

# Telemedicine in neurology: current evidence

## Telemedicina na neurologia: evidências atuais

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### ABSTRACT

**Background:** Telemedicine was first introduced in Neurology as a tool to facilitate access to acute stroke treatment. More recently, evidence has emerged of the use of telemedicine in several other areas of Neurology. With the advent of the COVID-19 pandemic and the need for social isolation, Brazilian authorities have expanded the regulation of the use of telemedicine, thus allowing the treatment of many patients with neurological diseases to be conducted with less risk of SARS-CoV-2 contamination. **Objective:** This study aimed to critically review the current evidence of the use, efficacy, safety, and usefulness of telemedicine in Neurology. **Methods:** A review of PubMed indexed articles was carried out by searching for the terms “telemedicine AND”: “headache”, “multiple sclerosis”, “vestibular disorders”, “cerebrovascular diseases”, “epilepsy”, “neuromuscular diseases”, “dementia”, and “movement disorders”. The more relevant studies in each of these areas were critically analyzed. **Results:** Several articles were found and analyzed in each of these areas of Neurology. The main described contributions of telemedicine in the diagnosis and treatment of such neurological conditions were presented, indicating a great potential of use of this type of assistance in all these fields. **Conclusion:** Current evidence supports that teleneurology can be a tool to increase care for patients suffering from neurological diseases.

**Keywords:** Telemedicine; Neurology; Coronavirus Infections; Teleneurology.

### RESUMO

**Introdução:** A telemedicina surge pela primeira vez na neurologia como uma ferramenta para facilitar o acesso ao tratamento do acidente vascular cerebral (AVC) Agudo. Mais recentemente, inúmeras evidências têm surgido acerca da eficácia e da segurança do uso da telemedicina em várias outras áreas da neurologia. Com o advento da pandemia de COVID-19 e a necessidade de isolamento social, as autoridades brasileiras flexibilizaram a regulamentação da telemedicina, permitindo assim que inúmeros pacientes com doenças neurológicas possam ter acesso ao tratamento, com menor risco de exposição à contaminação pelo SARS-CoV-2. **Objetivo:** O objetivo deste artigo foi avaliar criticamente as evidências correntes acerca da segurança e eficácia do uso da telemedicina em diversas áreas da neurologia. **Métodos:** Este artigo foi uma revisão de artigos indexados no PubMed, buscando os termos telemedicina, cefaleias, esclerose múltipla, doenças vestibulares, doenças cerebrovasculares, epilepsia, doenças neuromusculares, demência e desordens do movimento. Os artigos mais relevantes em cada uma das áreas anteriormente citadas. Os principais achados quanto às contribuições da telemedicina, para o diagnóstico e tratamento das condições, foram apresentados, indicando potenciais benefícios da telemedicina em todas as áreas buscadas. **Conclusão:** As evidências atuais indicam que a teleneurologia é uma potencial ferramenta para ampliar o acesso ao cuidado em inúmeras áreas da neurologia.

**Palavras-chave:** Telemedicina; Neurologia; Infecções por Coronavírus; Teleneurologia.

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## INTRODUCTION

Telemedicine, according to the World Health Organization, means the provision of health services when distance is a critical factor, by professionals who use information and communication technology to exchange valid information for the diagnosis, treatment and prevention of diseases, as well as for research, and the continuing education of professionals<sup>1</sup>. The history of telemedicine begun in the early 20<sup>th</sup> century, and in 1967 the first structured system was created, integrating the Massachusetts General Hospital with Boston Logan Airport. Since the emergence of the Internet in 1990, the possibilities of telemedicine have expanded and there has been an increase in its use in several areas of Medicine<sup>2</sup>. Telemedicine is used to connect two or more physicians or a physician with a patients, and includes different modalities such as teleconsultation, teleorientation, telemonitoring, screening, and remote reports<sup>3</sup>.

