carry out the examination, functioning as tele-presenter for the remote team. The virtual round model allows health-care providers to guarantee patients care even during therapeutic or prophylactic quarantine. In addition, this allows for a rotating schedule which can be used to address staff shortages.

Tele-ICU

Telemedicine enables remote monitoring of patients in intensive care units (ICUs) without continuous availability of critical care expertise, in order to expand coverage, similar to telestroke coverage of emergency departments. Management of neurological emergencies, such as status epilepticus, may be facilitated by telemedicine, thanks to remote access to subspecialty expertise.

In the pre-COVID-19 era, a metanalysis reported on a reduction in mortality and hospital lengths of stay with tele-ICU[33]. The neurological ICU population is not specifically addressed in most studies, although one report demonstrated reduced response times and shorter lengths of stay[34].

The pandemic has been the turning point for digital transformation also in neurocritical care. The tele-ICU solution can triage and manage patients in isolation, conserving PPE, avoiding infection, and optimizing human resources with constant remote monitoring. Close range telemedicine called 'ePPE' has evolved and wireless monitoring has been developed[35]. Mobile devices are used to communicate with patients who can be physically attended to immediately if needed. Workforce sustainability, fewer burnout episodes, and lower incidence of specialists having to quarantine are consequences of tele- ICUs. Video conferencing helps decrease infection risk during the pandemic. Moreover, tele-EEG monitoring can be used for diagnosing non-convulsive status epilepticus as a cause of unexplained consciousness in COVID-19 patients[36]. The remote reading of EEG helps reduce the risk of infection. Furthermore, telemedicine may also help to establish a dedicated command unit for critical care support by linking ICUs of COVID hospitals on a single platform[37].

Outpatient teleneurology

Studies across multiple neurological subspecialties report non-inferiority of outpatient evaluations by telemedicine compared with in-person evaluations in terms of patient and caregiver satisfaction and diagnostic accuracy[38].

Telemedicine has the potential to address challenges in the transition between hospital and home. In the pre-COVID-19 era, transitional care models had showed the potential to improve outpatient management, mostly for post-stroke patients[39]. However, these models were not really incorporated into global routine practice until today. Pre-pandemic barriers to widespread use of telemedicine for outpatient care have mostly been due to reimbursement challenges and lack of infrastructures[40].

With the pandemic, social distancing requirements and restrictions on non-essential visits to the clinic created an urgent need for outpatient telemedicine in the stroke population[25,41,42] and in several chronic neurological diseases, such as Parkinson's disease[7,4349], and other movement disorders[2,50-53], epilepsy[54-68], Alzheimer's disease[69-73], multiple sclerosis[74-81] and migraine[82–84].

The integration of telemedicine into outpatient practice has required a rapid adaptation of the standard clinic practice[85]. In the US, for example, a policy of expansion of Centers for Medicare and reimbursement for Medicaid Services in March 2020 led to the implementation of telestroke services[38]. Institutional support is strongly required for widespread adoption and sustainability of technology, such as hardware, audiovisual platforms, Electronic Health Records integration, and server support. Scheduling, billing and coding integration have also to be considered in any staffing changes. Training for providers and staff, patient education, and on-call technology assistance for both patients and providers must also be guaranteed. The main limitation of the application of teleneurology in outpatient care concerns its feasibility in elderly patients, frequently with motor and cognitive issues, and having little contact with the younger generation who are more experienced with technology.

Preliminary experience suggests positive results of telemedicine use during the pandemic, both via video and phone. However, disparities in health care delivery emerged, and these were exacerbated by inequalities in access to technology in socially or economically disadvantaged populations[86]. Lack of adequate access to technology, high-speed internet services and increased need for technology support will need to be addressed to achieve widespread improvements in access to care.

