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ITS VIRTUALLY HERE: TELEMEDICINE, VIRTUAL CARE, AND NEUROMUSCULAR DISEASE

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Abstract

The COVID-19 pandemic forced a partial shift in neuromuscular clinical practice away from in-person care to remote means. However, this shift was unexpected, abrupt, reactive to the emergency of a pandemic and disruptive to the usual manner of care, without adequate time to adapt or study the optimal manner to provide care remotely. While traditionally associated with hub-and-spoke telemedicine models, the pandemic popularized direct-to-home virtual care, mostly unsupported by on-site examiners or standardized platforms. In chronic neuromuscular disorders such as amyotrophic lateral sclerosis (ALS) and myasthenia gravis (MG), virtual care has demonstrated feasibility, patient satisfaction, and potential cost savings, particularly for geographically or functionally disadvantaged populations. Disease-specific adaptations such as the Myasthenia Gravis Core Exam and wearable-based assessments (e.g., home spirometry, grip strength monitoring, and digital outcome measures) have enabled more structured remote evaluations. However, diagnostic accuracy may be compromised by the inability to perform detailed neurological examinations or electrodiagnostic studies. Equity concerns persist due to variability in digital literacy, internet and digital device access, and socioeconomic status. Post-pandemic, patients with disabilities may continue to benefit in a combined virtual/ in-person paradigm of care. More evidence is required to evaluate the impact of virtual care on neuromuscular practice quality of care and outcomes. We outline some of the questions that require further study, hoping to spur research and quality improvement investigations of these new care models.

Introduction and Definitions

The severe acute respiratory syndrome coronavirus 2 (SARS-COV-2) pandemic, and the resulting serious, prolonged limitations to the provision of in-person medical care impacted the organization and delivery of health care across the world, bringing various types of remote care models to the forefront.[1] To facilitate this transition, recommendations were rapidly developed to guide clinicians in selecting patients for in-person versus remote assessments.[2–5] However, this rapid transition to remote care, although appropriate for the situation, meant that there was inadequate time to educate clinicians and patients to ensure a safe transition to remote care, or to design and evaluate remote care prior to adoption in order to build the evidence-base for this practice. The skills necessary to evaluate and manage patients through remote methods were also not well-defined, beyond telestroke, which is a well-established model developed to address access to thrombolytic therapy in acute stroke.[6]

Remote care refers generally to all modalities where care is provided without the patient being present at the clinician's office. This could be as simple as a phone call or e-mail, or as complex as sophisticated audio-visual systems.[7–10] In the setting of the pandemic, the term "virtual care" became popular. Virtual care and telemedicine (or teleneurology) are often used interchangeably. Both have in common the provision of medical care by a clinician to a patient at a remote location using any means of electronic communication.[7–10] However, a distinction needs to be made between virtual care as provided during the pandemic, compared to what many consider "traditional" telemedicine approaches in which the encounter between the remote clinician and the patient is facilitated by a local clinician at the same location as the patient, usually at a health-care facility (Table 1). The most widely studied and recognized example of the telemedicine paradigm in neurology is "telestroke", in which a neurologist (often sub-

specialized in stroke and in a tertiary medical setting), is located remotely from a patient with a suspected acute stroke, and is evaluating the patient with the assistance of a clinician at the patient's location. This is termed a "hub and spoke" model in which patients attend a local healthcare facility ("*spokes"*) and are evaluated through a specific telemedicine platform by a specialist at a central location (the "*hub*"). This requires a dedicated platform, many of which are available commercially, and a trained examiner performing the neurological exam at the patient's location. A variation is the "store-and- forward" model, in which the patient is assessed by a single trained individual in their home (which serves as the spoke), with a recording of the encounter reviewed later by the clinician, who communicates their impressions asynchronously back to the patient.[11]

