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A Protocol Towards Best Practice for Ictal-Postictal Assessment in Children and Adolescents with Epilepsy

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ABSTRACT:
Background: Epilepsy is a chronic neurological disorder characterized by recurrent unprovoked seizures, which constitute the unique elementary event of epilepsy. The ictal examination is crucial for seizure phenotyping and neuroanatomic localization of seizure onset. This work aimed to set up a valid and adapted protocol for Ictal-Postictal assessment.
Methods: Children with epilepsy aged less than 18 years old were included in the ictal-postictal evaluation based on the procedure developed in 2016 by the European Joint Task Force of ILAE for Testing during seizures. We recorded: age, gender, epileptic syndrome, disease management, seizure duration, and semiology, and completion of different items of the 2016 ILAE procedure for patients Testing during seizures.
Results: We evaluated 60 children, 34 males (56.6%) and 26 females (43.3%), with a mean age of 8.4 years old (2-18 years old). The examiner was able to perform the ictal evaluation in 10% of children within a mean seizure duration of more than 4 minutes. He noted he did not attend the seizures of 29 children (48.3%), and the duration of the seizures was less than 2 minutes in 18 children (30%). Ictal cognitive impairment predominantly affected the short-term verbal and visual episodic memory.
Conclusions: The approach adopted during this study allowed us to identify the difficulties encountered and to propose adaptations for the tests used. Our results suggest that the cognitive profile of individuals with epilepsy does not correspond to a fixed state but a dynamic state in chronological relation to the occurrence of seizures.

KEYWORDS: Ictal postictal assessment; non-motor seizures; cognition; epilepsy

1. INTRODUCTION

Epilepsy is a chronic neurological disorder characterized by recurrent unprovoked seizures due to an intrinsic neuronal predisposition to generate abnormal paroxysmal electrical discharges. It affects around 50 million people worldwide, with approximately 80% of people with epilepsy living in low- and middle-income countries. The incidence of epilepsy across different age groups is a U-shaped curve with the highest rates observed in young children and older adults (Chen et al., 2023).

Epileptic seizures constitute the unique elementary event of epilepsy. However, they have polymorphic and overlapping semiology. Indeed, epileptic seizures manifest clinically either by an easily recognized motor phenomenology, or a non-motor phenomenology (dyscognitive, emotional, sensory, …) often difficult to perceive, especially taking into account the frequency of cognitive-behavioral comorbidities in patients. Most research aimed to identify localizing ictal symptoms relied on motor phenomenology since the 2017 and 2025 International League Against Epilepsy (ILAE) classification for seizures specifies different types of motor phenomena, whilst cognitive manifestations are all grouped under the general term dyscognitive (Robert S Fisher, 2017; Sándor Beniczky et al., 2025). The recognition of ictal pathways spanning non-motor seizures benefited greatly from studies using high-tech, but expensive, functional neuroimaging systems. Thanks to resting-state fMRI, previous case-control studies showed decreased brain connectivity across various resting-state networks, including sensorimotor, visual, auditory, and default-mode networks, depending on the epilepsy syndrome, such as absence and focal epilepsy, including temporal lobe epilepsy (Csaba Juhász, 2020). Other studies demonstrated PET-Scan as a useful tool to identify Psychogenic Non Epileptic seizures (PNES), once they seem virtually indistinguishable from epileptic seizures (Jose GallucciNeto, 2021). Hence, these high-tech neuroimaging techniques improved diagnostic yield in epilepsy in addition to their common indication for pre-surgical evaluation (Csaba Juhász, 2020). However, such sophisticated equipment requires a well-trained staff and is still too expensive and so not easily accessible for most people in low-income countries. Thus, the development of alternative and affordable devices is yet quite useful for epilepsy diagnosis and management within low- and middle-income countries. A focus on non-motor seizures is particularly thought-provoking since people with recurrent seizures have increased cognitive issues and psychiatric comorbidities. Indeed, the impact of epilepsy on the cognitive aspects and psychology of children has been a subject of discussion for a long time (Coste-Zeitoun et al., 2009). A bidirectional arm rules the complex relationship between epilepsy and cognition. Epilepsy itself, due to frequent seizures and abundant inter-ictal discharges, can directly alter attention, memory, and other cognitive processes, or indirectly due to cognitive side effects of anti-seizure medications (ASM). On the other hand, pre-existing cognitive disorders can also worsen epilepsy with poor compliance to anti-seizure medications (ASM) or difficulty obtaining seizure freedom using only molecules devoid of cognitive side effects, and resort to polytherapy. Hence, epilepsy balance seems a key point towards social adaptation and mental well-being of children with epilepsy, as it improves the quality of life and promotes their overall function. Likewise, understanding the relationship between epilepsy and other comorbid conditions affecting the functioning of patients with epilepsy is crucial to the establishment of multimodal assessment and overall epilepsy management of patients.

Since then, training of medical and paramedical staff to conduct thorough clinical assessments, especially an evaluation of cognitive status during a seizure, would enable better characterization of the intellectual performance of these children during seizure, the peri- and interictal periods. In this issue, the ILAE developed a specific procedure for ictal-postictal assessment in 2016. Mutual attempts to integrate the procedure have also been published and have highlighted the contribution of staff training to improving the efficiency of the proposed procedure (O'Kula et al., 2021). Through the present work, we aimed to:

-Provide guidance and train clinicians in the use of the ictal-post-ictal assessment protocol proposed by ILAE in 2016, taking into account the socio-cultural context, patients' characteristics. -Understand the plausible seizure-related cognitive changes in children with epilepsy.

-Identify and propose practical solutions to the contextual difficulties of implementing an ictal-postictal assessment.

2. MATERIALS AND METHODS

2.1. Design and Study Setting:

This prospective cohort study was conducted during the patient's stay in the "Epilepsy Monitoring Unit" (EMU) and/or the inpatient sector of the Child Neurology Department at XXXX. The EMU is equipped with an Electroencephalogram (EEG) for short-term recordings, and a Holter EEG for long-term recordings. Both allow the detection of cerebral electrogenesis on the scalp using a 10-20 system. The inpatient sector has a maximum capacity of 14 beds that are not assisted by surveillance cameras or an alert system to warn staff of the onset of seizures.

2.2. Participants:

We included children aged less than 18 years old with a follow-up for epilepsy or a referral for paroxysmal events. Epilepsy diagnoses was based on the 2014 ILAE practical clinical definition of epilepsy (Robert S Fisher et al., 2014). Children admitted for acute symptomatic seizure or febrile seizure were not considered, and those with neurosensory deficit, severe intellectual disability, acquired large brain injury, or progressive encephalopathy were excluded.

2.3. Data Collection:

Pre-established forms were used to record the following data: age, gender, perinatal and family history, comorbidities, initial development, seizure type (according to caregivers' reports, home video, video obtained during ictal EEG), seizure duration, epileptic syndrome, aetiology, and disease management. Videos were considered reliable when they were captured in a well-lit room, showed the entire patient's body and face, the whole seizure from the start to its end. When available, ictal EEG was useful for seizure classification, but not mandatory and clinical description was enough. We referred to the 2025 ILAE Operational Classification of Seizure Types for seizure phenomenology narration. The seizure duration was graded as follows: (1) less than 2 minutes; (2) between 2 and 4 minutes; (3) more than 4 minutes; (4) more than T1 (T1 is defined as the point time beyond which the seizure should be regarded as "continuous seizure activity" and thus indication ASM administration). The performance of patients on cognitive tasks presented at 3 time points; respectively during seizure (ictal), immediately after seizure (post-ictal), and during the inter-ictal period was noted. Reasons preventing the evaluation from being carried out were recorded.