In Brazil, telemedicine was first regulated by the Federal Council of Medicine (CFM) in 2002, by the resolution no. 1,643<sup>4</sup>. However, several telemedicine procedures, such as teleconsultation, were not regulated until recently. With the advent of the COVID-19 pandemic and the need for social isolation determined by local health authorities, there also emerged a need to regulate these procedures as a way to maintain the provision of medical care, not only for SARS-CoV-2-infected patients but also for those with other medical conditions. This was done through ordinance no. 467<sup>5</sup> of the Ministry of Health and Law no. 13,989<sup>6</sup> of March 2020. Meanwhile, the CFM is working along with Brazilian medical specialty societies in order to achieve a broader and more definitive regulation of the practice of telemedicine in Brazil.

In Neurology, telemedicine was first used in the acute management of stroke patients, more than 10 years ago<sup>7</sup>. More recently, other areas of Neurology have been addressed, with controlled studies evaluating the safety, effectiveness, cost-benefit, and satisfaction of patients with the use of telemedicine. The results of these studies have been presented in reviews and official documents of neurological societies<sup>8</sup>. In order to contribute to the ongoing discussions about telemedicine in Brazil, the Brazilian Academy of Neurology (ABN) has created an Open Committee on Telemedicine (CAT-ABN), with the purpose of compiling and analyzing current evidence in teleneurology. This critical review is a result of this initiative and aims to present the current evidence about the use of telemedicine in the care of patients in several areas of Neurology. The literature search was performed in February 2020 and revised in June 2020. Articles were selected by authors, based on their attributed relevance, type, and current evidence in the different areas of Neurology. For each of these areas, we analyzed those studies performed according to the best methodological recommendations. To achieve our goal of properly contributing to a better practice in this field, whenever possible, we retrieved data from well-designed clinical trials.

## HEADACHE

Primary headaches have high prevalence and great impact; however, most of the patients with primary headaches in Brazil are not properly diagnosed and managed<sup>9</sup>. This is also true in other countries, including developed ones<sup>10</sup>. This difficulty in access has encouraged initiatives evaluating the use of telemedicine and teleconsultations in the care of these patients.

The search for the terms “headache AND telemedicine” returned 55 articles in the PubMed database. Many were small group studies, case reports, and e-Health studies evaluating electronic headache diaries and digital tools to improve adherence to treatment. Eleven were considered the most important, since they were controlled clinical trial studies comparing telemedicine with conventional face-to-face appointments<sup>11,12,13,14,15</sup>. Some included all non-acute headache types and some were restricted to specific populations, such as people suffering from migraine and medication-over-use headache<sup>14,15</sup>.

The first parameter analyzed in the studies was the effectiveness of telemedicine care when compared to face-to-face interaction in terms of clinical outcomes, such as a reduction in the frequency of headache attacks. The papers showed that the results obtained with the use of telemedicine were not inferior or significantly different from those obtained with face-to-face care as regards the reduction or improvement of attacks measured by scales such as the Migraine Disability Assessment (MIDAS) and the Headache Impact Test (HIT-6), and comorbidities<sup>11,14,15,16</sup>.

Another parameter evaluated was safety in identifying potential secondary headaches. In this regard, the studies showed that after an initial adequate screening carried out by a primary care service physician or an initial consultation with a specialist, patients' follow-up through teleconsultations was comparable to face-to-face care in identifying the need for neuroimaging tests, abnormalities in neuroimaging tests, the need for hospitalization, and headaches due to more serious diseases<sup>13,16</sup>. One study calculated that over 20,000 telemedicine consultations are necessary to miss the diagnosis of one case of secondary headache<sup>13</sup>.

The studies also showed good cost-effectiveness, reduced travel costs, increased access, and high user satisfaction<sup>12,15,16</sup>. Small studies also demonstrated the feasibility of telemedicine in the management of children with primary headaches<sup>17,18</sup>. As yet there are no satisfactory reports on the safety and effectiveness of telemedicine for emergency headache care.