Virtual care, as initially practiced during the pandemic and which continues to be practiced post-pandemic, differs in that patients are usually located at their place of residence during a remote medical encounter, rather than at a healthcare facility. The clinician may also be at home, rather than in the hospital or clinic setting. Since there is no clinician at the patient location to facilitate the encounter, the remote clinician must adapt their usual in-person examination to the remote scenario[12,13]. A specific platform is not required to perform the remote "visit" or consultation, which can be performed by commercially-available platforms available for remote communication (taking into account local privacy and security regulations). This care-model has been greatly facilitated by the widespread availability of smartphones with video-capability and high-speed internet. As many neuromuscular conditions follow a chronic course, this new model of virtual care offers an easier opportunity for follow-up without delays, especially for patients with geographic or physical barriers. There remain scant data about the

optimal methods, effectiveness, safety and confidentiality of virtual care in most medical specialties, given its evolution organically and urgently in the setting of a world-wide crisis in healthcare delivery due to the COVID-19 pandemic. In addition, an even broader application of virtual care is facilitated by advances in remote monitoring with commercially available wearable digital devices, which provide hitherto unavailable “real time” access to data such as step counts and sleep quality aimed at enhancing focused and personalized care in neurology subspecialties like movement disorders and sleep medicine.[14,15]

In this manuscript, we use the term “virtual care” to encapsulate this recent adaptation of telemedicine as initially practiced during the pandemic, in order to separate it from the more traditional hub-and-spoke model of telemedicine (Figure 1). We discuss the evidence available for remote care in neuromuscular disease, and highlight the unique challenges and opportunities for neuromuscular physicians, including areas for future research and quality improvement work. Many of the studies referenced do not necessarily make this distinction, and words such as “telemedicine” or “teleneurology” may be used in the literature to describe any type of remote care, including the more recent adaptation of “virtual care”.

1. What evidence exists for remote care in neuromuscular disease?

The neuromuscular literature for all forms of remote care is limited, and usually describes the evaluation of patients with established diagnoses, often where teleneurology is used for follow-up visits, after an initial in-person consultation and evaluation.[16,17] In many studies, telephone visits were the primary mode of follow-up rather than video-conferencing, limiting the ability to perform an examination.[12,13] Wilson et al. developed and validated a new examination scale comprising examination

elements that were modified for the teleneurology setting to diagnose and monitor patients with peripheral neuropathy via videoconference.[17] This study showed relatively concordant results for in-person and remote evaluations, where the remote examinations were performed by a clinician (either a neurologist, medical assistant or nurse), while a remote neurologist observed the examination, thus adhering to a traditional hub-and-spoke model.[18,19]

The bulk of the literature in neuromuscular virtual care draws from ALS and provides support for the feasibility and acceptability of remote care in ALS multidisciplinary management both prior to and during the pandemic.[9,18–21] In most of the studies performed before the pandemic, patients were evaluated at home, without clinicians present, approximating how virtual care has been implemented during the pandemic.[18,20] A recent review outlines the evidence and applicability of virtual ALS care prior to the pandemic.[9] Remote ALS clinic visits were convenient, allowed for satisfactory discussions around medication management, medication changes, alterations to equipment, and goals of care,[18,19] although in one study patients preferred in-person discussions for issues around diagnosis acceptance and planning around death.[19] Geronimo et al.[20] noted that patients and caregivers viewed virtual appointments more favourably than physicians, particularly when asked if care was equal to in-person visits. ALS patients who used virtual care methods were more likely to have more advanced disease and reside farther from the ALS center, further supporting the hypothesis that virtual care may be especially useful for those with travel and mobility limitations. As an added bonus, a cost effectiveness analysis demonstrated an 89% cost savings ($997) for patients and a 41% cost savings ($327) for the institution per ALS in-clinic visit.[22] Remote delivery and monitoring of pulmonary function

tests (PFT), with home-based FVC testing, was found to correlate well with standard in-person testing in ALS patients, and garnered positive sentiment from patients regarding convenience and ease of use.[23] Finally, a recent review also discusses how remote care can be used in the context of ALS clinical trials for recruitment, consent, and clinical assessments,[24] using a mixture of traditional telemedicine and virtual care, to ensure that vital trials are not postponed or disrupted by events such as the pandemic. Recruitment may also be improved if patients are not required to travel to major academic centers frequently.

