



Electroencephalography during SARS-CoV-2 outbreak: practical recommendations from the task force of the Italian Society of Neurophysiology (SINC), the Italian League Against Epilepsy (LICE), and the Italian Association of Neurophysiology Technologists (AITN)

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Abstract

Background During COVID-19 lockdown, non-urgent medical procedures were suspended. Grade of urgency of electroencephalography (EEG) may vary according to the clinical indication, setting, and status of infection of SARS-CoV-2 virus. “Italian Society of Clinical Neurophysiology” (SINC), “Italian League Against Epilepsy” (LICE), and the “Italian Association of Neurophysiology Technologists” (AITN) aimed to provide clinical and technical recommendation for EEG indications and recording standards in this pandemic era.

Methods Presidents of SINC, LICE, and AITN endorsed three members per each society to formulate recommendations: classification of the degree of urgency of EEG clinical indications, management and behavior of physicians and neurophysiology technologists, hygiene and personal protection standards, and use of technical equipment.

Results Scientific societies endorsed a paper conveying the recommendation for EEG execution in accordance with clinical urgency, setting (inpatients/outpatients), status of SARS-CoV-2 virus infection (positive, negative and uncertain), and phase of governmental restrictions (phase 1 and 2). Briefly, in phase 1, EEG was recommended only for those acute/subacute neurological symptoms where EEG is necessary for diagnosis, prognosis, or therapy. Outpatient examinations should be avoided in phase 1, while they should be recommended in urgent cases in phase 2 when they could prevent an emergency room access. Reduction of staff contacts must be encouraged through rescheduling job shifts. The use of disposable electrodes and dedicated EEG devices for COVID-19-positive patients are recommended.

Conclusions During the different phases of COVID-19 pandemic, the EEG should be reserved for patients really benefiting from its execution in terms of diagnosis, treatment, prognosis, and avoidance of emergency room access.

Keywords EEG · COVID-19 · Neurophysiology · Recommendations · Italy

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Introduction

The coronavirus pandemic (COVID-19) required a substantial reorganization of healthcare services. Since the beginning of the emergency period, international [1, 2] and Italian governmental agencies [3, 4] recommended the suspension of all elective and “non-urgent” procedures, including surgical procedures radiologic and neurophysiological tests. Therefore, routine outpatient visits were suspended and individual attempts of remote assistance (by telephone, e-mail or video-audio-conferencing consultations) tried to limit the harmful consequences for patients [5, 6]. However, the definition of “elective” or “non-urgent” is largely variable in relation to the type of specialty of the diagnostic procedures and clinical setting; therefore, classification of the clinical request is frequently left to the individual medical judgment.

Postponing non-essential health interventions is crucial to prevent the overload of Health System Services and its employees, in order to maintain stocks of personal protective equipment (PPE) and care supplies, and to ensure the safety of patients, the community, and healthcare workers. However, despite the COVID-19 pandemic and its related risks, urgent care should be provided in a timely and safe manner to avoid delays in diagnoses and treatments. Clinical decisions on the priorities of examinations are not always easy to balance. In acute life-threatening conditions, there is no doubt about acting. In other situations, as in the case of neurophysiological procedures such as electroencephalogram (EEG), the choice can be questionable. EEG is a commonly used neurophysiological diagnostic procedure and is particularly useful for neurological conditions with acute/subacute onset. In such circumstances, EEG cannot be indefinitely postponed. In this scenario, there is an urgent need to carefully identify clinical indications for EEG according to criteria of appropriateness and priority [7].

The most representative scientific societies of health professionals involved in the EEG execution and reporting, “Italian Society of Clinical Neurophysiology” (SINC), “Italian League Against Epilepsy” (LICE), and the “Italian Association of Neurophysiology Technologists (AITN), received several requests for indications on how to perform EEG examinations during this health emergency from their members. Other professionals (emergency doctors, intensivists, etc.) also expressed the need for a specialistic regulation of the patient selection for EEG. For these reasons, SINC, LICE, and AITN decided to draw up the following recommendations for the selection of appropriate clinical indications in different contexts (inpatient or outpatient) and of the procedures to follow during the execution of the EEG.

Methods

Representative members of SINC, LICE, and AITN were mandated by the Presidents of their respective scientific societies to provide a joint paper on recommendations about the clinical indications and technical precautions to perform EEGs during the COVID-19 pandemic.

