

Telemedicine applied to neuromuscular disorders: focus on the COVID-19 pandemic era

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Neuromuscular diseases are rare and usually chronic progressive disorders that require a multidisciplinary clinical evaluation and functional monitoring. The patient-physician relationship and therapies are also key elements to be provided. The COVID-19 pandemic dramatically changed the way patients' health was managed and national health care services underwent a radical reorganization. Telemedicine, with the use of Information and Communication Technology (ICT) by health professionals, became the main strategy to ensure the continuation of care. However, the experience regarding the use of Telemedicine in neuromuscular disorders is very limited and the scientific literature is extremely scarce. From the first experiences in the '50s, the development of Telemedicine has been supplemented and supported by the implementation of ICT to guarantee the secure and effective transmission of medical data. Italian national guidelines (2010-2020) describe the technical and professional guarantees necessary to provide Telemedicine services. Nevertheless, at the time the pandemic appeared, no guidelines for clinical evaluation or for the administration of functional scales remotely were available for neuromuscular diseases. This has been a critical point when clinical evaluations were mandatory also for the renewal of drug prescriptions. However, the common opinion that telemedicine basic services were important to overcome the change in medical practice due to COVID-19 in neuromuscular diseases, even in pediatric age, emerged. Moreover, alternative digital modalities to evaluate patients at home in a kind of virtual clinic were considered as a field of future development.

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Note of the Editor

This paper summarizes the speeches on *Telemedicine in the COVID-19 era* presented during the webinars organized by the Italian Association of Myology (AIM) in September 2021. They had as focus the management of patients with neuromuscular diseases in the period of the pandemic: experiences emerged in Italian central-southern macro-areas.

Introduction

The Advance Informatics in Medicine defined in 1990 the Telemedicine as “the integration, monitoring and management of patients, and the education of patients and health care professionals, using systems that provide ready access to expert advice and patient information, regardless of where the individual, or the information, resides”.

Later, in 1997, the World Health Organization described Telemedicine as “the provision of health services where distance is a critical factor, requiring the use of Information and Communication Technology (ICT) by health professionals to exchange information for the diagnosis, treatment and prevention of disease, to ensure the provision of ongoing information to health care providers, and to support research and evaluation of care”^{1,2}.

If face-to-face consultation between physician and patient remains the gold standard of clinical care, Telemedicine may represent in some circumstances the only modality to evaluate the patient. It should be emphasized that Telemedicine services may represent a possible integration to the medical evaluation and it must be assimilated to any diagnostic/therapeutic health service, but do not replace the traditional healthcare service with an in-person relationship.

Telemedicine can take place between a physician and a patient or between two or more physicians, including other healthcare professionals, in situations where they are not in the same location.

The provision of healthcare services, using ICT, involves the secure transmission of medical data and information, through text, sound, images, or other forms needed for the prevention, diagnosis, treatment, and follow-up of patients. However, the use of ICT tools for the processing of health information or for data treatment, does not constitute Telemedicine in itself. Health information portals, social networks, forums, newsgroups, e-mails do not constitute Telemedicine (National Telemedicine Guidelines 2010)³.

History of telemedicine

Telemedicine started about in the '60s, to monitor patients far from the treatment centres. The first reports date back to W. Darrach, who described a mobile health service for migrant families⁴. Lately, telecommunications (telephone and radio at the beginning) have played an important role in the development of Telemedicine.

“Telognosis” the acronym for “teleo-roentgen-diagnosis”, was the diagnosis by telephone-transmitted roentgenograms which started in 1950 in Philadelphia.

“Telepsychiatry” began in Nebraska in 1964 when a two-way closed-circuit microwave television system was established between the Nebraska Psychiatric Institute and Norfolk State Hospital in Nebraska providing consultations, education, training, and research. In 1967 the Massachusetts General Hospital provided medical consultation over TV cameras to the Boston Logan Airport Medical station a close hospital in a very traffic area.