2.4. Study protocol:

Patient assessment during and in between seizures is mandatory for seizure type classification and seizure management. The protocol was structured to perform a three-time-points evaluation: during seizure (ictal), immediately after (post-ictal) and in-between seizure (interictal).

Testing during seizure followed the same steps proposed in 2016 by the European Joint Task Force of ILAE for patients testing during seizures (Beniczky et al., 2016). Safety manoeuvres were a top priority and included turning the patients on their sides, delivering oxygen/suction, turning the light on, uncovering the patient, and parenteral ASM for prolonged seizures (more than 5 minutes for generalized seizures and more than 10 minutes for focal seizures). Since rapidity, safety, and clinical assessment were the immediate priorities, cognitive evaluation was not carried out in patients who needed parenteral ASM administration. Other assessment components included: responsiveness (call, painful stimuli, motor prompts without then with demonstration), and orientation questions. In addition to items assessing cognitive aspects, the evaluation also included somatosensory assessment using double-stimulus tests and visual testing.

The second time point of the evaluation was the postictal period, defined as the period from the onset of seizure endpoint until the return to the patient's baseline. Post-ictal components were: orientation, verbal memory testing, motor assessment, and naming objects. The inter-ictal state was evaluated by repeating the same procedure when the patient was not under the influence of a seizure and at least one hour after the end of the postictal period for comparison.

2.5. Neuropsychological subtests adaptation:

The Cognitive Evaluation followed the same assessment items of the 2016 ILAE consensus (Beniczky et al., 2016). These included verbal memory testing, counting to 10, and naming objects (standardized list of ten objects by age range: <3 years; <4 years, <5 years, <6 years, <7 Years). Some adjustments to the cultural context and linguistic aspects were necessary. For word recall and naming items, strange objects were replaced with more familiar ones to our population, respecting their semantic field in the foreign version. New objects were approved by our department speech therapist (Mr M.B.O.). Patients were included only if they were seen at two different times relative to the onset of seizure (Ictal / Postictal, Ictal / Interictal, Postictal / Interictal). For each item, scoring was represented qualitatively using a binary variable ((1) Completed: if the patient succeeded in carrying out the order/ (2) Not completed: if the patient failed to carry out the order); or quantitatively considering the number of valid responses by the total required responses. If the seizure ended before the patient received the command, the item was considered as (3) Not evaluated. Patients who were seen during their ictal period and displayed completely impaired awareness were assigned the note "Not completed" for all items.

For adolescents more than 12 years old, the Inter-ictal assessment also included the Arabic version of the Depression, Anxiety, and Stress Scale (DASS-21). The DASS-21 is composed of three self-report scales comprising 7 questions (Q) each, and known to measure the emotional states of depression (D: Q 3, 5, 10, 13, 16, 17, 21), anxiety (A: Q 2, 4, 7, 9, 15, 19, 20), and stress (S: Q 1, 6, 8, 11, 12, 14, 18). These questions are rated on a 4-point severity grade. Then, scores are summed for each scale, and the total for each scale is multiplied by 2. Based on the total scale (D = Depression, A = Anxiety, S = Stress), the patient's emotional state was considered Normal (D=0-9; A=0-7; S=0-14); Mild (D=10-13; A=8-9; S=15-18); Moderate (D=14-20; A=10-14; S=19-25); Severe (D=21-27; A=15-19; S=26-33); or Very severe (D>28; A>20; S>34).

2.6. Evaluator Training:

The evaluator was a medical resident able to indicate and ensure timely safety measures and parenteral ASM administration if needed. Patient assessment was performed after the evaluator had received a training simulation session on the protocol steps and cognitive assessment items. The evaluator was provided with a video support for the simulation session, a printed document for the evaluation steps, and a preestablished file to record evaluation findings. The evaluator assisted the patient at onset seizure once called by the child's caregiver and/or the nurse caring for the child. The evaluator was warned of the need to note and communicate any disappointments or difficulties interfering with the completion of the patient assessment.

2.7. Feedback and Elaboration Future Recommendation:

This approach that contributed to the development of a more suitable assessment for the studied condition and the proposal of a simplified first-line assessment with guidance towards a second-line assessment. Benefits from the revised version of the study protocol was ascertained from a case study.

2.8. Statistical analysis

Statistical analysis was performed using Excel 2016 and XLSTAT for Windows. Qualitative variables were represented with frequencies. Hence, quantitative variables were reported with means and ranges. Variables distribution was checked using Kolmogorov-Smirnov test. Frequencies were compared using the chi-squared test or Fisher's exact test. For normal quantitative variables, we used the Student test or the ANOVA test to compare two or more means, respectively. For non-normal quantitative variables, we used the Wilcoxon Rank-Sum Test or the Kruskal-Wallis H test to compare two or more medians, respectively. The calculated p-value was considered significant for values below the alpha = 0.05 significance level.

3. RESULTS

3.1. Study population characteristics

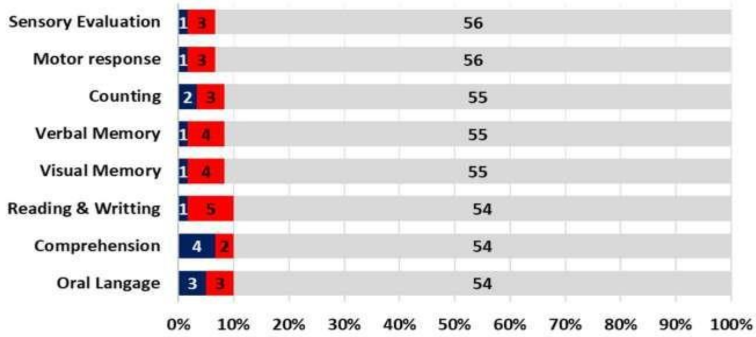
We evaluated 60 children with a mean age of 8.4 years old (2-18 years old). There were 34 males (56.6%) and 26 females (43.3%) (Sex Ratio M/F=1.3). Data about seizure types classification are summarized in Table 1.

Table 1: The table shows seizure classification based on whether the caregivers' reports or seizure videos were used

	Caregivers' description	Video analysis	p
Onset			0.008
Focal	23.3%	50%	
Generalized	26.6%	10%	
Unknown	50%	40%	
Onset phenomenology			0.25
Motor	71.6%	60%	
Non-motor	28.3%	40%	
Elementary phenomenology			-
Tonic	25%	26.6% 5%	
Clonic	6.6%	23.3%	
Tonic-clonic	23.3%	10%	
Myoclonic	6.6%	3.3% 6.6%	
Hyperkinetic	-	3.3%	
Epileptic Spasms	-		
Automatism	-		
Awareness			0.058
Impaired	58.3%	55%	
Preserved	41.6%	45%	

The proportions of patients able to complete different items of the cognitive evaluation at onset and after a seizure are represented in Figure 1.