The use of virtual care to manage ALS patients increased during the pandemic. Early reports of virtual care during the pandemic from Italy demonstrated the feasibility of assessments mostly via telephone, with video assessments used less frequently. These visits were used to identify patients who required hospital evaluation and collected clinical information and ALS Functional Rating Scale revised (ALSFRSr) scores.[21,25] Patients and/or caregivers were generally satisfied with the encounter and 90% wanted to continue with virtual follow-up in the future.[21] In another Italian study during the early pandemic, the multidisciplinary ALS care approach was reproduced via video visits, including neurologist, dietician, psychologist and physiotherapist assessments, while patients with more urgent needs were still seen in-person as required.[26] This study found high patient satisfaction and stable clinical parameters over the mean 7 week duration of the study.[26]

A small study of 4 siblings with severe facioscapulohumeral muscular dystrophy (FSHD) showed that these patients could be followed safely and efficiently remotely.[16] These patients were assessed via videoconferencing (neurological, respiratory and psychological supports), and cardiorespiratory variables were assessed via a remote

monitoring system (heart rate, blood pressure, oxygen saturation). Patients could access the telemonitoring system via their smartphone.[16] They found that remote monitoring allowed physiologic abnormalities to be detected early and potentially avoid admission.[16]

Guidon et al. published an expert guidance document on remotely evaluating and managing MG, including information on how to prepare for the virtual visit, how to structure the visit, an expert-developed MG-specific examination (MG core exam, MG-CE). The MG-CE was developed by experts through discussion and unblinded voting, as a way to standardize the evaluation of MG patients through video assessments.[27] The 8 core elements are: ptosis, diplopia, facial strength, bulbar strength, counting to 50, arm strength, single breath count, and sit-to-stand. The authors provide suggestions for scoring each element (absent, mild, moderate, severe), and a description of examination pitfalls.[27] They note that MG Quality of Life scale (MGQOL) can be performed by the patient prior to the visit, and that the MG Activities of Daily Living (MG-ADL) scale can be evaluated by phone.[27,28] Lesport et al. (2024) validated an artificial-intellgence telemedicine platform for remote assessment of the MG-CE using natural-language processing and computer-vision video segmentation. The system could reliably identify and score test components with high accuracy, with reduced physician review time, providing some evidence that digital analysis can improve the speed and reproducibility of some remote neuromuscular examinations.[29]

Table 2 summarizes some of the scales that have been proposed or recommended for use in remote care.

2. Incorporation of home-based monitoring to aid clinical decision making

A remote consultation is often complimented by collecting data regarding functional ability, sleep, activities of daily living, and other parameters. This is accomplished by the use of remote monitoring of various functions with commercially available equipment that is either developed specifically for such purposes, or, more frequently, available as applications ("apps") on smartwatches or other portable electronic devices.[30–32] For example, in ALS, there are data on the value of wearable devices for monitoring gait, which can assist with monitoring disease progression and mitigating fall risk.[33–35]

One measure of special importance in neuromuscular disease is pulmonary function testing (PFT). These measurements influence the timely management of respiratory insufficiency, such as the provision of non-invasive ventilation.[36] Measurement of vital capacity using spirometry is a standard of care in many neuromuscular and ALS clinics. However, this monitoring was halted as PFTs and other potentially aerosolizing procedures were limited to in-patient testing during the pandemic.[37] To mitigate this obstacle, there have been efforts to perform in-home vital capacity monitoring, while transmitting information on a digital platform to the health care professional (HCP).[38] At-home self-monitoring including vital capacity was shown to be feasible in the ALS population and provided accurate results and high patient-caregiver acceptance.[23] In another study, home spirometry was found to be feasible for patients with Duchenne muscular dystrophy, who also reported high compliance and satisfaction with this method of home respiratory monitoring.[39] Handheld, portable spirometers, as used in these studies, are convenient and function with software applications downloaded to patients' smartphones, allowing real-time transmission of data for storage and review by HCP.[39]

Studies of app- and wearable-based monitoring in MG have demonstrated good

adherence for logging patient-reported outcomes, use of a digital spirometer and a wearable activity tracker.[40,41] This suggests that interactive telemedicine platforms to collect patient-reported outcomes and passive data (e.g. from wearable devices) may be a feasible adjunct for monitoring of patients with neuromuscular diseases and potentially allow for early intervention to prevent disease deterioration or complications.[40] Studies evaluating the device in MG are ongoing.