The Italian tradition of experimental Telemedicine dates back to early 1970s when the Catholic Universi-

ty Hospital of Rome sets up a teleconsulting service for poisoning. In 1976 the University of Bologna introduced a prototype system for the acquisition and transmission of electrocardiograms (ECGs via telephone). In the same year, a teleconsulting service was established by the Research Centre of the Telecommunications Company between the Emergency Department of the Hospital S. Giovanni of Turin and the Civil Hospital of Susa.

In 1995 it was decided to fund a research and training project in the field of Telemedicine with the aim to improve the quality of health care and reduce costs⁵.

Due to technological progress, the dissemination and development of Telemedicine experiences have increased since 1995, in particular as a consequence of the growing of Internet network and the development of new digital technologies such as:

- transmission according to communication protocols (TCP/IP) up to WEB 2.0 http21st century;
- social networks;
- interoperability between electronic systems;
- collaboration and communication technologies that help to communicate and work together in real-time (synchronous) or at different times (asynchronous);
- Internet Voice over protocol for the provision of voice communications and multimedia sessions over Internet by using Internet Protocol networks;
- mobile phones that increased potential for real-time communication between professionals and patients.

The progressive increase of scientific publications with a peak in COVID-19 pandemic documented this technological development.

However, despite the positive experiences in the clinical practice, the technological advances and the good results in terms of cost-benefits balance, the diffusion of Telemedicine service was still not adequate for the need of health care in Italy as documented by an Italian Survey in 1995⁵.

Between the late '90s and early 2000s, Telemedicine had an important development so that the European Commission has issued the decree COM 2008/689 of the 4th of November 2008 (“Telemedicine for the benefit of patients, health systems and society”) to support the Member States in the implementation of Telemedicine services⁶. In 2010 the Italian Health Ministry finally edited national guidelines for Telemedicine services.

Telemedicine applied to the discipline of neurology (teleneurology) regarding neuromuscular patients has certainly seen a huge push forward, because these patients have been defined as fragile since the first moments of the pandemic, as they were considered at high risk of developing severe symptoms in case of SARS-CoV-2 infection.

On the 17th of December 2020, the State-Regions Conference implemented the Ministry of Health document

“National guidelines for the provision of Telemedicine services”, thus allowing digital medicine to enter definitely among the services provided and payable by the National Health System (NHS) ⁷. This new document highlights the applicability of Telemedicine in an innovative way also regarding the improving health services in favour of people whose pathology or condition is relevant for the governance of the NHS such as rare diseases (in adulthood and pediatric age), including neuromuscular diseases.

Types of telemedicine

We know different types of Telemedicine:

- *Tele-consultation (Tele-consult)*: real-time or deferred request for a remote diagnostic consultation;
- *Tele-visit*: one of the main telemedicine healthcare services that can be provided within the NHS. This is an outpatient activity made after a careful assessment of the situation and according to specific criteria;
- *Tele-reporting* of instrumental examinations, i.e. the identification of instrumental examinations carried out in peripheral departments that require specific experiences for diagnostic interpretation;
- *Tele-monitoring* of treatments, under the supervision of specialists, even in peripheral facilities;
- *Remote emergency services* of telematic communication with remotely located assistance centres in emergency and dangerous situations.

Telemedicine offers many advantages. In chronic disabled disorders it guarantees the continuity of care for isolated or distant patients. In acute situations it allows quicker medical solutions or responses. Overcoming the barrier of time and distance according to a hub and spoke model, it does not exclude a face-to-face evaluation, if necessary. A medical Teleconsultation (personalized healthcare) could be very important in emergency situations or when a specialist evaluation is needed, and this is not available locally.

Only an outpatient service that does not require a complete examination of the patient may be provided through a tele-visit. Indeed, although a tele-visit is carried out in real-time it does not replace the first visit that must be always done in a face-to-face way and it cannot be the exclusive doctor-patient relationship modality. It can be assessed only if a complete physical examination of the patient is not required. Moreover, a tele-visit is not a simple video call. Like the face-to-face visit, a tele-visit must develop according to an articulated and multi-professional process to ensure the safety of medical activities, the protection of personal data, the regularity for reporting purposes and use immediate and easy access tools for the patient.

