RESEARCH ARTICLE

Unrecognized Focal Nonmotor Seizures in Adolescents Presenting to Emergency Departments

Nora Jandhyala, BS, Monica Ferrer, MD, Jacob Pellinen, MD, Hadley T. Greenwood, BS, Dennis J. Dlugos, MD, MSCE, Kristen L. Park, MD, Liu Lin Thio, MD, PhD, and Jacqueline French, MD, for Human Epilepsy Project Investigators

Correspondence
Dr. French
jacqueline.french@nyulangone.org

Neurology® 2024;102:e209389. doi:10.1212/WNL.0000000000209389

Abstract

Background and Objectives

Many adolescents with undiagnosed focal epilepsy seek evaluation in emergency departments (EDs). Accurate history-taking is essential to prompt diagnosis and treatment. In this study, we investigated ED recognition of motor vs nonmotor seizures and its effect on management and treatment of focal epilepsy in adolescents.

Methods

This was a retrospective analysis of enrollment data from the Human Epilepsy Project (HEP), an international multi-institutional study that collected data from 34 sites between 2012 and 2017. Participants were 12 years or older, neurotypical, and within 4 months of treatment initiation for focal epilepsy. We used HEP enrollment medical records to review participants' initial diagnosis and management.

Results

A total of 83 adolescents were enrolled between 12 and 18 years. Fifty-eight (70%) presented to an ED before diagnosis of epilepsy. Although most ED presentations were for motor seizures (n = 52; 90%), many patients had a history of nonmotor seizures (20/52 or 38%). Adolescents with initial nonmotor seizures were less likely to present to EDs (26/44 or 59% vs 32/39 or 82%, $p = 0.02$), and nonmotor seizures were less likely to be correctly identified (2/6 or 33% vs 42/52 or 81%, $p = 0.008$). A history of initial nonmotor seizures was not recognized in any adolescent who presented for a first-lifetime motor seizure. As a result, initiation of treatment and admission from the ED was not more likely for these adolescents who met the definition of epilepsy compared with those with no seizure history. This lack of nonmotor seizure history recognition in the ED was greater than that observed in the adult group (0% vs 23%, $p = 0.03$) and occurred in both pediatric and nonpediatric ED settings.

Discussion

Our study supports growing evidence that nonmotor seizures are often undiagnosed, with many individuals coming to attention only after conversion to motor seizures. We found this treatment gap is exacerbated in the adolescent population. Our study highlights a critical need for physicians to inquire about the symptoms of nonmotor seizures, even when the presenting seizure is motor. Future interventions should focus on improving nonmotor seizure recognition for this population in EDs.

Introduction

Approximately 0.6% of the pediatric population in the United States has active epilepsy, which represents one of the most common chronic neurologic conditions in children.[1,2] Epileptic

From the Department of Neurology (N.J.), NYU Langone Health, New York; Departments of Pediatrics and Neurology (M.F.) and Neurology (H.T.G., J.F.), NYU Grossman School of Medicine, New York, NY; Departments of Neurology (J.P.) and Pediatrics and Neurology (K.L.P.), University of Colorado School of Medicine, Aurora; Department of Neurology (D.J.D.), Children's' Hospital of Philadelphia, PA; and Department of Neurology (L.L.T.), Washington University in St. Louis, MO.

Go to Neurology.org/N for full disclosures. Funding information and disclosures deemed relevant by the authors, if any, are provided at the end of the article.

Coinvestigators are listed at Neurology.org.

Glossary

ASM = antiseizure medication; **ED** = emergency department; **HEP** = Human Epilepsy Project; **ILAE** = International League Against Epilepsy.

seizures can result in injury and death, and delays in diagnosis of epilepsy have been linked to worse epilepsy outcomes, making early diagnosis of epilepsy of utmost importance.[3,4]

Characteristics of seizures at onset can vary greatly among individuals and play a role in seizure recognition. In fact, previous studies have noted that patients with initial nonmotor seizures have longer delays to diagnosis.[5] Nonmotor seizures present as subtle seizures without noticeable movements and may not be outwardly apparent (e.g., feeling of déjà vu, odd odors, or visual distortions); thus, identification of these seizures can be difficult for both family and providers. An additional challenge is presented by adolescent patients, who may be hesitant to verbalize internal experiences. If left untreated, these focal nonmotor seizures may progress to include motor features, potentially causing harm.[5] Despite a history of prior nonmotor seizures, many patients often delay evaluation until they have their first-lifetime motor seizure.

Emergency departments (EDs) are often the setting of an initial seizure evaluation; thus, EDs can serve as important sites of epilepsy recognition, neurology referral, and initiation of antiseizure medication (ASM). A detailed history and physical examination alone have been shown to yield diagnoses in approximately 85% of cases of suspected seizure.[5] Clinical history is of heightened importance in the context of suspected seizures, given that recognition of prior seizures can differentiate between a first-lifetime seizure vs recurrent unprovoked seizures indicating an epilepsy diagnosis. Furthermore, referral to neurology for consultation has been shown to significantly increase diagnostic certainty.[6] As such, recognition of epilepsy in pediatric and adolescent patients in EDs is a key area of intervention for earlier initiation of care. In this study, we investigated recognition of motor vs nonmotor seizures in the ED and its effect on management of focal epilepsy in adolescents.

