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# Expanding the International Classification of Seizures to provide localization information

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In 1981, the International League Against Epilepsy took a bold step by introducing a greatly simplified seizure classification, which subsequently became the universally accepted International Classification of Epileptic Seizures (ICES). This classification employs a double dichotomy that divides the seizures into generalized and partial seizures on one side, and further subdivides the partial seizures into "complex" and "simple" partial seizures depending on whether consciousness is lost (or altered) or preserved during the ictal event. For practical reasons, patients who were amnestic for the events occurring during the seizure are also considered to have suffered an ictal loss (or at least a significant alteration) of consciousness, and are therefore classified as having had a "complex" partial seizure.[1] Compared with the older classification, which focused on the highly variable seizure symptomatology, the ICES represented a major simplification that permitted correct classification of seizures even by nonexperts.

For pharmacologic treatment decisions, the dichotomies "generalized-versus-partial" and "simple-versus-complex" actually provide the most essential information regarding the drugs to select. Since partial seizures tend to respond more or less equally well to the same group of anticonvulsants *independent of the site of origin of the seizure,*[2] no detailed subdivision of partial seizures is necessary. On the other hand, generalized seizures tend to require different pharmacologic treatments depending on the type of generalized seizure.[2] Note that the ICES clearly differentiates between different types of generalized seizures that respond preferentially to one or another type of treatment[2] (for example, generalized tonic-clonic seizures versus absence seizures), but does not distinguish complex partial seizures arising from different locations (for example, psychomotor seizures arising from the temporal lobe and tonic seizures with loss of consciousness arising from the supplementary motor area).

The subdivision of partial seizures into "simple" and "complex" additionally emphasizes an essential characteristic that in many cases has significant repercussions on the quality of life of the epileptic patient. Specifically, most partial seizures without loss of consciousness have only a minor impact on the patient's quality of life, whereas partial seizures with loss of consciousness markedly disturb the patient's life. Therefore, when evaluating the success of a treatment, it is extremely important to carefully analyze the impact from the standpoint of seizure type—ie, a decrease of complex partial seizures (whose abundance tends to directly affect the quality of life) is far more meaningful than a change in the frequency of simple partial seizures (which will have little effect on the quality of life).

These considerations explain why the ICES has been almost universally accepted by epileptologists around the world: (1) simplicity irrespective of exact symptomatology, (2) correlation to optimal drug therapy, and (3) relationship to quality of life. However, the ICES has been less popular with neurologists evaluating epileptic patients for surgery. For characterizing focal seizures, many actually continue using one of the classic seizure classification systems, which stress seizure symptomatology as opposed to focusing on preservation or alteration of consciousness. Seizure symptomatology gives us important clues to the localization of the ictal onset zone and indirectly to the epileptogenic zone.[3] Important information that can be used to localize the seizure onset zone is neglected by classifying partial seizures into merely simple and complex.

Because of these shortcomings, it is logical to propose a special seizure classification for those interested in using seizure symptomatology as an important index of localization of the epileptogenic zone. Such a classification would differ fundamentally from the current ICES. In the following paragraphs, we will outline the limitations of the cur-

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rent ICES when applied for localization purposes and then present a proposal for a seizure classification that we feel is ideally suited for epilepsy centers whose primary interest is epilepsy surgery. The proposed classification, based on the wealth of localizing information contained in the seizure symptomatology, may also be of interest to the general neurologist interested in the localizing information provided by a careful analysis of seizure symptomatology. Details of this classification, which has been applied successfully at the Cleveland Clinic Epilepsy Program for the last 5 years, will be published elsewhere.

**Disadvantages of the International Classification of Epileptic Seizures when applied for localizing purposes.** *I. Misplaced emphasis on the main dichotomies, partial-versus-generalized and simple-versus-complex.* In the ICES, the seizures are first classified as generalized or partial; if partial, they are again subclassified as either simple or complex, depending on whether consciousness is altered (or lost) or maintained during the seizure. Unfortunately, it is not always possible to determine with precision if the seizure was generalized or partial, or if the consciousness was altered or lost during the seizure, without the detailed analysis usually provided only by a prolonged video/EEG study. This precise analysis is possible only in very selected cases, and certainly does not apply to the majority of epileptic patients. However, in the current ICES, all seizures that cannot be identified as generalized or partial are labeled "unclassified," and all partial seizures in which consciousness cannot be accurately determined are not classified further.