(a)



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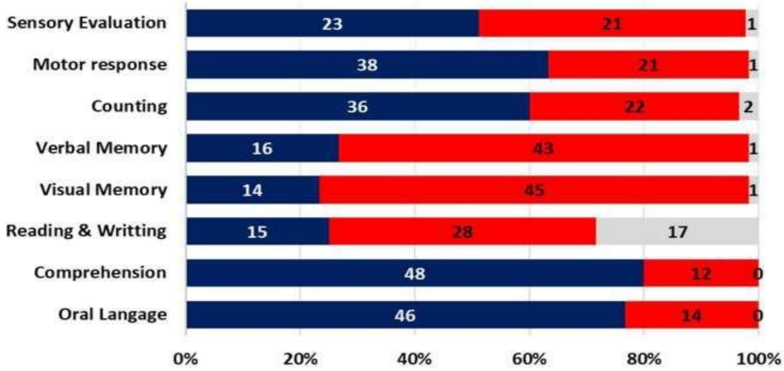


(c)

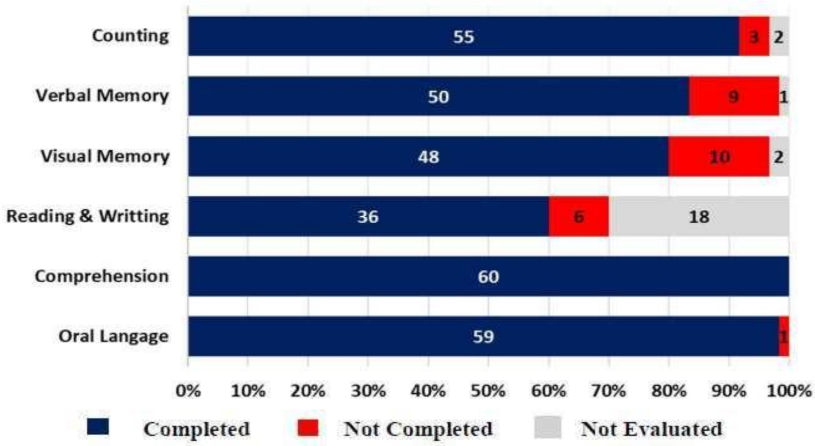
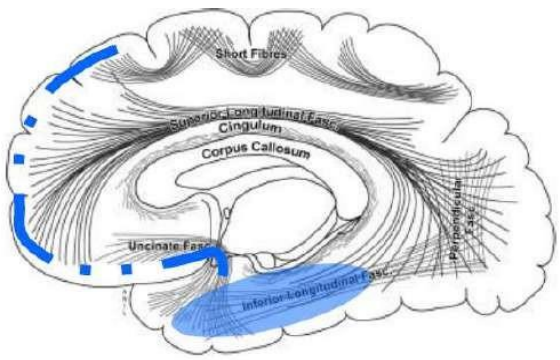


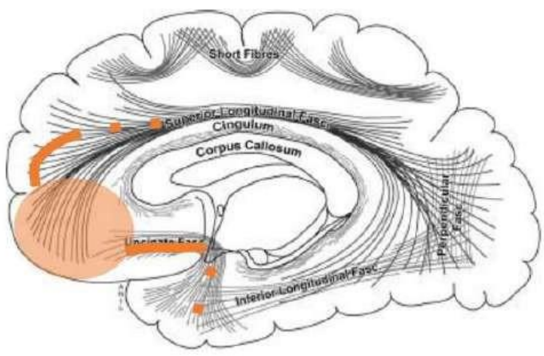
Figure 1. The figure shows the proportion of patients who completed the ictal postictal assessment at different time points (a: ictal; b: postictal, c: inter ictal).

Children seen in the ictal period showed overall ictal cognitive performance that differed significantly from their inter-ictal performance (χ^2 (2) = 12, p = 0.002). This difference was not noted when comparing ictal and postictal cognitive performance, reinforcing the idea that changes in the postictal brain are very similar to those enhanced by the ictal discharge. The difference in global cognitive performance of the study population during the postictal and interictal periods was not significant (F (7, 5) = 1,33, p = .782, IC à 95 % [0,19, 7,01]), raising the hypothesis that the persistent changes expressed interictally may begin as early as the postictal phase. 3.2. Ictal Evaluation

Ictal EEG was obtained in six children (10%). A similar proportion of children (10%) completed the ictal cognitive assessment. Their seizure duration exceeded 4 minutes compared to a mean seizure duration of less than 2 minutes in the remaining children (90%) (t(8.37) = 4.43, p = 0.002, 95% CI [1.16, 3.65]). Only four children had ictal EEG recordings and concomitant or a separate cognitive assessment during seizure recurrence within the inpatient clinical monitoring (6.6%). The ictal cognitive evaluation allowed the recognition of the focal nature of the seizures in one patient whose seizures were previously considered to be of unknown onset as an ictal EEG was never obtained. This patient displayed bilateral motor tonic movements during seizures, but he was able to complete the ictal evaluation at onset, proving the seizure's focal temporal origin. Still, the child had impaired verbal and visual memory but succeeded in naming 3 objects out of 10 before the seizure ended with bilateral tonic posturing without altering his consciousness (Figure 2a). Ictal cognitive assessment with electrographic correlation was obtained in one patient thought to have a motor seizure of unknown onset with confusion, fear expression, automatism with stereotyped head and trunk movement, and motor hyperkinetic movement of the four limbs. The EEG showed left frontopolar discharges of a rhythmic fast activity with temporal and spatial progression. Concomitant cognitive assessment showed that the child had impaired language, indicating the diffusion of discharges to the temporal cortex (Figure 2b).



(a)



(b)

Figure 2. The figure shows the epileptogenic network in two patients as presumed predicted based on their ictal assessment. (a) The patient exhibited altered verbal memory with spared language pointing out the onset of discharges at the mesio-temporal cortex Later aware bilateral tonic posturing indicates that the discharges spread to the supplementary sensorimotor area (SSMA) via the ventral root. (b) The patient displayed altered language and hyperkinetic movement of the four limbs, concomitant electroencephalogram showed initial left sided fronto-polar discharges with slow progression to the temporal cortex.

Considering all patients assessed during the onset of seizures, ictal cognitive impairment affected mainly the short-term verbal and visual memory ($\chi^2(7) = 16.01$, $p = 0.003$, IC95% [0,040; 0,381]). Other cognitive domains, such as counting, language, writing, and reading, which require the activation of widespread and complex subcortical networks in addition to cortical regions, were less involved (Figure 3a). In the Ictal Naming Test, an average of 3 out of 10 objects was identified. This rate improved during the post-ictal period (7/10) without reaching the threshold of significance (p=0.6), and normalized during inter-ictal periods.

(a) **(b)**

Figure 3. The figure shows the mean state ((1): Completed; (2): Not completed; (3): Not evaluated) in patient who underwent the ictal postictal assessment at different time points. (a) corresponds to data obtained from patients who completed the ictal assessment. (b) corresponds to data obtained from patients who completed at least two time points of the ictal post-ictal evaluation.

3.3. Post-ictal Evaluation

The post-ictal cognitive assessment revealed significant reading and writing difficulties, both functions sustained by complex subcortical networks belonging to the ventral system, closely linked with the limbic system and the emotional brain, the amygdala ($\chi^2(7) = 16.01$, $p = 0.002$, IC95% [0.039; 0.371]). Short-term memory impairment was less affected (Figure 3 b). More than half of the patients had normal comprehension and verbal functions (80% and 76.6% respectively), which were supported by subcortical networks belonging to the dorsal system (Figure 1b).

3.4. Inter-ictal Evaluation

Dysfunctions affecting the neuronal circuits supporting reading and writing functions were maintained during inter-ictal periods, reflecting irreversible reduced neuronal connectivity (Figure 1b). Higher scores within the Anxiety and Stress items of the DAS-21 scale were more frequently observed (26.6% and 25%, respectively) than those within the Depression items (10%) (Figure 4).