The document aims to provide guidance on:

1. Classification of clinical indications for the execution of EEGs according to the degree of urgency
2. Specific methods of management and behavior of medical personnel
3. Specific methods of management and behavior of neurophysiology technologist (NPT) personnel
4. Hygiene and personal protection standards, use of PPE
5. Use maintenance and disinfection of technical equipment

Recommendations are proposed for the different phases of COVID-19 pandemic:

- Phase 1 (restriction of outpatient services to emergencies)
- Phase 2 (intended as the initial outpatient reopening phase, with partial restrictions on services)

The clinical setting that could apply the recommendations have been identified as:

- Inpatients (emergency room, intensive care, ordinary ward, epilepsy monitoring unit)
- Outpatients

The different types of patients were classified, based on the results of the SARS-COVID-19 virus swab, in:

- COVID+ (positive)
- COVID-uncertain (suspected positive, pending swab outcome)
- COVID– (negative)

The document was approved by the respective Boards of Directors on May 7, 2020, and published on the Web sites of the respective scientific societies (www.sinc.it; www.lice.it; www.aitn.it).

Results

Urgency grading

The clinical conditions in which the EEG request is considered undeferrable or not are listed below.

Emergencies (undeferrable):

- Acute alterations in the level of consciousness (when clinical data and basic investigations do not identify the etiology; differential diagnosis with non-convulsive status epilepticus (NCSE))
- Monitoring of pharmacological treatment of convulsive and non-convulsive status epilepticus
- Suspicion of acute encephalitis
- Neonatal asphyxia and related treatment with therapeutic hypothermia
- Prognostic evaluation of post-anoxic coma
- Brain death assessment

Urgencies that can be postponed:

- First epileptic seizure
- Occurrence of unprovoked seizures in known epilepsy
- Prolonged neurological deficits after epileptic seizures
- Suspicion of psychogenic non-epileptic seizures

Phase 1 of the COVID-19 pandemic

EEG examinations should only be carried out in emergency situations and clinically cannot be delayed, both for inpatients and outpatients.

The scientific societies promoting the present document consider that, with the exception of the “undeferrable” category, the neurological specialist physician responsible for the EEG examination should assess a potentially useful diagnostic indication on a case-by-case analysis. However, the physician should always reserve the execution of the EEG only for critical patients in whom the findings of the examination could significantly change the diagnostic, prognostic, and therapeutic management.

EEG recording according to the patient COVID-19 status

It is advisable that:

- the neurological specialist assesses the clinical need and establishes the appropriate timing of all EEG studies in COVID+/COVID-uncertain patients, in collaboration with the team of clinicians involved in direct care;
- if the NPT staff is limited, the neurological specialist assesses the appropriateness of all EEG requests, regardless of COVID-19 status;
- the possibility of performing a prolonged EEG recording rather than repeated standard EEG examinations (20–30 min) is examined beforehand, depending on the

request, in order to reduce overall NPT efforts and the contact time of COVID+/COVID-uncertain patients;

- the usefulness/necessity of standard activation procedures, particularly hyperventilation, is carefully assessed in the individual case. Hyperventilation in COVID+/COVID-uncertain patients is not recommended. The execution of hyperventilation with the mask does not produce the physiological changes presumed to sustain an epileptiform EEG activation, thus it should never be performed.
- At the present, there are no reasons to use different rules and precautions (see below) for inpatients of intensive care units respect to those in non-intensive care units. Actually, the real or presumed COVID status (positive, negative, uncertain) is the only variable that should modify the medical and technical approach to the EEG.

Specific indications for EEG examinations in outpatients

Currently, following the Italian Ministry of Health’s disposal [3, 4], non-urgent and elective outpatient activities are suspended (i.e., they can be postponed without compromising the subject’s state of health). Exceptions are all services related to transplanted patients or for oncological pathologies or perinatal neurological problems requiring serious controls. Some limitations may be prolonged and possibly extended to later stages of the pandemic.

It is therefore considered appropriate to provide some generic indications, useful both in phase 1 and 2, until new conditions arise.

When booking the examination, however, the patient should always be informed that the examination will be postponed if he/she presents, in the days preceding the date of the appointment, one or more symptoms which described in the first stages of SARS-CoV-2 infection: headache, myalgia, cough, fever ($> 37.5^{\circ}$), dyspnea, generalized asthenia, gastrointestinal symptoms, ageusia, anosmia, etc. (for a facsimile triage card, see attachment 1).