It must be organized to ensure a real benefit for health but also logistical and operational for the patient and the

entire organization. Tele-visit must always be reported and the cost is the same as a visit. Unlike the tele-visit, teleconsultation is considered an integral part of the medical work, it is not included in the tariff nomenclator and it does not need a prescription. It is usually registered into a local database, but it is not detected in the institutional medical activity registry. Teleconsultation can be done with many specialists.

Telemedicine may be synchronous or asynchronous.

“Synchronous Telemedicine” is like a “live video-conferencing,” which is a “two-way” audiovisual link between a patient and a care provider. Synchronous Telemedicine requires the presence of both parties at the same time and a communication link between them that allows a real-time interaction to take place. Usually, during real-time telehealth sessions, operators such as technicians or nurses, can handle special telehealth-enabled tools in order to remotely perform a neurophysiologic examination (e.g.: EMG) under consulting provider’s direction and according to national recommendations ⁸.

“Asynchronous telemedicine” is like a “store-and-forward video-conferencing” and consists of the recorded health history transmission to a health practitioner, usually a specialist. It involves acquiring medical data, then transmitting this data to a doctor or medical specialist at a convenient time for assessment offline ⁹.

As an assimilated health care service, it must also comply with all the rights and obligations of a health service.

Professional guarantees must be provided:

- organization guarantees concerning the set of procedures to offer a quality service;
- guarantees of access to the service in a clear and verifiable modality;
- clinical guarantees that the activity is designed and implemented in accordance with evidence-based medicine;
- technological guarantees concerning the integrity of the information transmitted.
- Another very important aspect to consider is that Telecommunication infrastructure must assure:
- interoperability of networks and protocols according to guidelines;
- continuity of service during the supply period;
- safety for the citizen by ensuring data protection;
- source verification (authentication);
- information security ^{3,7}.

Telemedicine in neurologic-neuromuscular disorders

The quality of patient-physician relationship, the modality of remote clinical assessment and monitoring, and

the administration of therapies are the key elements to be provided in neuromuscular Telemedicine. Regarding the doctor-patient relationship, Telemedicine permits the maintenance of a close patient-physician relationship and can be a simple tool to facilitate the resumption of normal follow-ups at the end of the pandemic. It is reported in literature¹⁰⁻¹² that thanks to telemedicine there has been a decrease in accesses to the hospital, with positive effects also on the psychological sphere of the patients. The direct clinical evaluation of the neurological patient is very important to first make a correct diagnosis and then to evaluate the course of the pathology, especially for the neuromuscular patient. Hence the development of TV models, instructing patients and caregivers to evaluate some parameters of the neurological physical examination (e.g.: muscle strength assessment). Furthermore, scales have been identified to assess the severity of polyneuropathies and the impact of functional limitations on the patient's quality of life such as VANS scale (the Veterans Affairs Neuropathy Scale), ONLS scale (Overall Nlimitations Scale) and i-RODS scale (Inflammatory Rasch-built Overall Disability Scale).

The second element of Telemedicine concerns remote monitoring. This means identifying the parameters that can be monitored over time, such as heart rate, arterial saturation, the extent of movements (the latter through dedicated instrumentation, such as accelerometers, actigraphs, etc.), the exact measurement of the strength of individual fingers or the whole hand using the vigorimeter.

The third element is digital therapies: i.e., access in hospital settings to perform medical therapies that can be performed only and exclusively in protected settings (such as antisense oligonucleotides for the treatment of SMA or Patisiran for genetic amyloidosis). Some treatments can be home-based, such as subcutaneous immunoglobulins instead of the intravenous formulation for forms of dysimmune polyneuropathy¹³.