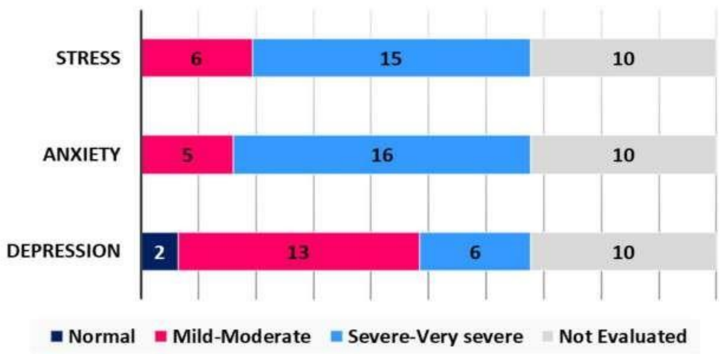


Figure 4. The figure shows the proportion of patients with mood disturbances and their severity as evaluated by the DAS-21 scale.

3.5. Feedback and Intervention:

The examiner noted he did not attend the seizures of 29 children (48.3%), the duration of the seizures was very brief in 18 children (30%), and 7 patients (11.6%) did not cooperate, which constituted reasons for inability to perform the ictal evaluation. The identification of these factors allowed defining the following parameters: environment, individuals (patient and examiner), and tests used as the cornerstones of the ictal evaluation, which act as drivers to define the speed of the ictal evaluation. Hence, the investigator's intervention consisted of adjusting these parameters with the intention of achieving faster and more efficient testing (Table 2).

Table 2: Differences between the initial version and the revised version of the study protocol

Study Protocol	Initial Version		Revised Version	
Duration (minutes)	>2 min (4-5 min)		<2 min	
Environment Video Alarm agent /system Well-lit room	 No No Yes		 Mandatory At least alarm agent* Yes	
Individuals	Patients	Examiner	Patients	Examiner
Tests	Long / Complex	No ordered Steps / Numerous word list	Short form/ Domain specific Minitests	Ordered Steps/ Two word list

*Could be an alarm device or a person who accompany the patient and call the examiner at onset of seizure aura

3.6. Evaluation using the revised protocol

The revised protocol allowed the management of an 8-year-old girl with a diagnosis of probable seronegative autoimmune encephalitis. Clinical picture at onset associated with subacute behavioral changes, deterioration of academic performance, and frequent focal motor tonic seizures.

The child received high-dose intravenous steroids, followed by oral corticosteroids in addition to ASM, with seizure freedom and EEG normalization by one month. During corticosteroid withdrawal, the child presented three months later for seizure recrudescence. Ictal EEG recorded left-sided frontal discharges of fast activity rapidly involving the whole cortex concomitant to asymmetric posturing with right upper limb elevation and head deviation to the right side, followed by agitation. Interictal EEG showed continuous high-amplitude predominantly anterior spike and waves activity, in addition to “extreme delta brush sign”. Between seizures, the child displayed slow speech and slurred words with perseverative behavior. For treatment adjustment, there was a need to answer the question whether such a state matched with a larval status epilepticus, comprehension problem, or executive dysfunction due to the underlying condition or epileptic activity.

Second-line assessment language ascertained major oral expression impairment with speech initiation difficulties consistent with motor transcortical aphasia. Since both seizure semiology and interictal cognitive pattern indicate dysfunction within the supplementary motor area with normal brain MRI and significant recovery after intravenous phenobarbital and veinoglobulin, it was possible to attribute cognitive deterioration to epileptic activity.

4. DISCUSSION

4.1. Ictal Evaluation Input:

According to the current research, cognitive ictal assessment contributes as much to seizure recording as EEG. The concomitant ictal cognitive and electrical assessments were more effective in locating the seizure origin “march”. The rate of 27% assessed seizures within 30 seconds reached in a previous UK study (Kandler et al., 2013; Kinney et al., 2019), exceeded that of 10% assessed seizures within 4 to 5 minutes in our study. Differences may be related to disparities in infrastructure (video assistance, alarm system), and considerations relative to the study objectives and design. In fact, the US study authors focused only on the step of safety measures before assessment. In addition, our results revealed cognitive assessment as an effective tool not only for drawing the cognitive profile of patients with epilepsy but also for outlining epileptogenic networks. These findings are both basic for epileptic disease phenotyping and deciding pharmacological and non-pharmacological therapeutic options for patients with epilepsy. However, the transient and brief nature of seizures, delays in patient attendance before the seizure ends, and patient reluctance were among the reasons preventing the accomplishment of ictal-postictal assessment. Supplementary reasons stated by other researchers were the lack of well-trained and experienced staff and poor standardization of testing across centers (Beniczky et al., 2016; Hamandi et al., 2017). Others rather, advocated the development of an appropriate battery of ictal examination (O’Kula et al., 2021). Indeed, setting valid circuits for immediate and systematic patient assistance during seizures requires the elaboration of structured batteries devoted to looking after non-motor symptoms, which often escape from video recording and even EEG once a deep focal discharge does not spread, and cannot be detected using surface electrodes (Alim-Marvasti et al., 2022). Hence, considering such symptoms usually neglected by the examiner is the only guarantee for an early positive and differential diagnosis necessary for adequate personalized care.

For example, our first patient (Figure 2a) was thought to have motor seizures of unknown onset, considering their clinical expression with bilateral motor phenomenology contrasting with spared consciousness. After the ictal assessment, it was possible to identify the dyscognitive state at the onset of the seizure with impaired visual and verbal memory. Such ascertainment enabled us to rule out PNES characterized by preserved recall during bilateral motor events (Kinney et al., 2019). On the other hand, it pinpointed the middle and anterior temporal cortex as the initial source of epileptic discharge, before it spread to the inferior frontal cortex via the ventral root; a neuronal pathway previously proposed to support single-word repetition maintenance processes (Majerus, 2013; Olive et al., 2023). Regarding aware bilateral tonic posturing, reports about the occurrence of symmetric diffuse tonic seizures during childhood onset focal epilepsy date back to the 90s. Based on these observations, it has been suggested that tonic seizures result from the activation of the supplementary motor area (SMA), less frequently of the premotor and anterior cingulate area. Bilateral tonic seizures with preserved awareness, as seen in our report, were related to the activation of the supplementary sensorimotor area (SSMA) (Shasha Wu et al., 2023). For our second patient (Figure 2b), based on clinical assessment only, it was challenging to accurately establish the seizure origin as recent neuroimaging studies proved initial temporal lobe involvement during seizures manifesting with hyperkinetic features contrary to the eminent dogma that hyperkinetic seizures mostly originate from the prefrontal cortex (L. Vaugier et al., 2009; Wang et al., 2018). Therefore, the correlations between the initial fronto-polar discharges on the ictal EEG and language impairment during the ictal cognitive assessment allowed us to outline the flow trajectory of the epileptic discharge from the frontal to the temporal regions.