Methods

Study Design

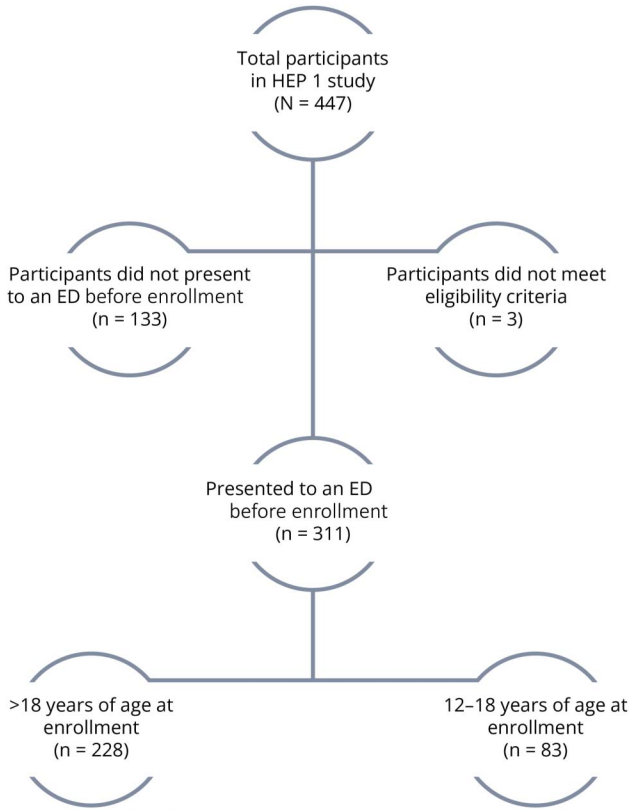
This study is a secondary analysis of data from the Human Epilepsy Project (HEP), an observational study of individuals with newly diagnosed and treated focal epilepsy. HEP was a multicenter prospective cohort study that collected data from 34 sites, including children's hospitals, across the United States, Canada, Austria, Finland, and Australia from June 2012 to November 2017. Participants enrolled were 12 years or older and within 4 months of treatment initiation for focal epilepsy. Exceptions were made for those near their 12th birthday. Age at seizure onset was also collected because patients may have been having seizures for varying durations before enrollment. All participants required a diagnosis of epilepsy confirmed by an epilepsy specialist to be enrolled. Participants met specific inclusion and exclusion criteria when enrolled in the HEP study, as reported in all investigations of the HEP database (Table 1).

A flow diagram illustrating the selection of participants from the overall HEP cohort for this study is shown in Figure 1. We evaluated participant records from the HEP database, including all participants who (1) presented to an ED before

Table 1 Inclusion and Exclusion Criteria Used for Participant Enrollment in Human Epilepsy Project

Inclusion criteria	Exclusion criteria
1. Clinical seizure(s) and history consistent with focal epilepsy 2. Age 12–60 y at the time of enrollment 3. At least 1 confirmed spontaneous seizure in the 12 mo before enrollment with one of the following 1. Normal MRI with interictal EEG showing focal abnormality 2. Normal MRI and normal interictal EEG, with clinical or electrographic seizure activity on ictal EEG 3. Focal lesion (nonprogressive) on MRI with normal EEG 4. Focal lesion (nonprogressive) on MRI with focal abnormality on EEG 5. If normal EEG and normal or no MRI, a second spontaneous seizure and adjudication required 4. Medical treatment (for seizures) instituted no more than 4 mo before enrollment 5. Complete medication history before enrollment	1. Epilepsy of presumed genetic origin or symptomatic generalized epilepsy 2. Mixed epilepsy syndromes 3. Any epilepsy etiology that could produce significant gliosis or brain injury and would be likely to alter biomarkers. These include traumatic brain injury that involves direct disruption of brain tissue, stroke, encephalitis, or intracranial hemorrhage 4. Identified genetic epilepsy syndrome: focal genetic epilepsy (may include only 1 participant per family) 5. Progressive neurologic disorder 6. Major medical comorbidities such as renal failure requiring dialysis, metastatic cancer, HIV, or significant liver or renal disease 7. Autism spectrum disorder 8. Presence of moderate or greater developmental or cognitive delay before seizure onset 9. History of chronic drug or alcohol abuse within the past 2 y 10. Antiseizure medication given for nonseizure indication at or above an antiseizure "target dose" and not stopped at least 5 half-lives before first seizure 11. Seizures only during pregnancy 12. History of previous or current significant psychiatric disorder that would interfere with conduct of the study

Figure 1 Flow Diagram Demonstrating the Selection of Participants in This Study



ED = emergency department; HEP = Human Epilepsy Project.

diagnosis of epilepsy, as indicated by their medical records, (2) were 18 years or younger of age at the time of enrollment. Using a similar approach to a prior study of adults presenting to EDs, we assessed the initial seizure semiology and the seizure type that prompted ED evaluation, stratifying by motor vs nonmotor seizures.[8] We then evaluated, using clinical notes, whether the presenting seizure type was correctly identified, and whether any prior seizures were identified at the time of ED visit. Next, we examined diagnosis of epilepsy, category of ED (pediatric vs nonpediatric), initiation of ASM, admission from the ED, and referral to neurologists.