Selected examples clarify this point. Episodes of selective loss of consciousness with no motor manifestations can be classified only if we know whether the seizure discharge during the episodes was generalized or partial. Otherwise, the episodes must be labeled "unclassified seizures" even if we have detailed information about the symptomatology during the seizures. The same is true for convulsive episodes, where we have detailed information about the motor symptomatology during the seizure, but the available evidence does not permit us to classify the seizure as generalized or partial. The typical example is of tonic seizures affecting limbs bilaterally, which can be the result of either generalized or localized seizure discharges (supplementary motor area). This shortcoming of the ICES can be resolved by focusing primarily on seizure symptomatology and only secondarily on the dichotomy specified above. By analyzing only seizure manifestations, the two examples presented above could be designated absence seizures in the first case and clonic, tonic, tonic-clonic, myoclonic or, in a more nonspecific way, motor seizures in the second case. This certainly provides significantly more information than the label "unclassified seizures" used by the ICES. In a study of epileptics performed in a nontertiary referral center, 23.3% of the epilepsies were unclassifiable because it was not possible to define whether they had generalized or focal seizures even though the observers involved other important information about the seizure symptomatology itself in many cases.[4]

The division of partial seizures into simple partial seizures and complex partial seizures depending on whether alteration or loss of consciousness occurs clearly establishes the priorities of seizure symptomatology, assigning top priority to alteration or loss of consciousness. This has the disadvantage (see below under Unwieldy Terminology) that the rest of the seizure symptomatology, which for localizing purposes contains the more important information, tends to be neglected. For simple partial seizures, the rest of the symptomatology is indicated only as a secondary characteristic. For example, visual auras are classified as simple partial seizures with visual symptomatology. Moreover, seizures with loss of consciousness are subclassified into only two subgroups in the ICES, namely, complex partial seizures with impairment of consciousness only and complex partial seizures with automatisms. The ICES provides no option for specifying other symptomatology that frequently occurs during the loss of consciousness. Therefore, for example, psychomotor seizures of temporal lobe origin and tonic seizures with loss of consciousness arising from the supplementary motor area would both be classified as complex partial seizures. This indicates only that the patient lost consciousness during the seizure but completely neglects the actual seizure symptomatology (automatisms in one case and bilateral tonic posturing in the other), which provides extremely important clues for defining the seizure origins.

*II. Unwieldy terminology.* For epileptologists interested primarily in defining the exact localization of the epileptogenic zone, the dichotomy of complex-versus-simple partial seizures not only overemphasizes the importance of the loss or alteration of consciousness but also produces verbose terminology, too cumbersome for colloquial use without abbreviation. For example, a left visual aura would be labeled a "simple partial seizure with visual symptomatology," and a left hand clonic seizure would be labeled a "simple partial seizure with clonic symptomatology" (assuming no alteration or loss of consciousness during the seizure). Notice also that not only is the ICES classification significantly longer, but it also contains less precise definition of the seizure type due to the absence of information about the lateralization or the somatotopic distribution of the symptomatology. The verbosity of the ICES has led to the common use of abbreviated forms in which partial seizures are specified simply by the expressions "simple partial seizure" or "complex partial seizure." Frequently, however, epileptologists or neurologists are unaware of the imprecision of the terminology they

are using. By definition, a simple partial seizure refers to all partial seizures during which consciousness is not altered, and therefore includes all the different types of auras as well as all the different types of motor seizures without impairment of consciousness. Through this classification, any indication regarding the origin of the seizure is lost, since seizures without loss of consciousness can originate from any part of the brain. This includes even psychomotor seizures originating from the mesial temporal lobe, which are occasionally unaccompanied by alteration of consciousness.[5] The same drawback applies to complex partial seizures; moreover, as mentioned above, the ICES does not provide any mechanism to define the symptomatology during the loss of consciousness. For example, the classification of both a right clonic seizure (during which there was an alteration or loss of consciousness) and a psychomotor seizure (with an alteration or loss of consciousness) as complex partial seizures neglects all the other associated symptomatology that gives us essential clues about the origin of the seizure.