A study by Lemmen et al. evaluated the potential of a monitoring app to address treatment response, relapse, and stability in immune-mediated neuropathies like MMN and CIDP.[42] Patients were monitored weekly or monthly, based on disease stability and patient preference, using grip strength, modified timed-up-and go (mTUG), and patient-reported outcome measures (PROMs). Tele-neuromonitoring was feasible and reliable, showing high adherence and positive user experience.[42] Longitudinal home-based assessments were found to be useful to assess treatment effectiveness and IVIG treatment-related fluctuations (TRFs) in CIDP, and one study deploying home collection of daily grip strength in CIDP showed that a change in grip strength by ≥10% was found to be a useful, practical, and evidence-based approach to identify clinically meaningful TRFs.[43] The grip strength collection by patients at home was reliable, valid, and feasible and could help optimize treatment strategies via both face-to-face and virtual video or telephone patient encounters.[43]

Functional measures which can assess decline in motor function by change in ambulation is an important milestone in Duchenne muscular dystrophy (DMD) outcomes assessment. A novel a wearable device-derived clinical outcome assessment has demonstrated sensitivity to ambulatory decline over short intervals in DMD.[44]

3. The neurologic examination performed virtually

Prior to the COVID-19 pandemic, several studies demonstrated that traditional hub-and spoke teleneurology examinations in which HCPs present with the patient perform and report the examination to a remote neurologist are generally as good as in-person examinations.[45] Telepresenters have been used in research studies to perform physical examinations while being observed by study personnel.[24] However, these data cannot be extrapolated to neurologic examinations performed in virtual consultations, where a neurologist instructs a patient to perform various maneuvers while observing through video. In the absence of evidence, different approaches to performing the neurologic examination virtually have been proposed, though these “virtual neurological examinations” have not been prospectively validated.[12,13,46–49]

The ability to perform a detailed neurological examination that is accurate and comparable to an in-person examination remains a challenge to the adoption of remote care in neurological specialties, especially those that depend on changes in the examination to direct management, such as neuromuscular medicine. The type of referral and suspected diagnosis often influence the ability to perform a virtual examination. For example, in a patient referred for suspected ALS, even with video, identifying subtle weakness, assessing for the presence of fasciculations may be difficult, and it would not be possible to test muscle stretch reflexes or perform a reliable sensory examination. The lack of physical examination may lead to unnecessary testing and inaccurate diagnosis. This highlights the importance of a detailed neurologic history that may allow the clinician to identify red flags or concerning findings that prompt more urgent in-person evaluation or investigations, especially so in initial evaluations, but also to direct care on follow-up as needed.

In a retrospective study comparing the accuracy of localization and diagnosis between in-person and virtual neurologic examinations, there was moderate to substantial agreement between the two for several types of neurological signs, including gait abnormalities, extraocular and facial movements, dysarthria and fasciculations.[50] The virtual examination lacked sensitivity for detecting subtle abnormalities compared to the in-person examination, suggesting that with a concerning history, a normal virtual examination may not be sufficient.[50] Different subspecialties of neurology have also sought to develop and validate speciality-specific virtual assessments, including demonstration of comparable Unified Parkinson's Disease Scale (UPDRS) scores when patients were evaluated in-person vs. remotely, or the validation or remote cognitive assessments.[48,51–54] The MG-CE for MG virtual evaluation is one example in neuromuscular medicine.

However, even those components of the neurologic exam that can be performed on video, such as assessment of pronator drift or eye movements, are highly dependent on video quality, patient cooperation, or the presence of a third party who can hold and manipulate the camera. A degree of computer literacy is required from both the patient and HCP.

Examples of other challenges include technical features of the device used. For instance, if the patient is using a smartphone instead of a computer, the screen size and the need to hold the phone can limit the exam. Propping up the phone only allows for a small view and examinations such as those of gait cannot be conveniently performed on most virtual exams including those with computer screens. These are situations in which traditional telemedicine with an on-site HCP facilitating the examination would be preferable, but the need for a specific platform and for the patient to travel to a local

facility where an examiner is available are obvious limitations. Conversely, there are situations in which a virtual examination can provide valuable information, such as in a patient with ocular MG, where several useful examination maneuvers can be evaluated,[27,47,55] as well as additional maneuvers such as the ice-pack test.[12] Similarly, typical facial features of myotonic dystrophy type 1 may immediately clue-in the physician to the appropriate diagnosis and direct early testing.