4.2. Postictal Evaluation Input:

Assessment of patients during the postictal period provided reliable clues to guide localization and lateralization for a long time (Kinney et al., 2019). Interestingly, in our study, cognitive evaluation during this period revealed a state of anaesthesia within the neuronal circuits not involved in the ictal discharge. These results suggest that the process responsible for the extinction of electrical discharges can lead to long-term inhibition of spared brain regions beyond epileptic activity. This hypothesis is consistent with results from functional neuroimaging studies, although they are more representative of the immediate postictal effects. Indeed, the onset of seizure spreads speed and related artefacts often reduce the quality of acquisitions obtained during the ictal period when functional neuroimaging is used for the pre-surgical evaluation. Nonetheless, analysis of data from the postictal period could also be fruitful. It is suggested that neurotransmitter depletion, changes in receptor concentration, active inhibition, and cerebral blood flow shunts are inherent to molecular mechanisms underlying postictal symptoms (Koepp et al., 2010). We particularly stress the dynamic role of endogenous opioids in terminating seizures, whose release requires high-frequency firing, a condition best met during a seizure. Enhanced opioids _known to have analgesic, rewarding, addictive, and mood-regulatory effects_ could delay or diminish the intensity of the ictus. Additionally, eloquent cortical and subcortical brain areas probably have an increased response to opioids due to a feedback loop toward reconstituting the released neurotransmitter and its corresponding receptors (Koepp et al., 2010). This sensitivity is sufficient to explain the Todd phenomenon, which often indicates the focal onset of a seizure in the cortex region supporting the dysfunction.

4.3. Interictal Evaluation Input:

Similarly, permanent disruption of reading and writing neuronal networks between seizures documented in the present study supports the hypothesis that recurrent seizures may lead to persistent defects in brain neuro-circuitries similar to those described as intoxication by opioids (Christopher A. Blackwood et al., 2021). Accordingly, neuroimaging studies found that stimuli-induced reduction in endogenous opioid neurotransmission was associated to affect dysregulation, and higher plasma levels of stress hormones (cortisol, ACTH, …), implying a widespread network of regions implicated in emotion regulation (Peciña et al., 2019). These data could elucidate mood changes exhibited by our population study.

4.4. Protocol Adaptation:

The major contribution of this study lies in recognizing the practical constraints to implementing the evaluation. Interestingly, the examiner's feedback enabled us to set up an adapted version for ictal-postictal testing, responding to the following recommendations:

-Test duration not exceeding an average seizure length of 1–2 minutes, resorting to abbreviated mini-tests assessing global cognition and domain-specific cognitive deficits, respectively.

-Recommend two times assessments during at least 2 separate seizures, using as first-line assessment a short-form assessment for global cognition (Figure 5), and as second-line assessment a targeted evaluation for domain-specific cognitive deficits (Figure 6).

1. The short form assessment for global cognition (Figure 5a) consisted of a six-item questionnaire recording responsiveness, sensory response, motor response, language, orientation, and memory. The double stimulus test evaluates sensory response (Figure 5b). Objects (Figure 5c) and words are the same as in the first version at the beginning of the study. However, in this new version, we have adopted an easier and time-saving approach using only two lists of three objects/words instead of ten objects/words for two age groups (less than 5 years, non-scholarly, versus more than 5 years, scholarly) to reduce the time delay in assisting a seizure.

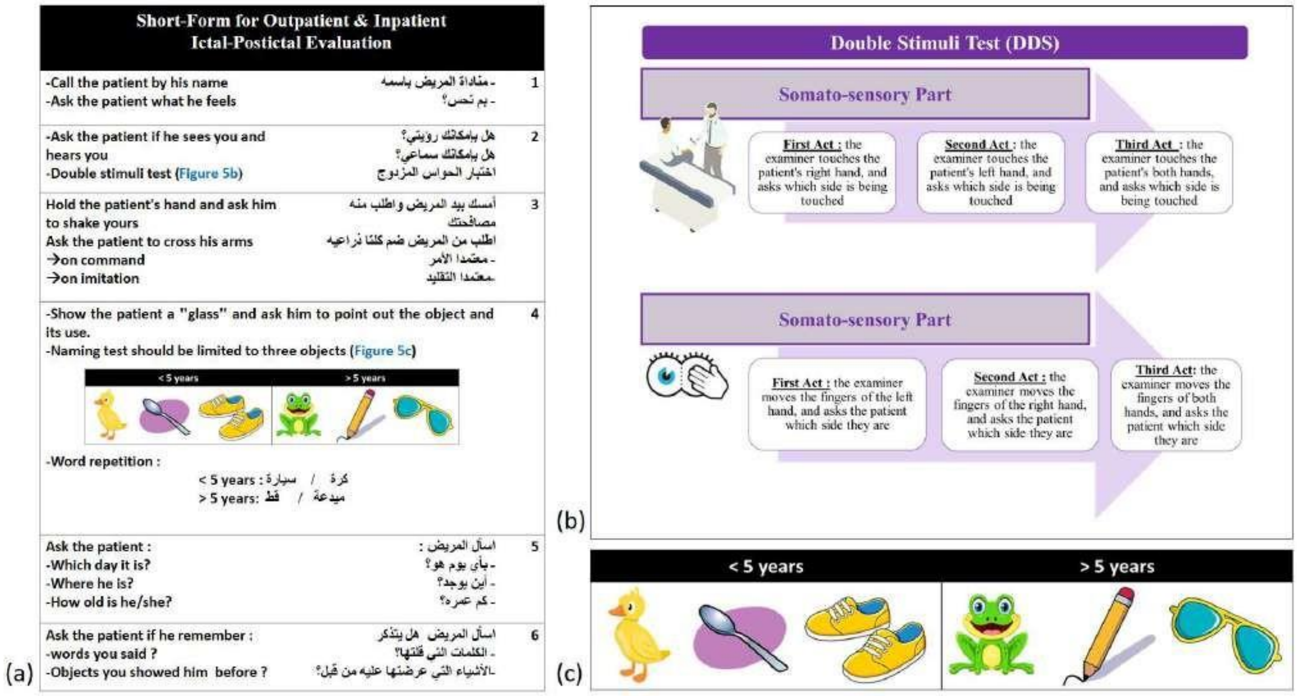


Figure 5. The figure shows the items of the Arabic version of our Short Form for Outpatient and Inpatient Ictal Postictal Evaluation. Panel (a) shows the steps of the short-form assessment for global cognition for first-line assessment. Panel (b) shows the double stimulus test. Panel (c) shows the list of objects used for the naming test with respect to the patient's age (< or > 5 years).

2. The choice of an adequate mini-test for second-line domain-specific assessment depends on the state of impaired and/or spared functions during the first-line assessment of a previous seizure (Figure 6a).

Further studies with large population size would be required to answer the question whether ictal cognitive changes have a specific pattern that should be prioritized during domain-specific assessment. Unless, we raise the following issues:

-Sensory impairment can manifest as an unresponsive state. If spared, test for minor sensory alterations using mini-tests in Figure 6b

-Normal praxis is fundamental for normal motor response and language production. Test for praxis (ask the patient to open his mouth, make puppets, combine two Lego pieces, …) before concluding motor deficit or language dysfunction.

-Mini-tests proposed in Figure 6c will enable the subtype of language impairment (comprehension, expression, …), Memory, and academic skills. Items for memory (Episodic Memory, Working Memory) and academic skills (reading, writing, counting) assessment could be applied only if language is spared.

-In the case of evident non-motor seizure aura available through (seizure semiology narration, video, or completed outpatient ictal short-form evaluation, the inpatient ictal-post-ictal assessment could use the second line subtests from the start.