At the time of the appointment, it is advisable to ask the patient if he/she has performed serological tests or swabs and if the symptoms listed above have occurred among the cohabitants.

For a correct and safe organization of the booking and execution of the examinations, it is advisable to observe some precautions:

- Increase the pause time between consecutive examinations so as not to prolong the patients’ stay in the waiting room allowing the sanitation of the outpatients’ clinic and equipment.
- With the exception of minors and/or disabled people who need their presence, try to reduce as much as possible the

- presence of accompanying persons both in the waiting areas and in the laboratory.
- To distance the seats in the waiting room by at least 1 m from each other.
 - In the laboratory, the patient must always wear a surgical mask.
 - All surfaces and furnishings in the laboratory must be sanitized with antiseptic products and the room must be frequently ventilated.

Phase 2 of the COVID-19 pandemic

No change from phase 1 is expected with regard to EEG testing in hospitalized patients.

For outpatients' activities, the risks associated with the potential exposure of the patient and healthcare professionals to infection and the benefits of performing the examination should be balanced.

However, it is sometimes necessary to perform an urgent, non-delayable outpatient EEG, also in order to avoid improper access to the emergency department.

The followings are some decision-making criteria for the different EEG investigations:

Standard EEG

In phase 2 of the emergency, the specialist doctor should conduct a risk/benefit assessment that takes into account the following questions in particular:

- Can the standard EEG provide useful diagnostic information to prevent a possible and imminent emergency condition, thus avoiding access to the emergency room (ER, e.g., for a seizure or epileptic status), with an increased risk of exposure to infection and other comorbidities?
- Can the EEG be useful for changes to the treatment plan?

In addition to emergencies, in phase 2, the recording of a standard EEG in the outpatient clinic should be reserved for those with a first epileptic seizure, or cases in which there is a diagnostic doubt that may influence the treatment, or for those who have already received a diagnosis of epilepsy (especially if it is a severe and drug-resistant form) and who need accurate monitoring that cannot be postponed indefinitely (seizure recurrence; control effectiveness, changes or withdrawal of anti-seizure treatment, etc.).

Ambulatory EEG

Even more than standard EEG, this more laborious procedure should include a risk/benefit balance with regard to the impact that the examination results could have on therapeutic

procedures and on the reduction and prevention of accesses to the ER.

Some specific measures are recommended:

- If possible, the NPT personnel unit itself should take care of the application and dismantling of the equipment.
- The possibility to perform the connection/removal at the outpatient laboratory and not in the hospital should be considered in order to limit the patient's exposure and access to the hospital environment.

Polysomnography

This type of examination is at greater risk especially for NPT personnel who must remain in close contact with the patient during preparation, even for prolonged periods of time, and perform maneuvers on the face and near the upper respiratory tract (application of electrodes for electro-oculogram and electro-myogram of the mylohyoid muscle, oronasal/cannula sensor or positioning of masks for CPAP). It should be noted that during positive pressure positive airway ventilation (CPAP) healthcare workers are particularly exposed to aerosolized particles.

For this type of examination, the importance of cleaning and sanitizing all devices between consecutive recordings is an option to be considered.

LTM for epilepsy diagnostics

Long-term monitoring (LTM) is defined as a polygraphic recording associated with video. The purpose is not only diagnostic, but it allows individualized therapeutic approaches (based on the correct classification of seizures and EEG alterations), such as modification or withdrawal of the pharmacological treatment in progress in case of a diagnosis of a different syndrome.

Two are the modalities of execution of the LTM:

- Prolonged (variable length in terms of days) hospitalization for the recording of habitual seizures, for pre-surgical purposes
- daily recordings, lasting more than 4 h, often associated with sleep recording

In phase 1 of the pandemic, in line with national directives, which almost banned elective hospitalizations in order to optimize the availability of beds for potential COVID-19 patients, from March 2020, most facilities had to cancel elective hospitalizations for LTM, both for inpatients and outpatients.

In this phase, the LTM study with diagnostic purposes was considered almost always deferrable, unless special clinical conditions established the real unavoidable urgency.

In the daily management of patients at home, therefore, the acquisition by home-video witnesses of the reported critical manifestations, the recording of an ambulatory EEG (possibly associated with home-video), or the ex-adjuvantibus treatment with drugs can be considered useful alternatives. Considering that most of the new digital recording systems have a video program, it is possible to consider, for patients who present in the ER with frequent seizures, the possibility of performing an urgent hospitalization for video-EEG monitoring, which allows a quick diagnosis and may avoid further accesses to the ER, or an outpatient dynamic EEG if readily and quickly available.