As virtual care has remained convenient to patients and clinicians even after the pandemic, neuromuscular physicians need to consider whether we should develop and validate a new "remote" neuromuscular examination, separate from the established in-person neurological examination, rather than trying to adapt techniques that were not designed to be performed remotely. Some of the new evaluation methods may be used for hub-and-spoke televisits,[17] while others may be suitable for direct virtual care (without a third party).[27] This will require validating different and perhaps novel maneuvers that are aimed at the same, traditional goal of the neurological evaluation: to localize the lesion and direct diagnostic testing. For example, there are descriptions of techniques for patients or third parties to elicit deep tendon reflexes or plantar responses, though the reliability and reproducibility is not established.[13,47] Anecdotally, there are reports of good concordance between the clinical impression after a virtual visit and the findings at a subsequent in-person visit required for electrodiagnostic studies.[47]

4. What influences the adoption of virtual care in neuromuscular practice?

A European survey of neuromuscular specialists reported a dramatic uptick in the use of virtual care among practitioners (40% of surveyed practitioners had no experience with

telemedicine pre-pandemic, while 100% had used it during the pandemic).[56] The types of virtual visits included a mixture of phone and video, and were related to worsening symptoms, initial diagnosis, clinical trial evaluations, advice on physical therapy, and most-commonly, general follow-up.[56] There are some data on how neurologists triage patients to remote visits, and regarding the quality and patient safety implications of remote care delivery in neurology.[5,57] In a survey of neurologists' practice patterns during the pandemic, neuromuscular neurologists were among the most impacted subspecialists of neurology, with over 80% of respondents reducing their practices by 25% to 100%.[58] This likely reflects the necessity of a detailed examination in the neuromuscular clinic, compared to some other neurological sub-specialties such as epilepsy, headache or cognitive neurology, where management changes may be made based on the history, especially in follow-up visits.

Table 3 outlines some of the advantages and barriers of virtual care from the perspective of both the patient/caregiver and the clinician, based upon clinician experience, but also the few survey studies that have been carried out on this topic.[8,56,59–62]

From the perspective of the patient, barriers include access to technology, sub-optimal therapeutic alliance with the physician, and physical limitations that may impact the ability to utilize virtual platforms without caregiver assistance.[61,63,64] Healthcare inequities may be reinforced by remote care; an American study demonstrated fewer remote visits for patients who were older, non-white, and non-English speaking.[65] By contrast, another study showed a lower no-show rate for remote versus in-person visits, suggesting that remote care may provide an avenue to improve the access to care for neuromuscular patients.[62] In a survey of patients with muscular dystrophy, between 25

and 45% of respondents reported challenges with receiving care or obtaining treatment during the pandemic, and only 42% had participated in a telemedicine encounter.[60] Though the detailed reasons behind these findings were not elucidated in this survey, 10% of respondents felt that easier access and audiovisual improvements would facilitate telemedicine encounters, and 74.7% preferred in-person visits.[60] In a survey of 520 patients with neuromuscular disorders in the US and Canada performed during the pandemic, approximately 50% preferred in-person visits and approximately 25% preferred virtual visits.[66] Over 60% of patients felt that the physical interaction with the physician was very important, and 40% were concerned by the lack of a physical examination during a virtual visit. Reassuringly, over 90% of respondents felt comfortable with remote technology, the majority preferred video over phone.[66] In a survey of 46 neuromuscular patients or caregivers, over 90% rated remote visits as satisfactory or strongly satisfactory, and the majority would agree to remote care in the future, with younger age predicting higher satisfaction.[67]

A survey of members of the Northeast ALS consortium (NEALS) early in the pandemic, highlighted the difficulty in establishing a diagnosis of ALS without an in-person assessment and electrodiagnostic studies, and details recommendations to monitor patients remotely.[59] The type of visit (initial vs. follow-up) is another factor that influences the appropriateness of virtual care in neuromuscular practice, as follow-up visits may be naturally amenable to virtual care, since the patient would have already been examined in detail and perhaps had electrodiagnostic and other studies during an initial in-person consultation.[11] In a survey of neurologists in Ontario, Canada, the suitability of virtual care was influenced by the nature of the patient complaint, symptom acuity, and appointment type (new vs. follow-up).[68] New consultations for issues

commonly seen by neuromuscular neurologists (e.g. limb sensory change or weakness, balance disturbances) were rated as relatively unsuitable to virtual care assessment, compared to sleep, seizures or headache referrals.[68] However, the addition of video (as opposed to an entirely telephone assessment), and use in follow-up visits (rather than as the initial consultation), increased the reported suitability of sensory and motor complaints for virtual care.[68]