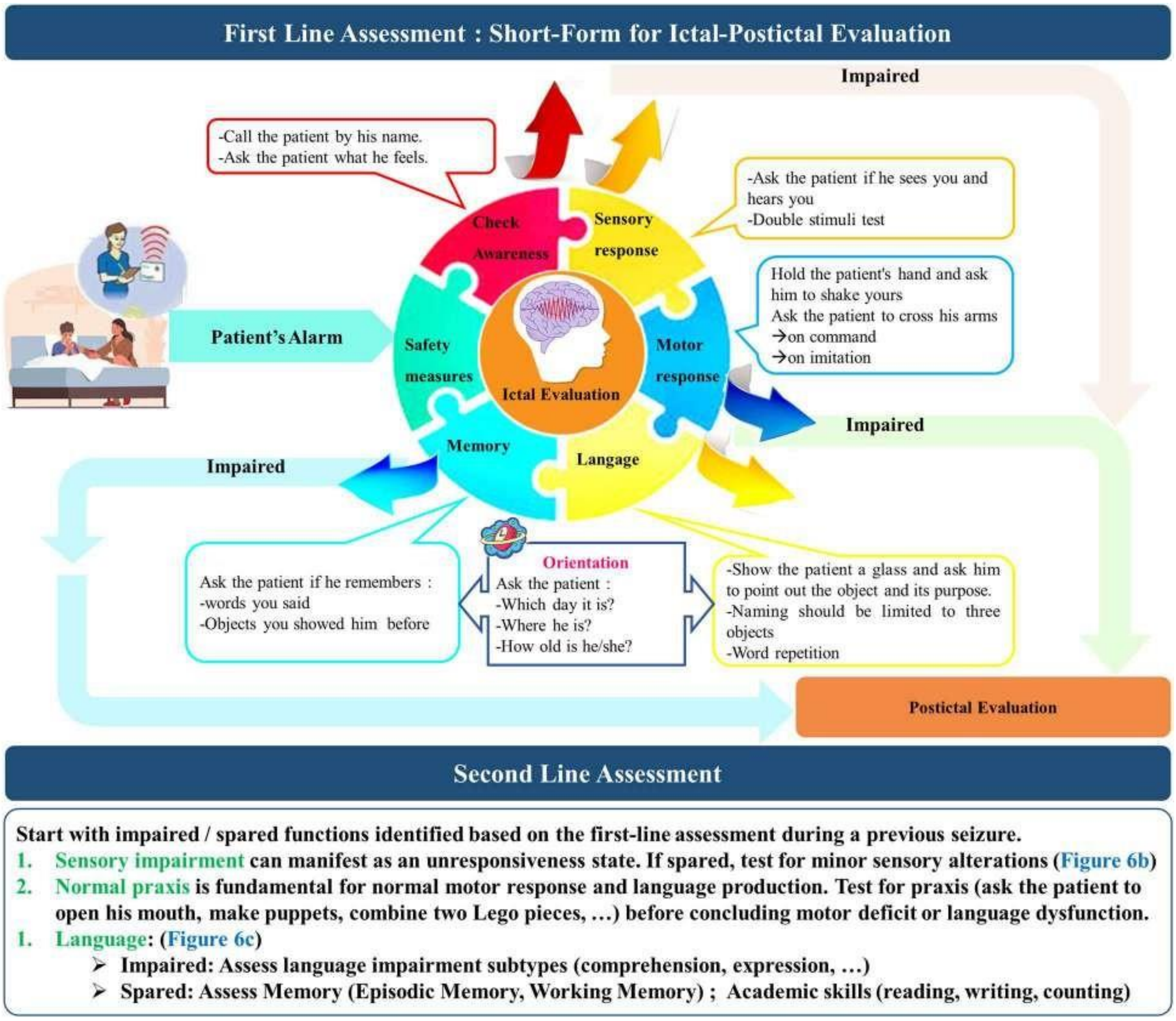
-Video monitoring in a well-lit room (and as possible an alarm agent/system) is highly recommended as it allows:

1. Improve the timely attendance of patients during seizures and so earlier safety measures
2. Record seizure semiology, including motor and non-motor features (facial expression, speech prosody, some autonomic features such as skin color, sweating…).
3. Record the emotional (facial expression, Laugh, cry, …); behavioural aspects (stereotypies, agitation, …) during seizures

-Training the health care staff on safety measures and the different mini-tests of ictal-postictal testing examination.

-Training patients' caregivers on safety measures and the short form of ictal-postictal testing for outpatient monitoring.

-For interictal evaluation, it would be more suitable to adopt an exhaustive approach based on adapted tests previously validated for epilepsy (Al-Joudi et al., 2019; Vogt et al., 2017).



First Line Assessment : Short-Form for Ictal-Postictal Evaluation
Impaired
-Call the patient by his name.
-Ask the patient what he feels.
-Ask the patient if he sees you and hears you
-Double stimuli test
Check Awareness
Sensory response
Hold the patient's hand and ask him to shake yours
Ask the patient to cross his arms
→on command
→on imitation
Patient's Alarm
Safety measures
Ictal Evaluation
Motor response
Impaired
Memory
Langage
Impaired
Orientation
Ask the patient :
-Which day it is?
-Where he is?
-How old is he/she?
Ask the patient if he remembers :
-words you said
-Objects you showed him before
-Show the patient a glass and ask him to point out the object and its purpose.
-Naming should be limited to three objects
-Word repetition
Postictal Evaluation
Second Line Assessment
Start with impaired / spared functions identified based on the first-line assessment during a previous seizure.
1. Sensory impairment can manifest as an unresponsiveness state. If spared, test for minor sensory alterations (Figure 6b)
2. Normal praxis is fundamental for normal motor response and language production. Test for praxis (ask the patient to open his mouth, make puppets, combine two Lego pieces, …) before concluding motor deficit or language dysfunction.
1. Language: (Figure 6c)
Impaired: Assess language impairment subtypes (comprehension, expression, …)
Spared: Assess Memory (Episodic Memory, Working Memory) ; Academic skills (reading, writing, counting)

(a)