Demographic data included age, sex, race, ethnicity, handedness, employment, age at seizure onset, age at enrollment, family history of seizures, and brain imaging abnormalities. Participants aged older than 18 years were included for comparisons with the adolescent cohort.

Seizure Semiology

Patients were categorized according to the International League Against Epilepsy (ILAE) seizure classification system.[9] Seizure characterization was determined by the DISCOVER form—a structured interview performed with each patient to determine seizure semiology.[10] A post hoc classification of seizures was performed using the DISCOVER form, seizure diaries, and medical records. Participants were classified by symptoms into nonmotor and motor groups. Focal motor seizures were defined as observable activity including tonic or clonic movements, extremity movements, vocalizations, or focal to bilateral tonic-clonic seizures. Focal nonmotor seizures were defined as those with only cognitive, sensory, or autonomic symptoms. Two epileptologists (J.F. and J.P.) independently classified seizures and were concordant in all cases. This was performed both for initial presenting seizure and for subsequent seizures.

The participants were assigned to a group based on the seizure semiology of their first-lifetime seizure that is, nonmotor onset and motor onset groups. The participants were then split into further groupings based on their presentation to the ED as follows: (1) whether they presented for a first-lifetime seizure or a recurrent seizure and (2) the semiology of the presenting seizure (Figure 2).

Seizure Recognition and Management

Medical records from enrollment were used to collect information on ED visits before diagnosis of epilepsy. Information gathered from records included whether presentation was for a first-lifetime seizure, whether the event was recognized as a seizure, and whether a history of prior seizures was recognized (if a patient had experienced other lifetime events). All ED seizures were reviewed to determine whether they were confirmed to be epileptic seizures by the HEP investigator at enrollment.

To evaluate management, information was also collected on whether patients were admitted from the ED, started on any ASM, and referred to neurology for further work-up. Recognition and management were then compared with the adult cohort by using this same information abstracted from the medical records of those aged older than 18 years.

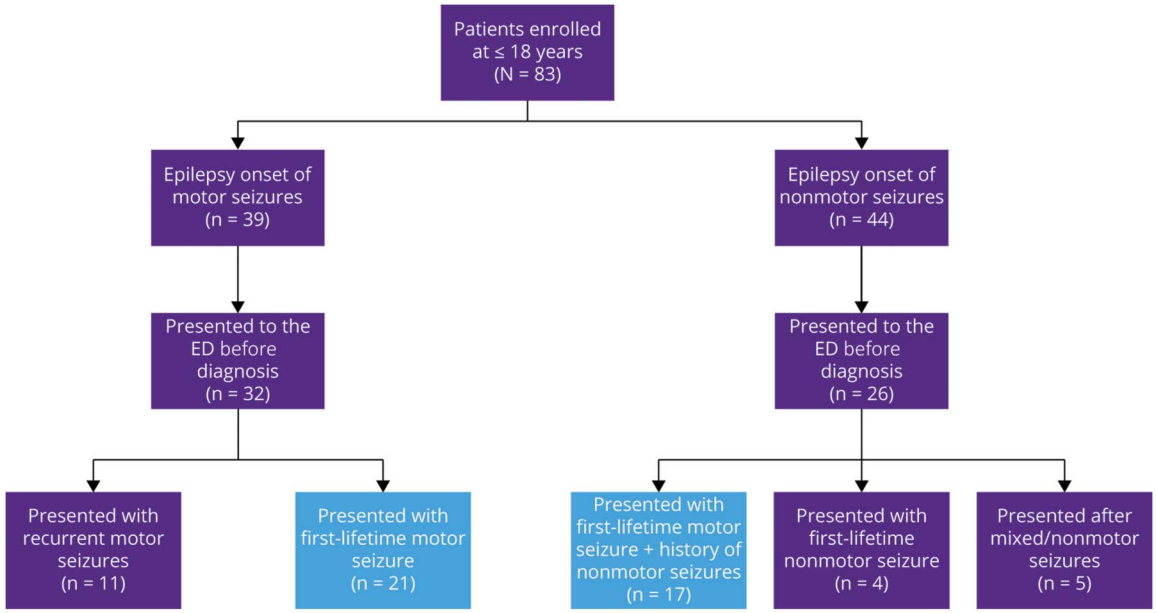
Statistical Analyses

SPSS version 26.0 was used to perform statistical analysis. Differences between participants presenting to the ED with a motor seizure as the first-lifetime seizure vs participants with a first-lifetime motor seizure and a history of prior nonmotor seizures were evaluated. Baseline demographics and clinical characteristics including seizure recognition, neurology referral, inpatient admission, and ASM initiation were described for both groups. Chi-squared, Mann-Whitney, and student t-test testing were used for demographic and clinical comparisons. Chi-squared was applied for categorical variables, student t-test for continuous variables that were normally distributed, and Mann-Whitney for continuous variables that were not normally distributed. A p-value of <0.05 was taken to be significant and was reported with 95% confidence intervals where applicable.

Standard Protocol Approvals, Registrations, and Patient Consents

The study plan, data collection, and quality assurance were designed before enrollment, all participants signed written informed consent forms before participation, and HEP was approved by the Institutional Review Board at each participating site.