The LTM study for pre-surgical purposes has no urgency at this stage.

In Phase 2 of the pandemic, in view of the reopening of LTM in the inpatient settings, the following points should be considered:

- Careful pre-hospitalization triage to avoid hospitalization of COVID-19+ patients and caregivers
- A second triage for the patient and the accompanying person at the time of admission (in accordance with the local institutional policy of screening new admissions) knowing that family members are essential for safety and diagnostic accuracy, especially in case of intellectual disability and in the pediatric population
- The presence of the minimum necessary staff, considering the possible reallocation of the rest of the staff to other wards
- Differentiated access routes to the ward and laboratory (if different from hospitalization)
- The exclusion of visits by relatives and friends during hospitalization

During the hospitalization, the following aspects should be evaluated and organized:

- The availability of masks and gloves for patients and caregivers
- The availability of masks and gloves for NPT and physicians in the laboratory;
- particular attention to physical contacts with patients having seizures and during clinical examination
- The sanitization of the recording room and the assembly room after each procedure;
- The disinfection of electrodes and other recording devices
- The availability of intensive care beds (for possible onset of epileptic status during the reduction of antiepileptic drugs or as a habitual feature of the individual patient)

Finally, it should be stressed that the mask worn by the patient, if maintained throughout the registration period (especially in persons with disabilities and children), will prevent

the acquisition of clinical elements that could be fundamental and hardly tolerated.

Specific management and behavior of medical staff

During the pandemic, it is desirable that specialist medical staff (neurologists, neurophysiopathologists, child neurologists) can work remotely whenever possible (examination reports, surveillance of EEG monitoring, video-consultations, etc.) making maximum use of telemedicine resources (see National Guidelines - Clinical Teleneurophysiology, SINC Intercompany GdS - DIGITAL SIT [8]). It is advisable to consult in advance with the hospital administrations to develop a plan to provide the necessary neurophysiological services while supporting the needs of the hospital itself [9].

The institutional recommendations concerning the participation in the care activity of medical specialists in training, contract workers, doctoral students, and students of the degree courses in NPT should be followed.

In addition, due to the reduction in the volume of EEG examinations, it should be considered that medical staff may be able to work on alternate days or rotating shifts to limit exposure to the infection, or may be moved to other areas depending on the needs of the hospital.

Specific methods of management and behavior of EEG NPT

The current guidelines of the Italian Higher Institute of Health [10] recommend all staff to always wear surgical masks while in clinical care areas or unable to maintain a safe social distance in hospital facilities where there are possible COVID+ cases. In general, these masks should be used for the entire shift and replaced during the shift in case of deterioration. The guidelines also recommend that all people in the hospital's environment (patients, family members, etc.) should wear a surgical mask. Institutional policies should regulate inpatient visits and only one family member/caregiver should accompany patients for outpatient procedures and monitor patients and staff on a daily basis for symptoms related to possible infection by completing questionnaires and measuring body temperature.

Information should be collected on any COVID+ or COVID-uncertain status prior to performing the diagnostic procedure.

In case of COVID-uncertain inpatients it is necessary to consult the clinical team about the possibility to delay the procedure till the knowledge of serological results; if the EEG investigation is undeferrable, the patient should be considered as COVID+.

Since hospital policies and specific procedures are variable between institutions and operating units and could change over time, it is necessary to keep the NPT staff constantly updated.

During the pandemic period, many hospitals complained of a shortage of NPT staff for various contingent reasons (sick leave, parental leave, home quarantine, etc.). In case of persistence of such critical human resources issues, it may be necessary to reschedule the work plans (afternoon and holiday shifts, on call availability) of each facility.

In case of continuous/prolonged EEG monitoring, it would be desirable to limit the number of NPT entering the rooms of COVID+/COVID-uncertain patients.

Considerations should be given to quick mounting of electrodes (e.g., pre-wired headcap, possibly disposable, although this material is currently only available in a few hospitals).

Hygiene and personal protection standards, use of PPE

The following general provisions are recalled:

- To follow scrupulously WHO recommendations regarding hand hygiene [11]
- To maintain physical distance and to limit the number of people in the laboratory as much as possible
- To use PPE as recommended by institutional guidelines

For services distributed in different buildings, it is advisable to dedicate specific personnel to each service avoiding continuous exchanges of personnel with a consequent increase in the number of contacts.