## MULTIPLE SCLEROSIS

The search for the terms “multiple sclerosis AND telemedicine” generated a total of 133 articles via PubMed.

The aspects evaluated include therapeutic follow-up, remote assessment of functional status, use of technologies to aid in rehabilitation (telerehabilitation), remote neurocognitive assessment, remote psychological interventions, including cognitive-behavioral therapy, mindfulness, and neuropsychological rehabilitation, remote monitoring of activities, and assessment of adherence to medical therapy<sup>19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35</sup>.

With regard to therapeutic follow-up, some small studies showed the potential benefits of telemedicine as regards access to health professionals outside regular office hours, with the convenience of staying at home<sup>24,25,26</sup>. One of them compared face-to-face with telemedicine care in patients recruited at a referral center, showing the latter to be feasible, cost-effective, and appealing to persons with multiple sclerosis (MS) as well as physicians, and supporting its use as an additional tool in the care of MS patients<sup>27</sup>.

The assessment of functional status via telemedicine in patients with MS was analyzed. The expanded disability status scale (EDSS) assessment by telemedicine and by face-to-face evaluation was shown to obtain very close results; however, evaluation of some neurological examination items was found to be inferior by telemedicine, including that of sensitivity, brain stem functions, cerebellum, and functional system<sup>28,29</sup>.

Home rehabilitation with the help of telemedicine showed promise according to some small studies, with increased patient engagement and positive results in variables such as muscle strength and adherence to physical exercise<sup>30,31</sup>. Telemedicine was tested for neuropsychological and mental health assessment in MS patients<sup>32</sup>. Another study assessed the use of digital tools for neuropsychological rehabilitation in patients with MS<sup>35</sup>. These studies showed positive contributions of the use of technology both for the evaluation and for rehabilitation of these patients<sup>32,35</sup>.

In general, these investigations indicated the potential of telemedicine to reduce costs and achieve a good level of satisfaction with the use of digital tools, whether by patients, caregivers, or professionals. Therefore, they suggested a positive contribution of telemedicine for the assessment and monitoring of patients with, MS as well as by offering assistance in their rehabilitation, with a complementary role in relation to conventional care.

## VESTIBULAR DISORDERS

The search for the terms “telemedicine AND (dizziness OR vertigo)” returned 25 articles in the PubMed database. Three addressed the applications of telemedicine in the diagnosis of vestibular and balance disorders<sup>36,37,38,39</sup>. Thus, we note that research in this area is still very scarce.

Regarding recurrent vertigo, a study with 37 patients evaluated the use of a video of the patient's eyes during the

Dix-Hallpike maneuver, recorded by smartphone, in the diagnosis of vestibular disorders<sup>36</sup>. Seven patients were diagnosed with BPPV, the sensitivity of the method for this diagnosis being 92.86% and the specificity 100%.

In the emergency care context, there was a suggestion in the literature for the creation of TeleVertigo systems<sup>38</sup>, to remotely diagnose and manage patients with acute vertigo and dizziness, aiming at diagnostic clarification between peripheral or central origin. This protocol suggests the use of the quantitative horizontal video head impulse test (vHIT) to assess the vestibulo-ocular reflex.

A randomized controlled trial with 322 adults with chronic vestibular syndromes showed that internet-based vestibular rehabilitation resulted in a significant decrease in vestibular symptoms at six months, compared with usual care<sup>39</sup>.

## CEREBROVASCULAR DISEASES

The search for the terms “stroke AND telemedicine” via PubMed generated a total of 1,097 articles. Stroke care is the one of the most frequent and consolidated conditions in the telemedicine-assisted model, having been the first area of Neurology to effectively use and implement telemedicine. The factors that drove telestroke were the need to increase fast access to acute treatment with recombinant tissue plasminogen activator (rt-PA) and the finding that the complication rate with this therapy is higher when it is used by untrained physicians, at the same time that there are not enough trained neurologists to assist stroke patients in all world locations<sup>40,41</sup>.