Figure 2 Groupings of Participants According to Seizure Onset Semiology and Presentation to the Emergency Department



ED = emergency department; HEP = Human Epilepsy Project.

Data Availability

Data are available on request from any qualified researcher.

Results

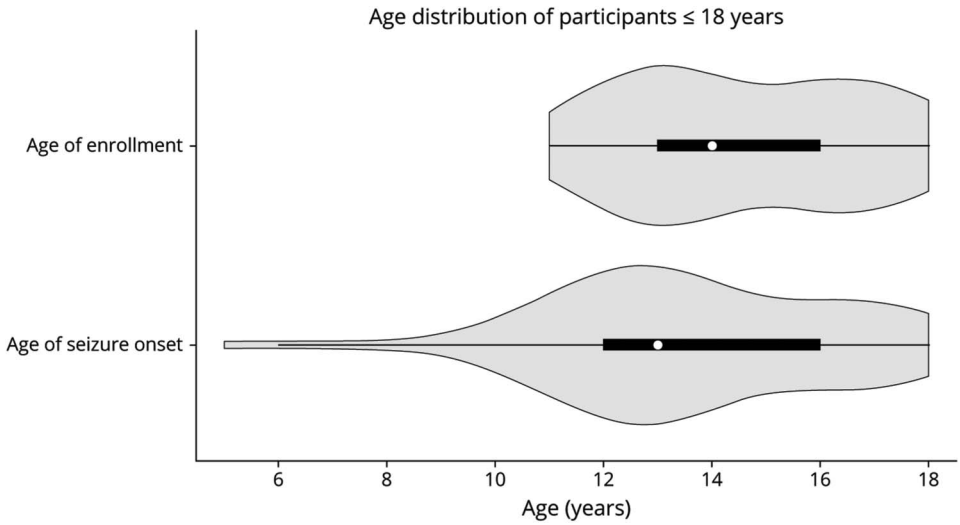
Participants

Eighty-three participants were 18 years or younger at the time of enrollment. Of the 83 participants, 58 (70%) presented to an ED for initial evaluation of undiagnosed focal epilepsy. Twenty-three (40%) presented to a pediatric emergency department. For those aged 18 years and younger, the median age of enrollment was 14 (ranging from 11 to 18) years and the median age at seizure onset was 13 (ranging from 5 to 18) years (Figure 3).

Seizure Presentations

A total of 26 of 44 (53%) participants with nonmotor seizures at epilepsy onset presented to the ED. Of these, 4 (15%) presented with a first-lifetime nonmotor seizure. The other 22 (85%) presented after recurrent seizures: 17 (65%) with

Figure 3 Violin Plots of the Ages of Seizure Onset and Ages of Study Enrollment for the 58 Participants Who Presented to an ED for Seizures Before 18 Years of Age



The white circle represents the median age. The black box limits indicate the 25th and 75th percentiles; whiskers extend to 1.5× the interquartile range.

previous exclusively nonmotor seizures presenting with a first-lifetime motor seizure and 5 (20%) with mixed motor and nonmotor seizures—3 presenting with a motor seizure and 2 with a nonmotor seizure (seizure presentations are displayed in Figure 2).

Participants with motor seizures at onset were significantly more likely to present to an ED as compared with those with nonmotor seizures at onset, with 32 of the 39 motor-onset group presenting to an ED vs 26 of the 44 nonmotor onset group (82% vs 59%, p = 0.02, 95% CI 3.2%–40%). When those with nonmotor seizures at onset did present to the ED, 17 of 26 (65%) did so only after a first-lifetime motor seizure, whereas only 4 of 26 (15%) did so with no history of motor seizures. Although most ED presentations were for motor-type seizures (52 of 58, 90%), a large proportion of patients had a history of nonmotor seizures (20 of 52, 38%).

The 2 groups that presented to an ED with a first-lifetime motor seizure (participants with a motor seizure as the first-lifetime seizure vs participants with a first-lifetime motor seizure and a history of prior nonmotor seizures) had similar baseline characteristics (Table 2). Regarding participant sex, 65% of those with a history of nonmotor seizures at the time of first motor seizure were female vs 33% of those with a first motor seizure alone (p = 0.054, CI 0.3%–56%).

Seizure Recognition

When participants were grouped by type of ED presentation, we found that those presenting with nonmotor seizures were significantly less likely to have their seizure correctly identified (2/6 or 33% of nonmotor seizures vs 42/52 or 81% of motor seizures were correctly recognized, p = 0.01, 95% CI 9.1%–72%). Alternate explanations for nonmotor seizures were variable and included GI complaints, anxiety, and dehydration.

Among participants presenting with a first-lifetime motor seizure with a history of nonmotor seizures, 0% (0/17) were recognized as having had prior nonmotor seizures (Figure 4). This is compared with the 23% (22/95) of participants aged older than 18 years (p = 0.03, CI 3.4%–32%). Eight of these participants (47%) presented to a pediatric emergency department. The description of history of nonmotor seizures for the 17 adolescent participants is included in Table 3.

Effect on Management

Specialist referral to neurology was more likely in participants presenting with a motor seizure plus a history of nonmotor seizures as compared with those presenting with only a first motor seizure (71% vs 38%, p = 0.06, CI 1.3%–56.6%). The 2 groups were admitted from the ED at similar rates (24% vs 38%, p = 0.37, CI –15.4% to 39.4%) and began ASM at similar rates (18% vs 14%, p = 0.78, CI –19.4% to 29.1%).