Everyday use of the ICES has also led to the common belief that the classic expression "psychomotor seizures" is a synonym for "complex partial seizures," which is not correct. Although most psychomotor seizures are associated with variable degrees of alteration of consciousness, there are well-documented exceptions.[5] More significantly, as already mentioned, there are many other types of seizures (without psychomotor symptomatology) that may be associated with loss of consciousness. For these seizures also, the ICES classification conceals important information helpful in localizing the origin of the seizures. For example, a right clonic seizure with loss of consciousness would suggest a left dorsolateral frontal seizure origin, a focal tonic seizure associated with a loss of consciousness would suggest a seizure origin in the supplementary motor area, and a psychomotor seizure with loss of consciousness would point primarily to a temporal lobe origin.

*III. Omission of lateralizing or somatotopic information.* The clinical manifestations of many seizures may contain valuable lateralizing or somatotopic information. For example, we may have left or right visual auras and we may have left or right motor seizures. This lateralizing information clearly specifying the hemisphere from which the seizures originate cannot be specified in the ICES. Other seizures may include even more precise localizing information that cannot be defined in the ICES. For example, left-hand somatosensory auras point to a seizure origin in the neighborhood of the right somatosensory hand region.

*IV. Inadequately specified seizure evolutions.* Specification of seizure progression under the ICES is permitted only in limited circumstances, namely, the evolution from simple partial seizures to complex partial seizures and in turn to generalized tonic-clonic seizures, or the evolution from a simple partial seizure to generalized tonic-clonic seizures. Seizure evolutions can be significantly more complex, and there is essential localizing information to be gained from better specifying the seizure evolution; for example, a left visual aura may evolve into a left hand somatosensory aura. This evolution clearly suggests that the seizure originated in the neighborhood of the right area 17[6] and then spread to the right hand somatosensory region. Such an evolution of a simple partial seizure to another type of simple partial seizure has not been considered in the ICES. Even attempting to specify it would lead to a ponderous and inconvenient expression: "simple partial seizure with visual symptomatology evolving into a simple partial seizure with somatosensory symptomatology."

Since the ICES allows for only one type of partial seizure associated with alteration or loss of consciousness, it fails to consider the frequent occurrence of different types of complex partial seizures in sequence. For example, a patient who suffers a psychomotor seizure that then evolves into a right face clonic seizure would simply be classified as having a "complex partial seizure," neglecting essential information provided by the seizure symptomatology during the loss of consciousness. The seizure symptomatology occurring while the patient was unconscious clearly suggests that the seizure discharge originates from the left temporal lobe and then spreads to involve the left face motor region. The ICES expression, "complex partial seizure," indicates only impairment of consciousness during a partial seizure without giving any clue to the origin or spread of the seizure, and it depends on the statistically high association of complex partial seizures with psychomotor seizures to link it with a probable temporal lobe origin. Likewise, the ICES fails to mention the not so infrequent evolution from one type of generalized seizure into another type of generalized seizure. A typical occurrence is the evolution from generalized myoclonic seizures to generalized tonic-clonic seizures in patients with juvenile myoclonic epilepsy, or the evolution from absence seizures to generalized tonic-clonic seizures in patients with classic petit mal epilepsy.[7] In addition, we have observed isolated cases wherein generalized seizures evolve into focal seizures, another possible evolution not considered by the ICES.

The expression "simple partial seizure evolving into complex partial seizure" provides very limited information because it does not specify the precise symptomatology associated with the "simple partial" or "complex partial" seizure. This expression means only that the patient had a partial seizure during which consciousness was initially preserved and subsequently lost. Following are a few examples of simple partial seizures that evolve into complex partial seizures, showing the variety of seizures that demonstrate such an evolution (the arrow indicates seizure evolution): (1) left visual aura → psychomotor seizure, (2) abdominal area →

psychomotor seizure, (3) left hand clonic seizure → left body clonic seizure, and (4) tonic seizure → left face clonic seizure.

*V. Dependence on EEG abnormalities in addition to seizure symptomatology.* The ICES seizure classification takes into account the EEG findings, which has the disadvantage that a seizure can be classified accurately only if the corresponding EEG is available. For example, an episode of pure loss of consciousness would be classified as an absence seizure if it was associated with generalized 3-Hz spike-and-wave discharges but as a "complex partial seizure" if a focal seizure discharge was present. EEG recordings of seizures are, however, available in only a minority of patients.

The ICES classification does not indicate whether the seizure classification is based exclusively on seizure symptomatology or on the results of ancillary testing as well. For example, episodes of loss of consciousness in a patient with a known right temporal lobe tumor would not be classified as absence seizures (even if no EEG had been obtained) because it is more likely that such a patient had a focal right temporal epilepsy. In other words, the whole clinical picture frequently influences the terminology the ICES uses to identify a seizure type.