The demonstration of the effectiveness of telemedicine in the care of stroke patients led to the structuring of stroke networks, many of them adopting telemedicine, with a spoke-hub model. The spoke is the service, including facilities and personnel, where the patient is assisted. On this site patients are submitted to neuroimaging methods such as non-contrast computed tomography (CT), receive thrombolytic therapy when indicated, and have vital functions managed. The hub is a stroke center, for instance, an academic hospital, with advanced diagnostic and therapeutic capability<sup>42,43</sup>. A deeper review of the specificities of each center involved in a stroke network is beyond the scope of this review; however, the relevance of telemedicine in the structuring and functioning of the stroke networks is clear.

Spoke-hub telestroke was demonstrated to be effective in clinical evaluation using the National Institutes of Health stroke scale (NIHSS)<sup>44,45</sup>, acute stroke triage<sup>46</sup>, evaluation of care quality<sup>47</sup>, evaluation of indications and contraindications of rt-PA use<sup>48,49</sup>, safety measures<sup>50</sup>, costs reduction<sup>51</sup>, and remote neuroradiological evaluation<sup>52,53</sup>. Therefore, the most common use of telemedicine in stroke care is in the acute phase, with physicians utilizing it on the patient's site and remotely to treat patients in the earliest and safest way.

There are few studies on the use of telemedicine for outpatients with stroke. Most of them refer to its value in improving care, for instance as regards control of the use of anticoagulant drugs, and management of risk factors in patients with previous stroke<sup>54,55</sup>.

## EPILEPSY

The search for the terms “telemedicine AND epilepsy” generated a total of 107 articles by PubMed. Fifteen were analyzed. Aspects assessed in the studies include: monitoring and management of epilepsy, use of telemedicine for electroencephalogram interpretation, treatment of neuropsychiatric comorbidities, support for diagnosis of epilepsy with non-physicians trained in low-resource settings, prescription and support of diets in the context of epilepsy, and patient support programs.

The studies were of different types, including cross-sectional, cohort, and randomized clinical trials (RCT). In general, their results are promising, generally well evaluated by doctors and patients, and with similar outcomes for conventional and telemedicine groups. An RCT showed that the follow-up of patients with epilepsy can be performed by telephone, with no difference between groups<sup>56</sup>. Another study revealed that the sensitivity and specificity of a structured telephone consultation to detect important clinical events are greater than 90% in patients with neurocysticercosis epilepsy<sup>57</sup>. A retrospective cohort showed that 43% of telemedicine consultations resulted in alterations in antiepileptic medication prescriptions, 35% of which involved discussions about the possibility of epilepsy surgery. Two thirds of the patients were free from attacks or had improved since the last consultation<sup>58</sup>. In a cross-sectional study comparing telemedicine and conventional consultations, no difference was found between the number of seizures, emergency visits or hospitalizations<sup>59</sup>. A study for the diagnosis of epilepsy was carried out in a location without access to specialists, with trained non-doctors, and with telemedicine support. A high level of agreement in relation to face-to-face consultation and a high level of satisfaction were achieved<sup>60</sup>.

Regarding the management of neuropsychiatric comorbidities, online support platforms were found to help in executive dysfunction<sup>61</sup> and depression<sup>62,63</sup>. Two studies about diet were found, one evaluating the support for adherence to the ketogenic diet<sup>64</sup> and another in which the modified Atkins diet was prescribed by email<sup>65</sup>.

Epileptic patients used few digital tools such as software, but they found them easy to use and helpful to improve health behaviors<sup>66</sup>. In addition, multidisciplinary interventions for managing epilepsy with online support were considered useful<sup>67,68</sup>. A study addressing the use of e-text message support revealed that it improved quality of life in the group using this resource<sup>69</sup>. A questionnaire about the use of

telemedicine among epileptologists in Canada showed that most consider it important and necessary<sup>70</sup>.

