Published in final edited form as:

J Pediatr. 2013 December ; 163(6): . doi:10.1016/j.jpeds.2013.07.046.

Injuries in adolescents with childhood-onset epilepsy compared with sibling controls

Christine B. Baca, MD, MSHS^{1,2}, Barbara G. Vickrey, MD, MPH^{1,2}, Stefanie D. Vassar, MS^{1,2}, Aaron Cook, BA, MPH¹, and Anne T. Berg, PhD⁴

¹Department of Neurology, University of California Los Angeles, Los Angeles, CA

²Department of Neurology, VA Greater Los Angeles Health Care System, Los Angeles, CA

⁴Ann & Robert H. Lurie Children's Hospital of Chicago, Epilepsy Center, and Northwestern Memorial Feinberg School of Medicine, Department of Pediatrics, Chicago, IL

Abstract

Objective—To compare the occurrence of injuries in adolescents with childhood-onset epilepsy and matched sibling controls.

Study design—Retrospective case-control lifetime injury assessments were obtained from a community-based cohort of adolescents with childhood-onset epilepsy diagnosed 9-years earlier, and their siblings. Children with epilepsy (n=501; mean age 15.3 years) included children with complicated (abnormal neurological exam or IQ<80; n=133) and uncomplicated (normal neurological exam and IQ ≥80; n=368) epilepsy. Children with uncomplicated epilepsy were matched to sibling controls (n=210 pairs). Children reported whether they had ever (before and after epilepsy diagnosis) experienced injuries, “serious enough to require medical attention” and the type of treatment required.

Results—49.1% of children with epilepsy experienced any injury, of whom 8.9% required surgery/hospitalization and 17.1% had an injury due to a seizure; fewer children with uncomplicated epilepsy had seizure-related injuries versus those with complicated epilepsy (13.6% vs. 27.4%; p = 0.01). The proportion of children with epilepsy with any injury by types (not mutually exclusive) were: 25.2% (n=126) fractures, 24.4% (n=122) head, 10.2% (n=51) other, 8.4% (n=42) dental and 8% (n=40) burns/scalds. A similar proportion of children with uncomplicated epilepsy experienced any injury (overall and by type) compared with matched sibling controls, with the exception that more children with uncomplicated epilepsy had head injuries (30.0% vs. 19.5%; p<0.02).

Conclusion—With the exception of head injuries, in a representative cohort of children with epilepsy compared with siblings there was no evidence of an increased risk of injury. This may reflect that the sample was not biased to more severe cases or that safety precautions to prevent injury were widely employed.

Corresponding Author: Christine B. Baca, MD, MSHS; Assistant Professor Neurology UCLA; Box 951769, C-247 RNRC; (Ph) 310-206-7671; (Fax) 310-794-7716; cbower@mednet.ucla.edu.

Conflict of interest information is available at www.jpeds.com (Appendix).

Portions of the study were presented as an abstract at the American Academy of Neurology meeting, New Orleans, LA, April 2012.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Search Terms

children; adolescents; epilepsy; injury; sibling controls

Persons with epilepsy are commonly thought to have a higher risk of accidental injury compared with the general population, resulting in significant morbidity, mortality and cost.^{1,2} The assessment of injury risk amongst persons with epilepsy, however, largely depends on the type of study population, how injuries are defined and assessed, whether or not it was seizure-related and the presence or absence of a control sample.³ Although several studies have examined injuries in children with epilepsy,^{4–19} the majority focused on clinic or hospital-based and often refractory samples.^{4,5,8,9,17,19} Even though studies of injuries of children with epilepsy (or including children with epilepsy) have included population-based samples,^{6,10,11,13–16,18} a limited number included control samples, some of which only focused on one injury or epilepsy type, and most such studies demonstrated higher rates of injury in children with epilepsy compared with controls.^{10,13,15,16,18}

As noted in the recent report by the Institute of Medicine, “scant data exist on injury in children with epilepsy”.²⁰ Injury occurrence in a representative cohort of children with epilepsy including those with uncomplicated epilepsy, defined as typical cognition and normal neurological exam, at long-term follow-up is unknown. The goal of this study was to assess histories of cumulative injuries in a community-based cohort of adolescents with childhood-onset epilepsy diagnosed 9-years earlier and followed prospectively, and compare these reports with matched sibling controls. We also sought to examine the proportion of cases with seizure-related injuries and to assess epilepsy-related risk factors for injury. We hypothesized a higher proportion of children with complicated epilepsy would report injuries compared with those with uncomplicated epilepsy.

METHODS

The Connecticut Study of Epilepsy is a community-based cohort study of 613 children (1 month through 15 years of age) with newly diagnosed epilepsy (≥ 2 unprovoked seizures) enrolled by participating pediatric neurologists between 1993 and 1997 and followed prospectively. The characteristics of this cohort are comparable with a Canadian study that is generally accepted as population-based with respect to age of onset, sex, and proportion of participants with certain well-recognized forms of epilepsy, intellectual disability, and mortality.^{21,22} Details of methods, recruitment and follow-up have been previously published.^{23,24}

Nine years after the diagnosis of epilepsy, a time interval felt to be sufficient to evaluate long-term outcomes, 501 (82%) children with epilepsy took part in a reassessment protocol that included a retrospective evaluation of cumulative injuries that had occurred at any time since birth (“lifetime” injuries) in children with epilepsy (cases) and their sibling controls (n=284; within 3 years of age of the child with epilepsy, with typical cognition and without significant neurological disability; Figure 1 available at www.jpeds.com). Children with epilepsy were subdivided into children with uncomplicated (n=368) and complicated (n=133) epilepsy. Children with uncomplicated epilepsy were defined as having a normal neurological exam and “typical cognition” (consistent with intelligence quotient, IQ ≥ 80), and children with complicated epilepsy had an abnormal neurological exam or “impaired cognition” (consistent with IQ < 80). An abnormal neurological exam (motor, sensory, coordination or gait abnormalities) was based on neurological medical chart review of the clinical exam and with consensus from three reviewing pediatric neurologists. Amongst the children with uncomplicated epilepsy, 210 had a matched sibling control.