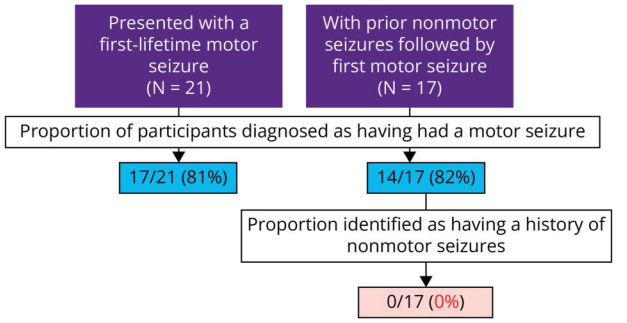
Illustrative Case

Missed identification of nonmotor seizure history is best illustrated through the stories of our participants. For example, a 14-year-old boy presented to the ED after a first-lifetime bilateral tonic-clonic seizure. He reported "hearing repeated phrases" before a witnessed seizure. In the ED, this event was believed to be his first-lifetime seizure, and he was discharged without a diagnosis of epilepsy and without ASM. However, this was not his first time experiencing the auditory

Table 2 Baseline Characteristics of Participants Presenting to the Emergency Department for a First-Lifetime Motor Seizure and a History of Nonmotor Seizures vs Those Presenting With a First-Lifetime Motor Seizure Without History of Nonmotor Seizures

	First motor seizure with nonmotor seizure history (N = 17)	First motor seizure alone (N = 21)
Age		
Median	15	14
Range	12–18	11–18
Sex, n (%)		
Male	6 (35)	14 (67)
Female	11 (65)	7 (33)
Handedness, n (%)		
Left	15 (88)	18 (86)
Right	2 (12)	3 (14)
Ethnicity, n (%)		
Hispanic or Latino	4 (24)	5 (24)
Non-Hispanic or Latino	13 (76)	15 (71)
Unknown	0	1 (5)
Language, n (%)		
English Primary	16 (94)	21 (100)
English Nonprimary	1 (6)	0
Family history of seizures, n (%)		
Yes	6 (35)	7 (33)
No	11 (65)	12 (57)
Unknown		2 (10)
History of febrile seizures, n (%)		
Yes	0	1 (5)
No	14 (100)	12 (57)
Unknown		8 (38)
Lesion on MRI, n (%)		
Yes	2 (12)	2 (10)
No	15 (88)	19 (90)

Figure 4 No Children Presenting With a Motor Seizure and a History of Nonmotor Seizures Were Recognized as Having a History of Nonmotor Seizures



phenomenon. In fact, he recalled recurrent episodes of hearing "repeated phrases in his head", seemingly from external voices, that sometimes occurred several times per day. These events had been happening for 2 years and were incorrectly attributed to anxiety until they culminated in a bilateral tonic-clonic seizure. This history was not collected until he was referred to a neurologist after having a second bilateral tonic-clonic seizure a week after evaluation in the ED. This case highlights a common missed opportunity for diagnosis. Nonmotor seizures often worsen over time and progress to bilateral tonic-clonic seizures when left untreated. As presented in Table 3, most of the 17 participants with a similar history had quite notable descriptions of nonmotor seizures that conceivably could have been elicited with a thorough review of systems that included a nonmotor line of questioning.

Discussion

There is growing evidence that nonmotor seizures often go undiagnosed and underdetected.[11] Our analysis of adolescents in the HEP study illustrates a variety of factors that contribute to this outcome. To begin with, participants were less likely to present to an ED with nonmotor seizures, and only a handful presented with first-lifetime nonmotor seizures. Furthermore, once they arrived at an ED, they were less likely to have their nonmotor seizure correctly identified than participants with motor-type seizures. This highlights the general difficulty of identifying nonmotor seizures for both patients and practitioners alike.[12]

Delays to diagnosis of epilepsy have significant consequences for adolescent health. Diagnostic delays have been found to be associated with risk for poor epilepsy outcome, and previous work has demonstrated higher rates of preventable injuries, particularly motor vehicle accidents, in those with significant delays.[5] It is important that diagnosis makes a difference—approximately 70% of children with epilepsy have been shown to achieve seizure freedom with ASM treatment.[5] Delays to diagnosis also place continued stress on parents and families, who expend time and resources seeking answers amid physician wait-times and misdiagnoses.

Although nonmotor seizures may infrequently present in the ED and be difficult to identify when they do, a significant number of those presenting with motor seizures in our study had a history of prior nonmotor seizures. Strikingly, *no* adolescents had their nonmotor history correctly identified. As a result, these patients, while meeting ILAE criteria for epilepsy, were treated as if presenting for only an isolated motor seizure and were no more likely to have ASM initiation or ED admission. This pattern of presentation only after conversion to motor seizures reflects previous findings in the literature.[5] It is important that this lack of recognition of a history of nonmotor seizures occurred in both pediatric and nonpediatric emergency departments, indicating the need for improvement in both ED settings.