The inability to perform electrodiagnostic testing is an obvious limitation of virtual care in neuromuscular medicine.[62] Another limitation of virtual care may be malpractice liability in the setting of limited access to patients' medical records and the lack of physical examination. The Centers for Medicare & Medicaid Services (CMS) substantially expanded telehealth regulations during the pandemic, allowing a broader range of HCPs to provide telehealth services, and included audio-only visits. As of October 1, 2025, many regulations have returned to pre-pandemic standards. Almost every state also had modified licensure requirements/renewal policies for health care providers in response to COVID-19 and immediately post-pandemic including relaxation of out-of-state requirements for telehealth but many have now reverted back to pre-pandemic licensure regulations. The regulatory, and consequently payer aspects, of providing remote care are important considerations, and a rapidly moving target. A more detailed discussion is beyond the scope of this manuscript.

7. Implications of adopting virtual care in neuromuscular medicine

In many studies of virtual care in ALS, patient and clinician satisfaction were high for many aspects of care, but satisfaction does not equal high quality care.[18–20,25] Few studies have examined clinical outcomes in patients managed with virtual care, a

major gap in the literature. The availability of virtual care may improve timeliness of access to subspecialist care, which is an important consideration, especially for patients in remote and rural areas. However, a potential efficiency drawback of virtual care that must be monitored is the possibility of unnecessary testing, since there may be an inclination to order more diagnostic tests for patients who have not been evaluated or examined in- person.

Equity is another area that requires careful consideration and evaluation. The rapid adoption of virtual care and video conferencing platforms has the potential to increase disparities in care, especially for populations that may already be marginalized such as those with low income, the elderly, those without smartphones, personal computers and high-speed internet access, or patients who require interpreter services.[69,70] Although no studies have formally compared video and telephone visits, unlike video virtual visits, telephone visits don't provide an opportunity to examine patients, and thus have added limitations in neuromuscular medicine. However, telephone visits may improve equity for disadvantaged populations, as the technological requirements are much more modest (no smartphone or internet access required).[71] The ability to see established patients in follow-up via telephone has been shown to increase patient access, decrease unnecessary emergency room and in-clinic visits, and thus potentially decrease overall costs of care and improve patient satisfaction in neuromuscular patients.[9,21,60,66] Thus, telephone visits have the potential to address population health while reducing cost in the correct clinical scenario. We must, however, be vigilant about the potential inequities of creating 2 "tiers" of virtual care (video vs. telephone), since some studies have shown that non-white, older, and low income patients are more less likely to have video as a modality for their virtual encounters.[70–72] Research is required to evaluate the clinical situations for which video or phone would be most appropriate in

neuromuscular medicine. Access to broadband internet is crucial to ensure improved digital literacy and equitable access to telehealth services for patients from underrepresented racial and socioeconomic populations.

8. Telemedicine Reimbursement Payment Parity and Covered Services

Amidst the COVID-19 outbreak, legislation removed reimbursement barriers to telemedicine in an effort to expand access to healthcare services.[42] However, understanding the intricacies of telemedicine reimbursement has become complicated. With the passage of the Coronavirus Preparedness and Response Supplemental Appropriations Act and the CARES Act, CMS adapted and continues to adapt the list of eligible services that can be provided via telehealth. CMS outlined Medicare telehealth coding guidelines, as well as a toolkit to help states more quickly adopt telemedicine coverage policies in the Medicaid and Children's Health Insurance Programs (CHIP) during COVID-19.[73] In the United States (US) the house passed the Advancing Telehealth Beyond COVID-19 Act of 2021 (HR 4040) allowing pandemic-era telehealth flexibilities to be extended through 2024.[74,75] Support for funding and appropriate reimbursement of clinical virtual care is essential to be able to continue to offer this service to neuromuscular patients.