During the COVID-19 pandemic, one of the most significant problems was physical therapy, which has been reduced by 93% due to the closure of rehabilitation centers and/or facilities. Starting from this finding tele-rehabilitation was developed, according to the guidelines of the Italian Society of Physical Medicine and Rehabilitation, which was aimed more at patients with vascular problems (ischemic events), degenerative diseases (such as Parkinson's disease) and multiple sclerosis. Tele-rehabilitation for neuromuscular patients has very limited experiences due to difficulties in managing electronic devices, inhomogeneity among families and countries and technical problems related to the network and the possibility of access to various devices. As a consequence, the scientific production is extremely limited.

Another important limitation of Telemedicine for neuromuscular patients is represented by the impossibil-

ity to perform remotely a key test for the neurophysiologist, which is electromyography. There are, however, few clinical situations that require an EMG-ENG examination with urgency and they are:

- Guillain-Barré syndrome;
- Myasthenia Gravis;
- rapidly progressive inflammatory neuropathies/myopathies;
- misdiagnosed motor neuron diseases.

In many of these cases, patients require hospital management from both a diagnostic and therapeutic point of view; in all other cases, EMG-ENG examination can be postponed.

The Bologna Pediatric Neuromuscular Unit experience, in the first phase of the pandemic era

In March 2020 the Bellaria Hospital (which hosts most of the neurological activities of the IRCCS Institute of Neurological Sciences), became a COVID-19 Hub Service and all the planned activities of the Neurological Services were suspended. Urgent neurological activities were guaranteed in other hospitals.

One of the consequences of the pandemic has been the emptying of general practice clinics and, to a large extent, specialist clinics as well. The fear of contagion has drastically decreased access to diagnostic services and hospital facilities, reducing the relationship with one's general practitioner or specialist only for bureaucratic reasons: due to all that, Telemedicine had a faster acceleration in the last two years.

Nevertheless, since national guidelines for Telemedicine services appeared only on the 17th December 2020, in the meanwhile, to cope with all the afore mentioned, we evaluated by ourselves different modalities to ensure the early diagnosis and monitor the health and the evolution of pediatric patients affected by rare neuromuscular diseases. In particular, we needed to carry out functional and neurological evaluations to prescribe innovative therapies. Exchanging points of view between colleagues of the team and from other neuromuscular centres was essential to find new creative strategies.

The first step was patients' stratification for their gravity. Patients with respiratory weakness (with or without non-invasive ventilation or cough machine), multi-organ involvement (cardiac, pulmonary), susceptibility to worsening during fever or infections, feeding difficulties or treated with immunosuppressive or disease-modifying therapy, required greater attention and close monitoring^{13,14}.

Afterward, each patient received a tele-visit to check the state of health and the absence of urgent needs. A tele-consultation to monitor and manage specific issues

was set up, to obtain informations particularly about blood pressure, heart rate, Sat% O² and psychological status.

Rehabilitation was stopped in many patients, but those with special needs received an online tele-visit by the physiotherapist of the Childhood Rehabilitation Medicine Unit and by the Territorial Child and Adolescence Neuropsychiatric Services which in Italy treat the patients in their outpatient's rehabilitation clinic. One of our main efforts was also to guarantee the continuation of clinical monitoring with functional scales, necessary for the prescription and the administration of intrathecal Nusinersen therapy for Spinal Muscular Atrophy.

We decided to develop alternative digital modalities (such as the use of smartphones or video platforms) to evaluate patients at home, in a kind of real-time virtual clinic. This modality needed parents to be instructed by the physiotherapist to perform ad-hoc maneuvers or functional scales at home. First, we assess the Internet connection (both for the family and for the team composed by child neuropsychiatrist and physiotherapist in the referral center). Technological devices capable of supporting a videocall were essential; moreover, even the quality of the image can significantly influence the clinical evaluation of the child, but also the possibility for the family to follow the practical demonstrations carried out by the operators, in order to perform the various items in front of the camera.