Over half of adolescents in this study presented to an ED for evaluation before diagnosis, indicating just how important EDs are as a point of early contact with medical care for children and adolescents with seizures. As such, the ED represents a setting wherein delays to diagnosis can be reduced, and patients can be given appropriate follow-up to reduce additional suffering. However, our findings indicate that adolescents meeting criteria for epilepsy are missed. This illustrates a critical need for education so that a history of nonmotor seizures is elicited for every child and adolescent presenting with what seems to be a first-lifetime motor seizure.

Education about the presenting symptoms of nonmotor seizures and applying this to history-taking for ED providers, primary care physicians, including pediatricians, and neurologists could be central to reducing delays to diagnosis and morbidity in adolescent populations. Just as physicians inquire about tongue-biting and urinary incontinence, nonmotor seizure symptoms can be added to the line of questioning. Two simple questions could increase the likelihood of correct diagnosis: (1) Did you feel anything at the beginning of the seizure? If so, have you ever felt the same thing before? (2) Before today, did you have any feelings (such as feeling scared, anxious, or worried, a sudden thought out of nowhere, a "déjà vu") that come on suddenly for no reason and last less than 5 minutes?[10] A recent qualitative study investigated common themes for identifying whether an event is a seizure and identified 5 key characteristics suggestive of seizures: sudden-onset, short-lasting, strange or difficult-to-describe, stereotyped, and postictal symptoms.[13] As such, questions that address these specific characteristics should be added to the arsenal of the disease-specific review of systems for new-onset seizures.

The greater nonrecognition of nonmotor seizures in adolescents vs adults with ED presentations may be due to the internal nature of nonmotor seizures. To begin with, children likely have difficulty verbalizing these strange experiences and may not know that they are unusual. Older children may be hesitant to share potentially embarrassing internal

Table 3 Descriptions of Past Nonmotor Events for Those 17 Patients Who Presented With a First-Lifetime Motor Seizure Following Nonmotor Seizures

Participant number	Nonmotor history	Period	Participant number	Nonmotor history	Period
1	Episodes of visual disturbances where objects appear large and out of proportion	2 mo	9	Staring spells, the patient hears a "ringing noise," cannot comprehend speech, it is "like a daydream"	2 y
2	Episodes of hearing loud sounds described as "jumbled noises that increase in intensity"	2 y	10	Episodes of "zoning out"	4 mo
3	Episodes of dizziness, eventually including anxiety, reflux and déjà vu	5–6 y	11	Episodes of left-sided arm and face numbness and tingling with difficulty speaking, loss of taste	4 y
4	Episodes of right leg cramping and pain, "like someone is yanking my leg from the big toe"	6 mo	12	Episodes of "aura" where the patient feels out-of-body and odd awakenings during sleep	5 mo
5	Episodes of nausea, déjà vu, hearing voices	1 y	13	Episodes of grogginess and nausea, feels like daydreaming	6–7 mo
6	Episodes of hearing a voice followed by nausea, headache/fatigue, and seeing "geometric figures like a picasso painting"	2 y	14	Episodes of "pins and needles" starting in the right ankle and proceeding up the right leg, the patient feels odd, warm, and afraid	Unknown
7	Episodes of hearing voices say repeated phrases	2 y	15	Episodes of "aura"	3–4 mo
8	Staring episodes	1 y	16	Episodes of intense fear, feeling unable to think or speak	8 mo
			17	Episodes of an empty feeling in the chest	1 y 6 mo

The time over which these nonmotor symptoms occurred is also included.

experiences with others. Similarly, parents may be unable to recognize these descriptions as potential seizures given that media depictions are often motor in nature. In our adolescent cohort, there was also a trend in participant sex, with more girls presenting with a history of nonmotor seizures at the time of first motor seizure. This female predominance was not observed in the adult cohort.[10] This suggests that sex may be an additional factor impacting presentation and diagnosis in adolescents.

Education surrounding the long wait-times for neurologist follow-up and limitations of brief EEG is also essential.[5] Given the difficulty of identifying these events, overdiagnosis of nonepileptic nonmotor events and unnecessary ASM prescription could be an unintended consequence of this work. With this study, we aim to promote accurate diagnosis by both ED providers and neurologists, and timely and appropriate referrals to neurology. With these tools, providers may be better equipped to recognize potential epilepsy and coordinate appropriate follow-up.

There are several limitations to this study. First, initial nonmotor seizures may be underreported, particularly in a pediatric population who may have had difficulty identifying and communicating nonmotor seizures and for whom parental observation is key to early seizure history. The HEP study also did not enroll younger children, or those with developmental delay, who may face even greater barriers to communicating these experiences. In this sense, our study is an underestimate of the true burden of this problem. Second, the data collected at HEP enrollment did not always include specifics of the ED encounters, such as in-house subspecialty consults or discussions with primary care providers, although it is uncertain how this would influence the outcomes that were analyzed in our study. Finally, the study participants were recruited from tertiary care centers which limits generalizability of this study by not fully capturing the broad and diverse experiences of all people with epilepsy, although a relative strength is that it was a multinational study that gathered information from a wide range of clinical and cultural environments. Despite being conducted across different healthcare systems, nonrecognition of nonmotor seizures emerges as a common challenge.