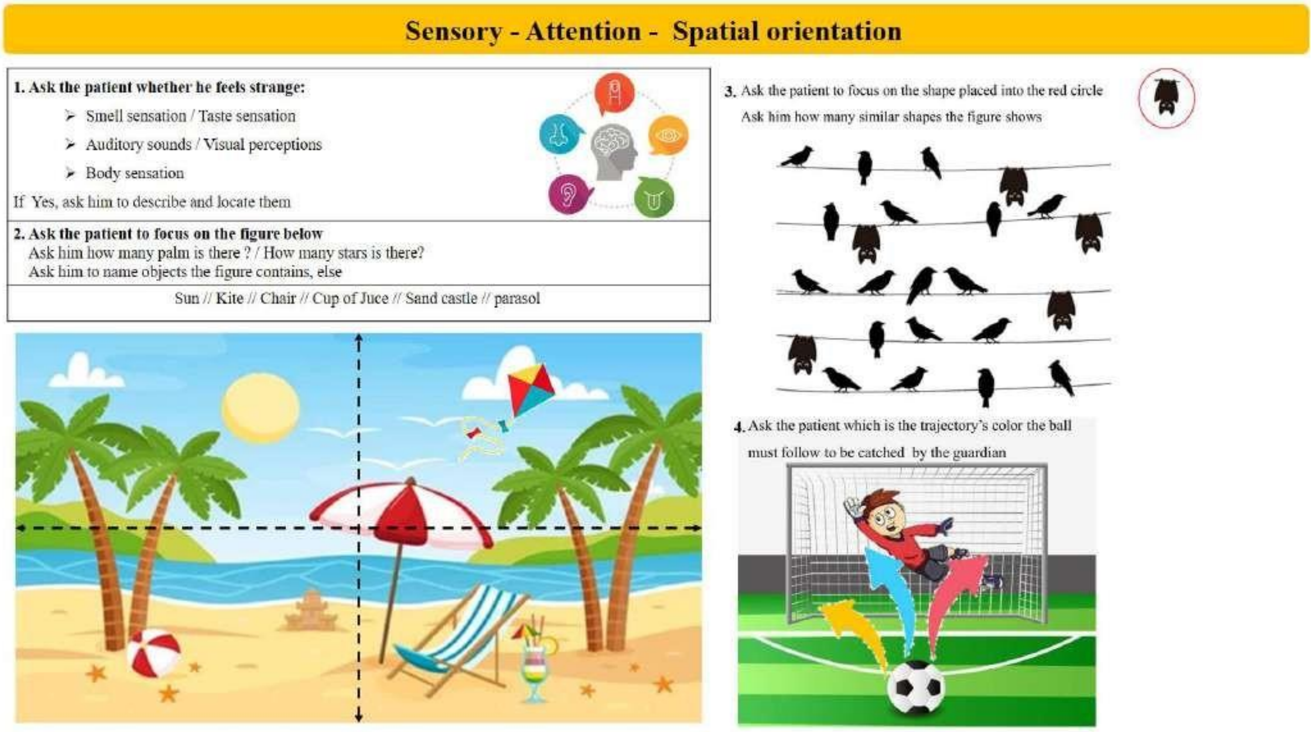


Figure 6b: the figure illustrates items used to test sensory skills (item 1), Attention (item 3, 4), and spatial orientation (item 4)

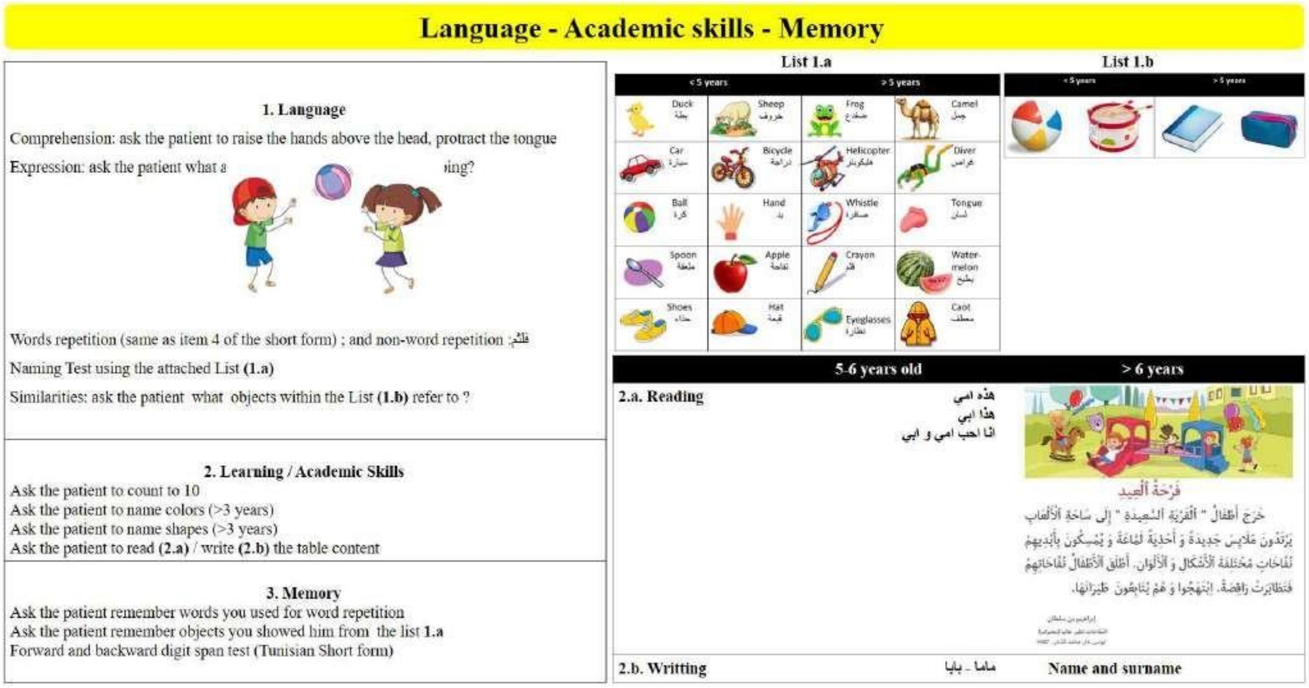


Figure 6c: the figure illustrates items used to test Language (item 1), Academic skills (item 2), and Memory (item 3)

(b)
(c)

Figure 6. The figure shows the revised approach for ictal and postictal assessment in patients with epilepsy. Panel (a) explain the choice of the second line mini-tests for domain-specific assessment. Panel (b) illustrates items used to evaluate sensory skills, attention and spatial orientation. Panel (c) illustrates items used to evaluate language, academic skills and memory.

4.5. Study Limitations:

The main limitation of our study consisted of focusing on the cognitive aspect, regardless of the factors that quietly affect cognitive function in children with epilepsy. It is hence important to note that diverse cognitive dysfunctions were reported in patients with epilepsy. This discordance is attributed to differences in the studied population range of age, origin, comorbid conditions, epileptic syndrome and aetiology, disease duration, management protocol, and seizure control (Andres M. Kanner, 2020; Auvin, 2022; Cao & Perfetti, 2016; Coste-Zeitoun et al., 2009; Longcamp et al., 2016; Novak et al., 2022). Epileptic activity was thought to trigger rapid cognitive deterioration responsible for epileptic encephalopathy for a long time. Further, longitudinal studies will be needed to answer the raised question of whether epilepsy is a neurodevelopmental disorder resulting from an ongoing process interfering with the normal maturation of cognitive function in children with epilepsy (Auvin, 2022; Bozzi et al., 2012).

5. CONCLUSIONS

The present project enabled us to set up our appropriate ictal examination protocol, respecting the principles of timely patient assistance, priority to patient safety, reducing the time required to administer the examination, and including comprehensive items relevant to non-motor symptoms assessment. Our proposed protocol takes advantage of the present study findings and provides an important basis for future innovation in ictal examination assessment. Further, analysis of collected results highlights the role of bivalent practical learning integrating medical practice learning within research protocols in improving medical professional skills, the efficiency of clinical examinations and patient care. Such approach also allowed through understanding the difficulties of translating theory into reality, the optimization of the use and application of resources (procedures, tests, examination maneuvers, etc.).