A seizure classification based exclusively on seizure symptomatology would have major advantages. First, it would always be clear that the only information taken into consideration when classifying a seizure was the seizure symptomatology. Different seizure types could be correlated as independent variables with all the other test results, including EEG. The value of the seizure symptomatology (again, independently from all other tests) for localization of different epileptogenic zones could be firmly established. This is particularly important for patients being evaluated for epilepsy surgery, in whom the convergence of independent tests is an essential index for accurate localization.

*VI. Nonstandard meaning of the terms "complex" and "simple."* As discussed above, the subdivision of partial seizures into "complex" versus "simple" depends only on whether consciousness was lost or altered during the seizure. In this context, a seizure with symptomatology of high complexity (for example, a tonic seizure from the supplementary motor area with an epileptic cry and violent proximal arm and leg movements but no loss of consciousness) would be labeled a "simple partial seizure," whereas other less complex seizures (characterized only by loss of consciousness, with essentially no motor symptomatology) would be labeled "complex partial seizures." Here the word "complex" certainly does not refer to what we usually understand as complex, namely, made up of many elaborately interrelated or interconnected parts.

**Proposal for a seizure classification more appropriate for localization purposes.** The acceptability of the ICES by epileptologists is probably related to its simplicity and suitability for epilepsy centers interested primarily in medical treatment of chronic epileptic patients. There is now, however, a need for a different classification scheme that takes into account the special requirements of epilepsy surgery centers. The classification scheme outlined below closely resembles some of the classic seizure classifications based primarily on detailed observation of the seizure symptomatology, unbiased by other test results (which were frequently unavailable at that time). Before the era of neuroimaging and other neurotesting (including EEG), the clinician depended on skillful assimilation of all available semiologic information to define the exact location of the brain lesion. For this reason, these classic seizure classifications contain a wealth of information that is extremely useful today for the clinician interested in using seizure semiology for localization purposes. The following seizure classification, which has been used extensively at selected epilepsy programs, addresses all the concerns expressed above, and seems ideally suited for use in epilepsy surgery programs.

### Seizure classification

1. Auras: (a) somatosensory aura; (b) visual aura; (c) olfactory aura; (d) gustatory aura; (e) auditory aura; (f) psychic aura; (g) autonomic aura; (h) abdominal aura
2. Absence seizure
3. Psychomotor seizure
4. Hypermotor seizure
5. Motor seizures: (a) myoclonic seizure; (b) clonic seizure; (c) tonic seizure; (d) tonic-clonic seizure; (e) atonic seizure; (f) versive seizure
6. Unclassified epileptic seizure
7. Unclassified event

The following can be applied to the above seizures:

- *Modifiers* to be used preceding the seizure type: (indicate portion of the body participating in the seizure symptomatology): *(i)* generalized; *(ii)* left; *(iii)* right; *(iv)* somatotopic: face, hand, arm, foot, leg
- *Evolution*. Arrow (→) linking two seizure types indicates seizure evolution (a detailed description of this seizure classification will be published elsewhere)

Following are some examples of how this seizure classification can be used to characterize selected seizures. The corresponding ICES is also given.

1. Abdominal aura → psychomotor seizure.

ICES: simple partial seizure with autonomic symptomatology evolving into a complex partial seizure.

2. Left visual aura → left hand clonic seizure → generalized tonic-clonic seizure.

ICES: if the patient loses consciousness during the left clonic hand seizure—simple partial seizure with visual symptomatology evolving into complex

partial seizure and then into a generalized tonic-clonic seizure.

3. Tonic seizure → left face clonic seizure → generalized tonic-clonic seizure.

ICES: if the patient loses consciousness during the left face clonic seizure—simple partial seizure with postural signs evolving into complex partial seizure and then into a generalized tonic-clonic seizure.

4. Gustatory aura → psychomotor seizure → left versive seizure → generalized tonic-clonic seizure.

ICES: Simple partial seizure with gustatory symptomatology evolving into complex partial seizure and then into a generalized tonic-clonic seizure.

Notice that the last three seizures, although of very different semiology, are classified almost identically in the ICES (except for the modifier for the simple partial seizure). The critical differences between these seizures, concealed by the ICES, are what provide the greatest help in localizing and lateralizing seizure onset and seizure spread accurately.