Teleneurology for long-term care facilities

Telemedicine can be applied to patients in long-term care and correctional facilities which have limited access to specialty care[87]. The COVID-19 pandemic

has raised a major concern in terms of a higher risk and exposure for this vulnerable population of patients and staff due to close living quarters and the need for frequent in-person assessments of healthcare needs. The use of telemedicine for post-acute care in long-term care settings has the advantage of staff support, which reduces the technological burden on patients, and on-site assistance with the physical examination. Telemedicine can also be useful to assess patients with stroke symptoms in these environments and to guide necessary triage decisions[88,89]. Telestroke could inform appropriate hospital destination choices for both thrombolytics and thrombectomy, minimizing the activation of emergency medical services and exposure of health care providers, and avoiding unnecessary transfer to the emergency room for high-risk patients.

Telerehabilitation

Telemedicine is important in rehabilitation[90]. During the pandemic, the standard model of in-person stroke rehabilitation, including physical, occupational, and speech and language therapies, has been reassessed. The drastic reduction in the availablity of rehabilitation facilities, due to their conversion to host COVID-19 patients, makes the telerehabilitation a key tool in this phase. On the Google trend engine, searches for the term "telerehab" grew by about 400% in the first week of March 2020.[91] Indeed, for COVID-19 patients with ischemic stroke, telerehabilitation has been shown to be beneficial[92] and it can dramatically lower the risk of infection without compromising post-stroke recovery.

Telerehabilitation has been performed with benefit in other neurological diseases such as Parkinson's disease[93-98] and multiple sclerosis[74,99,100].

Telerehabilitation might also have a role in achieving an adequate cognitive stimulation in several neurological diseases with associated cognitive issues in the era of social distancing due to the pandemic[101].

Terehabilitation is useful even for non-infected patients, reducing PPE consumption and the exposure of therapists and providers, and helping maintain patient safety in a fragile population[102]. The application of telerehabilitation may equally help patients in densely populated urban areas where the infection risk is higher, and for patients living in rural areas, with geographic barriers and shelter-at-home orders limiting their access to therapy and healthcare services[103].

New digital technologies

In parallel with the dramatic and far-reaching health crisis, the COVID-19 pandemic has boosted the integration of new digital technologies into our medical armamentarium for the management of several neurological disorders,

including stroke[104,105], Parkinson's disease,[106-108], epilepsy[109,110], multiple sclerosis[80,81] and dementia[73].

Novel applications for remote monitoring via e-diaries, sensors, vital sign monitoring, or even cardiac monitoring via smart watches have been applied for diagnostic, rehabilitation and research purposes and regular follow-up visits.

Stroke is the field which has probably seen a larger use of digital technologies compared to other neurological disciplines. Accelerometers and gyroscopes in smartphones have been shown to be effective in recording mechanical cardiac activity to support the diagnosis of atrial fibrillation (AF)[111].

Photoplethysmography with a smartphone camera has been applied for AF screening[112]. Apps specifically designed to record a rhythm strip using smartwatches have been seen to be accurate in differentiating AF from sinus rhythm[113]. More recently, an app for detecting AF has been applied in the Apple Heart Study[114].

Depending on the availability of the users, the telerehabilitation sessions can be performed by phone, via videoconferencing software or through dedicated apps (i.e., "REHABmyPatient," "myRehab," or "RehabPal")[91].

This pandemic might be the key moment in which to introduce a more widespread use of new technologies to improve management of neurological disorders.

Training and educational teleneurology

The COVID-19 pandemic greatly impacted neurology education and training, including lectures, grand rounds and international congresses.[115,116] With social distancing and closure of lecture halls, in-person teaching and lessons moved to on-line platforms, such as WebEx™, Zoom™ and Microsoft Teams™, requiring a rapid availablility for millions of people, the development of technology resources, and teachers and students had to adapt to these changes[117-119].

The advantages of this new educational delivery are the access to live/on demand lectures from any location or from different educational centers via virtual platforms[120] with no need to travel. The limitations include the reduction of trainees' exposure to elective procedures and bed-side teaching, resulting in a poorer clinical experience. Moreover, remote education for some neurological skills such as neurological examination may not be ideal.

The experience from the pandemic may be utilized to further improve neurology education and training, as current and future neurology education will likely consist of a mixture of in-person and virtual learning.