With regard to the help of technology in monitoring and management of epilepsy, several studies point to potential tools. Therefore, the work already published shows promising contributions, providing evidence that management of epilepsy by telemedicine can have outcomes similar to those reached by face-to-face management.

## NEUROMUSCULAR DISEASES

The search for the terms “telemedicine AND neuromuscular” OR “peripheral neuropathy” yielded a total of 47 articles by PubMed. Seven of these were considered more robust and were analyzed. The aspects assessed in the studies include: use of technologies for diagnosis or monitoring of diseases, monitoring of patients, ventilatory support in neuromuscular disorders, and aid in rehabilitation (telerehabilitation). There are few clinical trials in this area.

Most studies were small group or case series. Some showed that remote monitoring of mechanical ventilation is feasible with telemedicine. One demonstrated that monitoring of ventilation by telemedicine may be possible in patients with ALS<sup>71</sup>. A case series described the management of domestic ventilation<sup>72</sup>. Another study, a randomized clinical trial in patients with ventilatory dysfunction (more than 80% having neuromuscular causes) showed that starting mechanical ventilation at home was similar to starting it in the hospital with respect to initial monitoring on site or by telemedicine<sup>73</sup>.

A scale was created to assess peripheral neuropathy by telemedicine veterans affairs neuropathy scale (VANS). Specificity and sensitivity were greater than 90% to identify polyneuropathy<sup>74</sup>. Another study with chemotherapy-induced polyneuropathy patients indicated that telephone monitoring with action protocols led to fewer days of pain and less severe symptoms<sup>75</sup>. A series of four patients with muscular dystrophy was successfully treated with telemedicine<sup>76</sup>. A study assessing psychological care by videoconference for patients with rare neuromuscular diseases showed that telemedicine was able to precisely assess the quality of life in these patients<sup>7</sup>.

Therefore, studies in the area of neuromuscular disease are still lacking in order to assess the full potential of telemedicine in this field. Current studies point out that telemedicine-supported ventilation has great potential. In addition, monitoring patients with neuromuscular diseases seems promising.

## DEMENTIA

The search for the terms “telemedicine AND dementia” returns, by PubMed, a total of 289 articles. The aspects

evaluated in the studies include the use of telemedicine for the diagnosis of dementia, patients' follow-up, telerehabilitation for cognitive decline, and remote support for dementia caregivers.

Some studies comparing telemedicine with conventional face-to-face assessment focused on diagnostic accuracy and the reliability of the administration of common screening tests. Different cognitive assessment tools were used, including the Mini-Mental State Examination (MMSE), the Geriatric Depression Scale (GDS), the Katz Index of Independence in Activities of Daily Living, the Rowland Universal Dementia Assessment Scale (RUDAS) and the Montreal Cognitive Assessment (MoCA). There were no significant differences between the scores obtained by face-to-face and video assessments<sup>77,78,79,80,81,82,83</sup>. A prospective cohort study with 210 patients aged 50 years and older and referred to a memory disorder clinic compared the standard face-to-face with videoconference assessment and concluded that the video version was not inferior to the standard version in diagnosing dementia<sup>81</sup>.

In terms of patient outcomes, one study evaluated two groups of patients with dementia during clinical follow-up. One of the groups (n=90 patients) was followed up in person at a referral center for memory care, and the other (n=98 patients) was followed up by telemedicine. There was no significant difference in the decline of the MMSE score between the groups studied<sup>84</sup>. Another investigation including 427 patients with dementia compared the duration of treatment of patients evaluated by telemedicine with that of patients visiting a university hospital's dementia clinic, and concluded that the mean duration was significantly longer for the telemedicine group than for the face-to-face assessment group<sup>85</sup>.

A cognitive intervention program using telemedicine versus a conventional face-to-face method was evaluated in a study with twenty-two elderly patients with mild cognitive impairment and mild dementia, and there was similar cognitive improvement in patients in both treatment arms<sup>86</sup>.