Our study identifies the critical checkpoint that is the ED as one point of poor recognition of nonmotor seizures within the adolescent population, where nonmotor seizures were less likely to be correctly identified and a history of nonmotor seizures went entirely unrecognized. This occurred in both pediatric and nonpediatric EDs. This highlights an opportunity to significantly improve time to diagnosis for children with new-onset seizures through provider education on the presentation of nonmotor seizures and inclusion of nonmotor seizure symptoms in review of systems questioning. Improving seizure recognition in the ED may lead to increased appropriate neurology referrals, inpatient admissions, and treatment initiation with the goal of improving outcomes for children living with epilepsy.

Acknowledgment

Other Collaborators: Kaarkuzhali Krishnamurthy, MD, Giorgi Kuchukhidze, Gudrun Kalss, Alexandra Rohracher, and Margarethe Kirschner Jonathan Halford, M.D.

Study Funding

There was no targeted funding for this study. Creation of HEP was sponsored by the Epilepsy Study Consortium. Funding for HEP was received from industry, philanthropy, and foundations (UCB Pharma, Eisai, Pfizer, Lundbeck, Sunovion, the Andrews Foundation, the Vogelstein Foundation, Finding a Cure for Epilepsy and Seizures [FACES], and Friends of Faces).The funders of HEP had no role in the design or conduct of this study; collection, management, analysis, or interpretation of the data; preparation of the manuscript; or decision to submit the manuscript for publication.

Disclosure

N. Jandhyala reports no disclosures relevant to the manuscript; M. Ferrer reports no disclosures relevant to the manuscript; J. Pellinen has received research support from the Department of Neurology at the University of Colorado School of Medicine, the Colorado Clinical and Translational Sciences Institute, NIH/NINDS, and the American Epilepsy Society. J. Pellinen serves as chair of the professional advisory board for the Epilepsy Foundation of Colorado and Wyoming (unpaid), serves as the Epilepsy Section Editor for Current Neurology and Neuroscience Reports, and has received salary support for advisory board work for SK Life Science; H.T. Greenwood reports no disclosures relevant to the manuscript; D.J. Dlugos receives salary support from the Epilepsy Study Consortium for consulting work and/or attending Scientific Advisory Boards for Beacon Biosignals, Inc., Biohaven Pharmaceuticals, Encoded Therapeutics, Grin Therapeutics, GW Pharma, Jazz Pharmaceuticals, Longboard Pharmaceuticals, Marinus, Neurelis, Neurocrine, Praxis, Rapport Therapeutics, Inc., SK Life Sciences, Stoke, Takeda, UCB Inc., Xenon, Zogenix. He has received travel/meal reimbursement related to research, advisory meetings, or presentation of results at scientific meetings from the Epilepsy Study Consortium, the Epilepsy Foundation, the Lennox Gastaut Foundation, the France Foundation, Thomas Jefferson University, and the Ministry of Health of the United Arab Emirates; K.L. Park reports no disclosures relevant to the manuscript; L.L. Thio serves on the Editorial Board for Neurology and is a consultant for the Epilepsy Study Consortium through which he is a consultant for Anavex Life Sciences Corp, Eisai Inc., GW Pharmaceuticals, the LouLou Foundation, Marinus Pharmaceuticals Inc., Ovid Therapeutics, SK Biopharmaceuticals, Stoke Therapeutics, Takeda Pharmaceuticals Inc, and Zogenix; J.A. French receives salary support from the Epilepsy Foundation and from Epilepsy Study Consortium for consulting work and/or attending Scientific Advisory Boards for Agrithera, Inc., Alterity Therapeutics Limited, Angelini Pharma S.p.A, Arvelle Therapeutics, Inc., Autifony Therapeutics Limited, Baergic Bio, Beacon Biosignals, Inc., Biogen, Biohaven Pharmaceuticals, Bloom Science Inc., BridgeBio Pharma Inc., Bright Minds Biosciences, Inc., Camp4 Therapeutics Corporation, Cerebral Therapeutics, Cerecin Inc., Cerevel, Coda Biotherapeutics, Cognizance Biomarkers, Crossject, Eisai, Eliem Therapeutics, Encoded Therapeutics, Engrail, Epalex, Epihunter, Epitel Inc, Equilibre BioPharmaceuticals, Genentech, Inc., Grin Therapeutics, GW Pharma, iQure Pharma Inc., Janssen Pharmaceutica, Jazz Pharmaceuticals, Knopp Biosciences, Korro Bio Inc., Leal Therapeutics Inc, Lipocine, LivaNova, Longboard Pharmaceuticals, Lundbeck, Marinus, Modulight.bio, Neumirna Therapeutics, Neurelis, Neurocrine, Neuroelectrics USA Corporation, Neuronetics Inc., NeuroPro Therapeutics, Ono Pharmaceutical Co., Otsuka Pharmaceutical Development, Ovid Therapeutics Inc., Paladin Labs Inc., Pfizer, Praxis, PureTech LTY Inc., Rafa Laboratories Ltd, Rapport Therapeutics, Inc., Receptor Holdings Inc., Sage Therapeutics, Inc., SK Life Sciences, Stoke, Supernus, Takeda, Third Rock Ventures LLC, UCB Inc., Ventus Therapeutics, Vida Ventures Management, Xenon, Zogenix. J. French has also received research support from the Epilepsy Study Consortium (Funded by Eisai and UCB) Epilepsy Study Consortium/Epilepsy Foundation (Funded by UCB), GW/FACES/One8Foundation and NINDS. She is on the editorial board of Lancet Neurology and Neurology Today. She is Chief Medical/Innovation Officer for the Epilepsy Foundation. She has received travel/meal reimbursement related to research, advisory meetings, or presentation of results at scientific meetings from the Epilepsy Study Consortium, the Epilepsy Foundation, Angelini Pharma S.p.A., Biohaven Pharmaceuticals, Cerebral Therapeutics, Neurelis, Neurocrine, Praxis, Rapport, SK Life Science, Stoke, Takeda, Xenon. Go to Neurology.org/N for full disclosures.