Practical implications and future directions

In the post-pandemic era, the major limitations to the widespread use of teleneurology might be the lack of evidence for its efficacy, and understanding its proper place when in-person care is also available. Although randomized trials are challenging in teleneurology[121], the high volume of virtual visits during the COVID-19 crisis should allow patients' outcomes using telemedicine and in-person visits to be compared. Moreover, the role of evaluation through physical examination, provider-patient interaction, and workflow changes using telemedicine will need to be established.

In some ways, we might use teleneurology after the pandemic to improve on in-person visits. Indeed, telemedicine promotes a team approach by virtually bringing together providers from various disciplines in different locations without traveling and saving time. Similarly, teleneurology can allow family members to take part in tele-vists; they can provide medical history and receive counseling, and can be included in the decision-making process even if the medical team is working in remote, far from the patient and provider. For neurological patients in rural areas and those with limited mobility, telemedicine might have an important role when an in-person visit is not practical or the alternative is reduced care or no care at all. Teleneurology consultations in such situations has the potential to improve outcomes and reduce costs while saving time for busy clinicians.

Today teleneurology is still in its infancy. Along with digital transformation in other industries, teleneurology has considerable possibilities for further improvement[122]. The COVID-19 experience will lead to the development of new applications in large networks with analytics and big data. Moreover, artificial intelligence may automate some of the processes now requiring training and proficiency, improving teleneurology, diagnosis and outcomes. The integrated use of the electronic medical records and wearable devices adds important new information to increase teleneurology capabilities. Although teleneurology has limitations in terms of the physical examination, it may be enhanced through observational aids or in some cases the assistance of family members on site[123,124]. The integration of digital sensors and activity monitors into routine practice might provide additional information on patient characteristics not available during an in-person visit. With the growing use of home monitoring and wearable devices, health providers will need to learn how to monitor and to manage patient-generated data. Consequently, hospitals and health services need to develop new, more powerful informatics systems to manage a large inflow of data and to integrate it into electronic health records.

The pandemic has highlighted the problems of access to health care for those patients living in underserved areas[125]. The efforts of health systems, including community and long-term care facilities should be scrutinized to ensure an equal distribution of services, keeping patients in their own environment and optimizing the use of high-technology tools.

Moreover, telemedicine could provide specialist support for patients with neurological diseases needing a high level of expertise, such as movement disorders, epilepsy or stroke, avoiding the need to direct them to hub hospitals for lower-acuity problems. The goal should be to guarantee to all patients within any single system the same level of excellent care. This could consolidate subspecialty centers, reducing costs and avoiding duplication of valuable resources.

The use of telemedicine in the COVID-19 crisis has also changed the approach of the medical system to the patient, which was provider-based in the pre-pandemic era; this has now become patient-focused. The patient remains in his environment, saving time spent on transfers and visits. Moreover, tele-consultations with videos allow the provider to obtain important information about the patients' home environment, improving their overall care.

In conclusion, teleneurology expands access and availability across the spectrum from outpatient to acute care and rehabilitation[1]. The temporary enabling policies that expire with the public health emergency will hopefully translate into lasting changes. Private payers are increasing the coverage, and countries are considering new approaches to telemedicine licensing. These advances could dramatically improve the landscape for telemedicine and teleneurology. Hopefully, national, regional, private, and public entities will join forces to keep the development of telemedicine moving forward.

Take home message

- The COVID-19 pandemic has greatly pushed the development of teleneurology forward, reducing or removing technological, regulatory, political and clinical considerations, reimbursement issues, and social barriers.
- Teleneurology has been successfully applied in the COVID-19 era to manage outpatients, inpatients, and for rehabilitation purposes in several neurological disorders.
- The COVID-19 pandemic has boosted the integration of new digital technologies into the medical armamentarium for the management of neurological disesases.
- The pandemic has greatly impacted the scientific community and the academic activities, as all the congresses, and educational training and teaching courses have been turned into virtual conferences and webinars.
- After the pandemic, teleneurology could be used to improve on in-person visits and in academic activities, and to integrate the new technologies into our clinical practice.

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