Like many specialty organizations, the American Academy of Neurology (AAN) has developed a position statement advocating access to telehealth regardless of location coverage for telehealth services by all insurance, equitable provider reimbursement, simplified state licensing requirements easing access to virtual care, and expanding telehealth research and quality initiatives.[8]

9. Future Directions and Conclusions:

The development of virtual care, a new method of providing remote care is a testament to the resilience of the human spirit and the innovative power of technology use during the COVID-19 pandemic. It provides an opportunity to address inequalities in access to neuromuscular care, by bringing the neuromuscular specialist to the patient. This is especially valuable for patients who live in remote or rural areas, and to those who have mobility impairments. During crises, such as the COVID-19 pandemic, the adoption of virtual care likely prevented many patients from completely losing contact with their neuromuscular specialists. Therefore, virtual care is likely here to stay, but its role in the care of neuromuscular patients is evolving, and needs to be refined, with an aim of ensuring high quality healthcare. The form and the role of virtual care in overall healthcare will gradually develop and change over time depending on legislative changes, economic factors (affordability, reimbursement) and development of technology. Virtual care may be used to complement traditional in-person care or it can be used as its surrogate. Research and quality improvement work are needed to build an evidence base to support the use of virtual care in neuromuscular disease. Areas of greatest importance include: 1) How to optimize the adoption of virtual clinics, 2) How to select appropriate patients, and how to determine which types of consultations are most suitable for virtual care, video or telephone assessments, 3) Validating and building the evidence-base for use of virtual neurologic examination techniques, 4) Measuring the impact of virtual care on the different domains of quality, and the impact on value and costs, and 5) Ultimately determining the impact of virtual care on patient outcomes. We need to be vigilant in monitoring and avoiding unintended consequences, keeping the principle of equity in mind.

Table 1. Models of remote care

Model	**Definition**
Hub and spoke teleneurology	Patient attends a local healthcare setting (clinic, hospital), and is evaluated by a local health care practitioner, while a remote neurologist observes the evaluation over video
Virtual care	Patient is at home, and is assessed by a healthcare practitioner. Can occur via: - Telephone (audio only) - Video: Either a dedicated telemedicine platform, or commercially available platforms (e.g. Zoom®, FaceTime®, Doximity®)
Telemonitoring	Use of modern remote technology “wearables” to monitor various physiological parameters, with the data sent to a healthcare practitioner to review (e.g., step count, heart rate, oxygen saturation, etc.)

Table 2. Examples of neuromuscular virtual assessment tools

Disorder	Tool	Telemedicine model proposed	References
Myasthenia Gravis	MG Core Exam	Virtual care (video)	[27]
		Direct virtual care (telephone or video)	[27]
	MG-ADL and MG-QOL	Patient can complete prior to virtual visit	[27]
Peripheral neuropathy	VANS	Hub and spoke	[17]
	INCAT	Direct virtual care (telephone or video)	[76]
	RODS	Patient can complete prior to virtual visit	[77]
	CMTHI	Patient can complete prior to virtual visit	[78]
Amyotrophic lateral sclerosis	ALSFRS-R	Direct virtual care (telephone or video)	[9,59]

MG: myasthenia gravis; MG-ADL: MG Activities of Daily Living; MG-QOL: MG Quality of Life; VANS: Veterans Affairs Neuropathy Scale; INCAT: Inflammatory Neuropathy Cause and Treatment (INCAT) Disability Score; RODS: Rasch-built Overall Disability Scale; CMTHI: Charcot Marie Tooth-Health Index; ALSFRS-R: Amyotrophic Lateral Sclerosis Functional Rating Scale-Revised.

Table 3: Advantages and Disadvantages of virtual care in neuromuscular disease

Advantages	**Limitations or Barriers**

• Promotes patient-centered model of care
• Expanded access
• Efficiency and convenience:
  ○ Reduced travel time and cost
  ○ Reduced patient time spent on the entire episode of care (preparation, waiting)
• Cost-effectiveness of virtual clinics vs. in-person
• Ability to participate in clinical trials and other research
• Reduced caregiver loss of time and income
• Especially suitable for stable patients and follow-up of established patients
	• Poor technological literacy
	• Limited access to technology (smartphones, personal computers, high speed internet, video conferencing platforms)
	• May reinforce healthcare inequities for some populations
	• Technological hurdles (video or audio malfunction, connection issues)
	• Limited neurologic examination: Less suitable for new neuromuscular consultations when there is not an established diagnosis
	• Inability to perform diagnostic testing (electrodiagnostic testing, neuromuscular ultrasound)
	• Lack of “personal connection”
	• Need for a caregiver in certain situations (e.g. patients with mobility or other physical or cognitive limitations)
	• Concerns about privacy and security of interaction
	• Malpractice liability
	• Licensing issues, especially across state borders
	• Reimbursement issues
	• Limited, but growing evidence for the use of virtual care

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