Publication History

Received by *Neurology* October 25, 2023. Accepted in final form February 22, 2024. Submitted and externally peer reviewed. The handling editor was Associate Editor Courtney Wusthoff, MD, MS.

Appendix 1 Authors

Name	Location	Contribution
Nora Jandhyala, BS	Department of Neurology, NYU Langone Health, New York	Drafting/revision of the manuscript for content, including medical writing for content; study concept or design; analysis or interpretation of data
Monica Ferrer, MD	Department of Pediatrics and Neurology, NYU Grossman School of Medicine, New York	Drafting/revision of the manuscript for content, including medical writing for content; study concept or design; analysis or interpretation of data
Jacob Pellinen, MD	Department of Neurology, University of Colorado School of Medicine, New York	Drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data; study concept or design; analysis or interpretation of data

Appendix 1 *(continued)*

Name	Location	Contribution
Hadley T. Greenwood, BS	Department of Neurology, NYU Grossman School of Medicine, New York	Drafting/revision of the manuscript for content, including medical writing for content
Dennis J. Dlugos, MD, MSCE	Department of Neurology, Children's Hospital of Philadelphia, PA	Drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data; study concept or design
Kristen L. Park, MD	Department of Pediatrics and Neurology, University of Colorado School of Medicine, New York	Drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data; study concept or design
Liu Lin Thio, MD, PhD	Department of Neurology, Washington University in St. Louis, MO	Drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data; study concept or design
Jacqueline French, MD	Department of Neurology, NYU Grossman School of Medicine, New York	Drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data; study concept or design; analysis or interpretation of data

Appendix 2 Coinvestigators

Coinvestigators are listed at Neurology.org.

References

1. Zack MM, Kobau R. National and state estimates of the numbers of adults and children with active epilepsy—United States, 2015. *MMWR Morb Mortal Wkly Rep.* 2017;66(31):821-825. doi:10.15585/mmwr.mm6631a1
2. Russ SA, Larson K, Halfon N. A national profile of childhood epilepsy and seizure disorder. *Pediatrics*. 2012;129(2):256-264. doi:10.1542/peds.2010-1371
3. Khan A, Lim H, Almubarak S. Importance of prompt diagnosis in pediatric epilepsy outcomes. *Seizure*. 2020;80:24-30. doi:10.1016/j.seizure.2020.03.011
4. Berg AT, Loddenkemper T, Baca CB. Diagnostic delays in children with early onset epilepsy: impact, reasons, and opportunities to improve care. *Epilepsia*. 2014;55(1):123-132. doi:10.1111/epi.12479
5. Pellinen J, Tafuro E, Yang A, et al. Focal nonmotor versus motor seizures: the impact on diagnostic delay in focal epilepsy. *Epilepsia*. 2020;61(12):2643-2652. doi:10.1111/epi.16707
6. Angus-Leppan H. Diagnosing epilepsy in neurology clinics: a prospective study. *Seizure*. 2008;17(5):431-436. doi:10.1016/j.seizure.2007.12.010
7. Holper S, Foster E, Chen Z, Kwan P. Emergency presentation of new onset *versus* recurrent undiagnosed seizures: a retrospective review. *Emerg Med Australas*. 2020;32(3):430-437. doi:10.1111/1742-6723.13420
8. Pellinen J, Tafuro E, Baehr A, et al. The impact of clinical seizure characteristics on recognition and treatment of new-onset focal epilepsy in emergency departments. *Acad Emerg Med*. 2021;28(4):412-420. doi:10.1111/acem.14114
9. Fisher RS, Cross JH, D'Souza C, et al. Instruction manual for the ILAE 2017 operational classification of seizure types. *Epilepsia*. 2017;58(4):531-542. doi:10.1111/epi.13671
10. Saleem MN, Arencibia CA, McKenna K, et al. Investigation of patient and observer agreement on description of seizures at initial clinical visit. *Ann Clin Translational Neurol*. 2019;6(12):2601-2606. doi:10.1002/acn3.50950
11. Firkin AL, Marco DJ, Saya S, et al. Mind the gap: multiple events and lengthy delays before presentation with a "first seizure.". *Epilepsia*. 2015;56(10):1534-1541. doi:10.1111/epi.13127
12. Alessi N, Perucca P, McIntosh AM. Missed, mistaken, stalled: identifying components of delay to diagnosis in epilepsy. *Epilepsia*. 2021;62(7):1494-1504. doi:10.1111/epi.16929
13. Pellinen J, Snyder E, Knupp KG. The language of seizure identification: a qualitative investigation. *Epilepsy Behav*. 2022;126:108484. doi:10.1016/j.yebeh.2021.108484