**Is the proposed seizure classification addressing the identified disadvantages of the ICES?** *Misplaced emphasis on the dichotomies "generalized-versus-partial" and "complex-versus-simple."* The dichotomy "generalized-versus-partial" has been eliminated. Observers can avoid using any localizing or lateralizing modifier if they feel that the seizure semiology does not provide sufficient information. In those cases, where they are unable to define from seizure semiology alone whether the seizure is of partial or generalized origin, they can still provide detailed information about the main seizure semiology (eg, absence seizures, myoclonic seizures, and so forth). Since the presence or absence of consciousness is just another symptom of a seizure and does not overshadow the associated symptomatology, the dichotomy "simple" versus "complex" seizures has also been eliminated. Partial seizures with loss of consciousness can still be classified in detail, characterizing the rich semiology many of them show. For example, psychomotor seizures and focal motor seizures (both associated with loss of consciousness) can be clearly separated rather than lumped together as in the ICES, where both would be classified as "complex partial seizures."

*Unwieldy terminology.* In the proposed classification outlined above, special attention was paid to reducing the length of the terminology to a minimum, using classic terminology. For most neurologists (or epileptologists), this familiar terminology is easily understood and describes relatively complex seizure semiology in the most abbreviated form. The typical example is the expression "aura," which points to a specific subgroup of "simple partial seizures." The reintroduction of this term permits easy identification of this subgroup and greatly simplifies seizure terminology. Note that the expression "left visual aura" is not only significantly abbreviated as compared with the corresponding expression in the ICES ("simple partial seizure with visual symptomatology") but also more precise because it contains the corresponding lateralizing modifier. A similar strategy was used when choosing the appropriate terminology to identify the other types of seizures. The terminology was also selected with a view to its suitability for colloquial use. Simplification of the terminology is particularly important when describing the evolution of seizures, which occasionally may be rather complicated.

*Omission of lateralizing or somatotopic information.* Precise lateralizing, or, if appropriate, somatotopic information, can be defined in the seizure classification listed above. This added information can be extremely useful in selected cases, providing important additional localizing information.

*Inadequately specified seizure evolutions.* Experience has shown that seizure evolutions are extremely variable, with almost infinite permutations. To accommodate this variation, it is best to consider each seizure type a component, with seizure evolutions occurring from one component to the next.

*Dependence on EEG abnormalities in addition to seizure symptomatology.* The seizure classification listed above is based exclusively on seizure semiology. The results of ancillary tests, which directly or indirectly influence the categorization of seizures in the ICES, have no influence on the seizure classification presented here. This has the great advantage that we always know what information the observer considered when specifying a seizure type. It also leads to a more critical analysis of the seizure semiology independent of other test results.

The new system is, in part, contradictory to the existing ICES, and the clinician's current reliance on information beyond seizure semiology may initially produce some confusion. For example, under the present system, a patient with episodes of pure loss of consciousness will have a "complex partial seizure" if the associated EEG shows a focal discharge and an "absence seizure" if the EEG shows a 3-Hz spike-and-wave complex. In the proposed classification based exclusively on seizure symptomatology, the patient would have had an absence seizure, independent of EEG findings. Therefore, the epileptologist would again have to accept that absence seizures (as defined exclusively by symptomatology) can be produced by patients with petit mal epilepsy as well as by patients with focal epilepsies, such as temporal and frontal lobe epilepsies.

*Nonstandard meaning of the terms "complex" and "simple."* The seizure classification proposed here avoids using the expressions "simple" and "complex."

**Concluding remarks.** Our analysis began by discussing the advantages of the ICES when used by epileptologists primarily interested in (1) selecting the appropriate medical treatment and (2) evaluat-

ing the effect of the medication on the seizures. In this context, the ICES has certainly been a valuable contribution; it has facilitated the selection of antiepileptic drugs and greatly streamlined the evaluation of drug effectiveness. At the same time, additional work must further improve the usefulness of the ICES. This will not be discussed here, since criticizing the ICES as a tool for selecting and evaluating anticonvulsants is not the major emphasis of this manuscript.

The seizure classification proposed here represents a modification of the traditional seizure classification systems that were used by clinical neurologists when EEG and neuroimaging techniques were unavailable (or available only to a very limited degree) and seizure semiology was the primary tool for localization of a possible underlying structural lesion. The proposed seizure classification also tries to extract a maximum of clinically useful localizing information *exclusively* from seizure semiology independent of any other clinical information.

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