Telephone interventions for family caregivers of people with dementia have been studied and are associated with increased mental and physical health and reduced caregiver burden<sup>87,88,89</sup>.

Different studies show that video consultation is well accepted by both patients and caregivers and is also a way to improve patients' access to memory specialists<sup>90,91</sup>. In general, the studies suggest that telemedicine is a useful and viable alternative for the care of patients with dementia.

## MOVEMENT DISORDERS

The search for the terms "telemedicine AND movement disorders" generated a total of 85 articles by PubMed. Sixteen were analyzed. In addition, references were sought out, resulting in three more articles. The aspects evaluated

in the studies include: use of technologies for diagnosis or monitoring of the disease, neurological and psychiatric consultations for patients with movement disorders (teleconsultations) both by computer and mobile devices (tablets), including follow-up of deep brain stimulation (DBS), rehabilitation (telerehabilitation), and a questionnaire on patient and physician satisfaction.

The majority of studies were with Parkinson's disease (PD) patients. In general, they are cohorts or experiments (before and after intervention), without a control group. Most included small groups of patients. Their results were mostly promising and well evaluated by doctors and patients<sup>92</sup>. In a cross-over study using a tablet for teleconsultations compared with regular consultations, PD patients had similar Unified Parkinson's Disease Scale (UPDRS) and Hoehn and Yahr (H&Y) scales<sup>93</sup>. A small clinical trial with PD patients observed better outcomes in quality of life and UPDRS than those observed after regular consultations<sup>94</sup>. Another study showed similar outcomes for the same variables<sup>95</sup>. Another clinical trial with a larger group (total of 86 patients) exhibited a similar level of satisfaction and better UPDRS outcomes<sup>96</sup>. A large randomized clinical trial was carried out with 195 PD individuals followed for one year by teleconsultations or regular consultations and found no difference in quality of life or MDS-UPDRS<sup>97</sup>.

Regarding the DBS follow-up, a series with patients was described<sup>98,99,100</sup>. Most studies showed a preference of the patients for the use of telemedicine, in addition to a good evaluation by the doctors. On the other hand, two telerehabilitation studies showed problems with video quality and training time<sup>101,102</sup>.

In addition, evaluation through video conferencing of scales UPDRS<sup>103</sup>, Unified Huntington's Disease Scale (UHDRS)<sup>104</sup> and Abnormal Involuntary Movements Scale (AIMS)<sup>105</sup> proved similar to face-to-face evaluation. Another test used in the context of movement disorder, Montreal Cognitive Assessment (MoCA) can be applied by online videoconference for patients with PD<sup>106,107</sup> and Huntington's disease<sup>106</sup>.

Psychiatric support for patients with movement disorders by telemedicine showed to have satisfactory evaluations<sup>108</sup>. The telemedicine rehabilitation program for functional disorders seems to improve quality of life as assessed by scales<sup>109</sup>. In addition, a telephone support program appears to improve apathy in patients with PD when compared to controls without a support program<sup>110</sup>.

## FINAL REMARKS AND RECOMMENDATIONS

Telemedicine was incorporated into Neurology due to the need to provide access to acute stroke treatment. The present review has shown that the use of this tool has by now expanded into other areas of Neurology. Telemedicine has proven to be a useful tool which can be employed in a

complementary or hybrid way along with face-to-face consultations, always aiming at improving care access and increasing patient satisfaction. More studies are needed, among them nationwide studies evaluating the peculiarities of the use of these tools in our population. Telemedicine will never replace face-to-face assistance. Instead, it will complement it. A definitive telemedicine regulation will improve the safe

practice of telemedicine for the doctors as well as the patients involved. We have included in this review papers dealing with the provision of neurological assistance by neurologists with the use of telemedicine. Teleneurology is and must always be performed by neurologists, following the same principles of quality, commitment, and safety that guide the conventional care provided to all patients in all settings in this specialty.

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