The staff going to the ER or to departments dedicated to COVID+ patients should go alone, avoiding assemblage with other colleagues or other professional figures.

EEG examinations in COVID+ or COVID-uncertain patients

Before the contact with the patient, the EEG NPT must wear the following PPE in order to implement contact, droplet, and airborne isolation measures in addition to standard precautions and respiratory hygiene:

- a) Gloves, protective clothing (long-sleeved waterproof non-woven shirt, over-shoes, headgear) to protect the body
- b) Mask/eyewear for face protection
- c) FFP2 mask for respiratory protection

All PPE must be removed and disposed of in designated areas.

It is essential that PPE is dressed and undressed in accordance with procedures established by the Ministry of Health (http://www.salute.gov.it/portale/news/p3_2_7_0_1.jsp?menu=multimedia&id=2096) and WHO [12].

Use, maintenance, and sanitation of EEG equipment

- All surfaces of EEG equipment that have entered a COVID+/COVID-uncertain patient environment must be sanitized using antiseptic wipes (for equipment disinfection protocol see [13])
- EEG Equipment to be used in environments with COVID+/COVID-uncertain patients can be protected with a “super-stick” plastic film that can be removed after the examination (uneven surfaces that are difficult to sanitize with wet cleaning agents such as PC keyboards and mice should be particularly protected). The acquisition head can be covered with a transparent cellophane bag.
- Consideration may be given in keeping part of the EEG equipment out of the patient’s room (via long wires), thus minimizing contamination of the equipment and time the NPT remains in the same room with the patient. If available, it is preferable to use instrumentation with amplifiers transmitting wireless (Wi-Fi or Bluetooth) to the acquiring computer, thus reducing the time near the patient and the risk of contamination to the amplifiers alone.
- In COVID+/COVID-uncertain patients, the use of disposable electrodes and headcap is desirable.
- If disposable material cannot be used, WHO recommends the use of the following disinfectants [13]:
 - Seventy percent ethyl alcohol for non-disposable material, such as cup or head-cap (immersion for no more than 10 min in a cellophane bag).
 - Water, common detergent and 5% sodium hypochlorite or other disinfectant for cleaning rooms and surfaces.
- In EEG laboratories, it is advisable to limit the amount of EEG equipment and furniture exposed to possible contamination.
- If instrumental equipment permits, it is preferable to dedicate individual EEG equipment to COVID+ sectors.
- Both the environment and the EEG equipment should be sanitized in strict compliance with institutional policies.

The need to sanitize the EEG equipment, accessories, furnishings, and laboratory environment may however limit the number of examinations that can be carried out in a shift. This must be considered in the activities planning of the Neurophysiology Service.

Conclusions

Making a professional contribution to limiting the spread of SARS-CoV-2 virus infection, neurological specialists need to take in charge the complex assessment of the actual urgency/not deferrable of the different EEG exams, despite limited resources. The physician should examine the risks and benefits of each EEG examination and ensure appropriate precautions are properly applied. Delays or cancellations of an EEG examination can be problematic for both patients and physicians. It may be helpful to share unique messages to patients, based on ministerial recommendations, to reduce the risk of infection, while at the same time providing empathy with patients' concerns.

Involving the clinicians who are in charge of the patient in the decision-making process is important because the reasons for requesting the urgent EEG may not have been clearly expressed. A direct interview with the referring physician can therefore better explain the clinical manifestations and their course and refine the assessment of the various clinical scenarios, contributing to a rational decision. The patient's referring physician is therefore an excellent resource to evaluate the urgency of the EEG's request in a timely manner. Finally, in selected cases, a teleconsultation (telephone or video) with the outpatients can help the decision-making process on the execution of the EEG by reassuring the patient.

One of the limitations of this document is that not all clinical diagnostic scenarios can be reasonably described. However, our aim is to provide general recommendations to guide physicians and NPT staff so that patients requiring EEG studies continue to receive them according to safe and appropriate procedures, minimizing the risk of infection for healthcare professionals. The development of the COVID-19 pandemic is still under observation and increasing infection rates may require maintaining current restrictions over a long period of time. In the interest of patients and healthcare professionals, neurologists should engage as much as possible in planning EEG investigations to ensure patient and healthcare worker safety. The evolution of the pandemic and related health measures could open scenarios needing a revision of these recommendations in the next future.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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