REFERENCES

1) Alim-Marvasti, A., Romagnoli, G., Dahele, K., Modarres, H., Pérez-García, F., Sparks, R., Ourselin, S., Clarkson, M. J., Chowdhury, F., Diehl, B., & Duncan, J. S. (2022). Probabilistic landscape of seizure semiology localizing values. Brain Communications, 4(3), fcac130. https://doi.org/10.1093/braincomms/fcac130
2) Al-Joudi, H. F., Mincari, L., Baz, S., Nester, M., Al-Marzouki, N., Abalkhail, T., Aljehani, N., Al-Ibrahim, C., & Brandt, J. (2019). Standardization of an Arabic-Language Neuropsychological Battery for Epilepsy Surgical Evaluations. Journal of the International Neuropsychological Society, 25(7), 761–771. https://doi.org/10.1017/S1355617719000432
3) Andres M. Kanner. (2020). Cognitive disorders in epilepsy I: Clinical experience, real-world evidence and recommendations. Seizure, 83, 216–222. https://doi.org/10.1016/j.seizure.2020.10.009
4) Auvin, S. (2022). Paediatric epilepsy and cognition. Developmental Medicine & Child Neurology, 64(12), 1444–1452. https://doi.org/10.1111/dmcn.15337
5) Beniczky, S., Neufeld, M., Diehl, B., Dobesberger, J., Trinka, E., Mameniskiene, R., Rheims, S., Gil-Nagel, A., Craiu, D., Pressler, R., Krysl, D., Lebedinsky, A., Tassi, L., Rubboli, G., & Ryvlin, P. (2016). Testing patients during seizures: A European consensus procedure developed by a joint taskforce of the ILAE - Commission on European Affairs and the European Epilepsy Monitoring Unit Association. Epilepsia, 57(9), 1363–1368. https://doi.org/10.1111/epi.13472
6) Bozzi, Y., Casarosa, S., & Caleo, M. (2012). Epilepsy as a Neurodevelopmental Disorder. Frontiers in Psychiatry, 3. https://doi.org/10.3389/fpsyt.2012.00019
7) Cao, F., & Perfetti, C. (2016). Neural Signatures of the Reading-Writing Connection: Greater Involvement of Writing in Chinese Reading than English Reading. PLOS ONE, 11, e0168414. https://doi.org/10.1371/journal.pone.0168414
8) Chen, Z., Brodie, M. J., Ding, D., & Kwan, P. (2023). Editorial: Epidemiology of epilepsy and seizures. Frontiers in Epidemiology3. https://doi.org/10.3389/fepid.2023.1273163
9) Christopher A. Blackwood, Jean Lud Cadet. The molecular neurobiology and neuropathology of opioid use disorder. (2021). Current Research in Neurobiology, 2, 100023. https://doi.org/10.1016/j.crneur.2021.100023
10) Coste-Zeitoun, D., Bennoun, I., & Clément, M.-C. (2009). Les conséquences cognitives et comportementales de l'épilepsie chez l'enfant: Expérience du Sessad l'Essor. Neuropsychiatrie de l'Enfance et de l'Adolescence, 57(1), 85–90. https://doi.org/10.1016/j.neurenf.2008.11.008
11) Csaba Juhász. (2020). Utility of MRI, PET, and ictal SPECT in presurgical evaluation of non-lesional pediatric epilepsy. Seizure, 77, 15–28. https://doi.org/10.1016/j.seizure.2019.05.008
12) Hamandi, K., Beniczky, S., Diehl, B., Kandler, R. H., Pressler, R. M., Sen, A., Solomon, J., Walker, M. C., Bagary, M., & with ILAE British Chapter Workshop Attendees. (2017). Current practice and recommendations in UK epilepsy monitoring units. Report of a national survey and workshop. Seizure, 50, 92–98. https://doi.org/10.1016/j.seizure.2017.06.015
13) Jose Gallucci-Neto. (2021). Ictal SPECT in Psychogenic Nonepileptic and Epileptic Seizures. Journal of the Academy of ConsultationLiaison Psychiatry, 62(1), 29–37. https://doi.org/10.1016/j.psym.2020.05.016
14) Kandler, R., Lai, M., Ponnusamy, A., Bland, J., & Pang, C. (2013). The safety of UK video telemetry units: Results of a national service evaluation. Seizure, 22(10), 872–876. https://doi.org/10.1016/j.seizure.2013.08.001

15) Kinney, M. O., Kovac, S., & Diehl, B. (2019). Structured testing during seizures: A practical guide for assessing and interpreting ictal and postictal signs during video EEG long term monitoring. Seizure, 72, 13–22. https://doi.org/10.1016/j.seizure.2019.08.008
16) Koepp, M. J., Diehl, B., & Woermann, F. G. (2010). Functional neuroimaging in the postictal state. Epilepsy & Behavior, 19(2), 127– 130. https://doi.org/10.1016/j.yebeh.2010.06.036
17) Longcamp, M., Velay, J., Berninger, V. W., & Richards, T. (2016). Neuroanatomy of Handwriting and Related Reading and Writing
18) Skills in Adults and Children with and without Learning Disabilities: French-American Connections. Pratiques. Linguistique, Littérature, Didactique, 171–172, Article 171–172. https://doi.org/10.4000/pratiques.3175
19) Majerus, S. (2013). Language repetition and short-term memory: An integrative framework. Frontiers in Human Neuroscience, 7, 357. https://doi.org/10.3389/fnhum.2013.00357
20) L. Vaugier, S. Aubert, A. McGonigal, A. Trébuchon, M. Guye, M. Gavaret, J. Regis, P. Chauvel, F. Wendling, F. Bartolomei. Neural networks underlying hyperkinetic seizures of "temporal lobe" origin. (2009). Epilepsy Research, 86(2–3), 200–208. https://doi.org/10.1016/j.eplepsyres.2009.06.007
21) Novak, A., Vizjak, K., & Rakusa, M. (2022). Cognitive Impairment in People with Epilepsy. Journal of Clinical Medicine, 11(1), 267. https://doi.org/10.3390/jcm11010267
22) O'Kula, S. S., Faillace, L., Kulick-Soper, C. V., Reyes-Esteves, S., Raab, J., Davis, K. A., Kheder, A., & Hill, C. E. (2021). Developing and Implementing a Standardized Ictal Examination in the Epilepsy Monitoring Unit. Neurology: Clinical Practice, 11(2), 127–133. https://doi.org/10.1212/CPJ.0000000000000815
23) Olive, G., Peñaloza, C., Vaquero, L., Laine, M., Martin, N., & Rodriguez-Fornells, A. (2023). The right uncinate fasciculus supports verbal short-term memory in aphasia. Brain Structure and Function, 228, 1–19. https://doi.org/10.1007/s00429-023-02628-9
24) Peciña, M., Karp, J. F., Mathew, S., Todtenkopf, M. S., Ehrich, E. W., & Zubieta, J.-K. (2019). Endogenous opioid system dysregulation in depression: Implications for new therapeutic approaches. Molecular Psychiatry, 24(4), 576–587. https://doi.org/10.1038/s41380-018-0117-2
25) Robert S Fisher et al., ILAE official report: a practical clinical definition of epilepsy. Epilepsia. 2014 Apr;55(4):475-82. doi: 10.1111/epi.12550. Epub 2014 Apr 14
26) Robert S Fisher et al. The New Classification of Seizures by the International League Against Epilepsy 2017. Curr Neurol Neurosci Rep. 2017 Jun;17(6):48. doi: 10.1007/s11910-017-0758-6
27) Sándor Beniczky et al. Updated classification of epileptic seizures: Position paper of the International League Against Epilepsy. Epilepsia. 2025;66:1804–1823
28) Shasha Wu, Douglas R. Nordli. Tonic Seizure—An overview | ScienceDirect Topics. (n.d.). Handbook of clinical neurology, 2023. https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/tonic-seizure
29) Vogt, V. L., Äikiä, M., Del Barrio, A., Boon, P., Borbély, C., Bran, E., Braun, K., Carette, E., Clark, M., Cross, J. H., Dimova, P., Fabo, D., Foroglou, N., Francione, S., Gersamia, A., Gil-Nagel, A., Guekht, A., Harrison, S., Hecimovic, H., … E-PILEPSY consortium. (2017). Current standards of neuropsychological assessment in epilepsy surgery centers across Europe. Epilepsia, 58(3), 343–355. https://doi.org/10.1111/epi.13646
30) Wang, X., Hu, W., Zhang, K., Shao, X., Ma, Y., Sang, L., Zheng, Z., Zhang, C., Li, J., & Zhang, J. (2018). The Anatomo-Electrical Network Underlying Hypermotor Seizures. Frontiers in Neurology, 9. https://doi.org/10.3389/fneur.2018.00243