In order to carry out a reliable assessment, information was provided on adequate setting, furniture arrangement and number of caregivers needed to assist the child in performing the scales' items.

Emotional responses from children and language barriers that could hinder the understanding and therefore also the execution of the test were also considered.

The family was contacted by phone to make an appointment for the tele-evaluation. During this telephone interview, instructions were given to parents for the preparation of a proper setting and of the necessary tools to carry out the assessment.

Different assessment settings were defined according to the characteristics of the child: pathology, age, motor skills, etc. Different settings and tools were required according to the rating scale to be administered (North Star Ambulatory Assessment or Hammersmith Functional Motor Scale Expanded). Moreover, the type of videoplatform to be used has been agreed in advance with parents.

Results obtained from the online evaluation were very satisfactory, the majority of the functional scales items were well understood and realized. The monitoring of the clinical outcome was obtained. Family satisfaction was also high. It is important to consider that the popula-

tion tested was the one formerly belonging to our centre, and therefore consisted in people (children and parents) who already know the functional scales chosen for the tele-evaluation.

Conclusions

The COVID-19 pandemic has dramatically changed the way patients' health is managed, imposing new methods of visit and follow-up.

Telemedicine basic services were important to overcome the change in medical practice due to COVID-19. Advantages and disadvantages were noticed. Telemedicine is applicable in the monitoring of patients with rare neuromuscular diseases, even in developmental age. Unnecessary assessments can be reduced. Frequent evaluations are allowed in a family environment. Moreover, Telemedicine can be a useful tool in the management of ordinary care (monitoring of exams and parameters, comparison about patients and caregivers' doubts) and in the early identification of patients who require a face-to-face evaluation and/or to be directed to the Emergency Services.

In addition, Telemedicine can be useful also for multidisciplinary tele-consulting between the referral hub and peripheral centers specialists (child neuropsychiatrists, neurologists, physiatrists, pediatricians, palliative-care specialists, nutritionists, cardiologists, pulmonologists, endocrinologists, psychologists), both in a real-time way during the patients' visit at their residence centers (synchronous) or in a store-and-forward way (asynchronous), accessible to the professionals interested at a later time.

In this way, patients can get timely specialty care without the need to travel between the locations of their primary care providers and wait times for specialty care are lessened, especially in areas with shortages of medical specialists.

However, as regards the clinical tele-evaluation in neuromuscular disorders, some critical issues must be considered: functional scales could be incomplete or imprecisely administrated by the caregiver. It is not possible to evaluate articular range and the possible presence or worsening of joints contractures. Moreover, data collection from an online evaluation is not reliable for any ongoing experimental study.

It is mandatory to reach a consensus on the management of Telemedicine and the interoperability of networks at least at a regional level.

Further progress in Telemedicine applied to neuromuscular diseases in developmental age are possible: for example, by the creation of specific apps, remotely controlled by doctors, useful in the daily monitoring of changes in neuromuscular performances.

It is also important to train territorial physical therapists who perform the functional motor assessments at the patient's home or at the clinical centre for the tele-evaluation, in order to ensure a proper data collection.

According to the hub-spoke model, multidisciplinary tele-visit and tele-assistance (such as physical therapy) with local specialists can be extended near to the patient's place of residence, supported by technological platforms conform to regional administrative rules and authorization.

Although it is not a substitute for a face-to-face visit, Telemedicine can become an integral part of the follow-up of active patients, workers, parents, caregivers, minimizing the overall impact of the disease on their lives. It can also be an alternative for disease monitoring and ongoing chronic therapies.

Saving a journey (and consequently working hours and in general time and money) may improve patients and caregivers' compliance.

This may also lead to think about other scenarios of certain social validity, for example a "work break" to have an online medical assessment which takes just an hour off or less instead of a day off, or the possibility for a working parent or both to "virtually" accompany the minor child¹⁵⁻¹⁷.

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MG, CP wrote the draft. AP reviewed the final version of the paper.

Ethical consideration

No mention is made of sensitive data referable to patients.

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