Institutional Review Board approval was obtained at all sites. Written informed consent was obtained from the parent and written assent was obtained from children under the age of 18 at the time of enrollment and the 9-year reassessment. Written consent was obtained from case and sibling control participants 18 years old at the 9-year reassessment.

At the time of enrollment and the 9-year reassessment, clinical and demographic data of children were obtained via structured parent interviews by trained research associates. Interim review of neurological medical records and quarterly follow-up telephone interviews with parents were used to track seizure occurrence and treatment. Epilepsy syndromes and seizure types for each case were independently classified and agreed upon by three pediatric neurologists using data from parent interviews, neurological medical chart review, neuroimaging and electroencephalography. Epilepsy syndromes were categorized according to recent recommendations.²⁵ Cognitive status was assessed using information from neurological medical records, parent interviews, school records and standardized neuropsychological testing using the Wechsler Intelligence Scale for Children.²³ Children with epilepsy were characterized as with “typical” (consistent with IQ ≥ 80) or “impaired” (consistent with IQ < 80) cognition. At the 9-year reassessment, seizure remission was defined as being 5-years seizure-free based on the date of the last recorded seizure. Medication status was characterized as currently taking one or more AEDs versus none.

Injury assessment

At the 9-year reassessment, lifetime injuries were assessed amongst cases and sibling controls. Each child (or parent-proxy) answered the following question; “*Have you ever suffered any of the following injuries seriously enough to require medical attention?*”: (a) a burn or a scald (simple dressing, skin grafting); (b) a head injury (stitches, skull fracture, operation); (c) a dental injury (loss of teeth, fractured jaw, surgery); (d) any other fracture (which bone); and (e) other injury (specify). For each injury type, children with epilepsy were asked, “*Did you suffer this injury as a result of a seizure?*”. Participants were asked, “*Did the injury require hospitalization?*” The interviewer recorded free text responses describing the injuries and the type of medical treatment required.

Free text responses were reviewed and coded into injury types and subtypes and treatment categories. Injury types and subtypes were classified: “burns/scalds” included any mention of a burn or scald; “head injury” included concussion, laceration of face or scalp, fall or hit head, skull fracture and other unspecified head injury; “dental injury” included loss of teeth, chipped teeth, fractured jaw, and other unspecified tooth injury; “fracture” included large bone (leg/arm) fracture, medium bone (wrist/hand/ankle/foot) fracture, small bone (finger/toe) fracture, or other (nose, growth plate, or unspecified) fracture; “other” injury included laceration or abrasion in area other than face or head, dislocation, sprain or strain, and other injury (bite, bruise, eye or unspecified injury) (Table I; available at www.jpeds.com). Some initial injury type responses were reclassified using information from free text responses in order to most appropriately reflect accurate injury types and subtypes. Medical treatment types were classified into: non-surgical procedure, surgery, hospitalization, other care (outpatient visit, emergency room visit, physical therapy, medication, or medical visit not specified), unspecified (no explicit characterization or description of treatment), or no treatment (explicit statement that no treatment was required) (Table II; available at www.jpeds.com). Two independent coders completed coding of injury types and subtypes and treatment categories, with high inter-rater agreement for 10% of the sample (agreement 87.0–100%).

Statistical Analyses

Sociodemographic and clinical characteristics, and the proportion of children with injuries (by type and overall) and medical treatment types between children with epilepsy and sibling controls and between different subgroups of children with epilepsy were compared using appropriate bivariate statistics (t-test, chi-square, Fisher exact test two-sided, or McNemar test for paired comparisons). The proportion of children with a given injury type and subtype was calculated for all children with epilepsy, including those with uncomplicated and complicated epilepsy, and for the subsample of children with uncomplicated epilepsy with matched sibling pairs and compared between these groups. An individual participant could report more than one type and subtype of injury. Overall injury rates were calculated as the proportion of children in a given sample with at least one reported injury type. In the overall group of children with epilepsy, injury rates in cases with age of epilepsy onset <5 years were compared with those with age of epilepsy onset ≥5 years, those ≥5 years seizure-free at the 9-year follow-up versus not, in addition to those that were self-reporting injuries versus those that were parent-proxy reported. The proportion of injured cases with seizure-related injuries was calculated. The number of children receiving a given treatment for an injury type divided by the total number of children who reported any of that injury type was calculated. Treatment comparisons between children with uncomplicated versus complicated epilepsy and between children with uncomplicated epilepsy and matched sibling pairs were made; because there were a different number of injuries between children with uncomplicated epilepsy and sibling pairs the analysis was not matched. A sensitivity analysis excluding those children that had self-reported injuries was conducted between children with uncomplicated epilepsy versus children with complicated epilepsy. Analyses were performed using SAS (9.2), setting an a priori p-value of $p = 0.05$ for statistical significance. This study was powered at >80% to detect a 15% point difference in injury occurrence between the 210 cases and control matched pairs (2 tailed $\alpha = 0.05$).

RESULTS

Sociodemographic characteristics were not different between children with uncomplicated epilepsy ($n=368$) and sibling controls ($n=284$), including the matched children with uncomplicated epilepsy-sibling pairs ($n=210$ pairs) (Table III). Compared with children with uncomplicated epilepsy ($n=368$), children with complicated epilepsy ($n=133$) had a slightly younger age of epilepsy onset (4.3 vs. 6.4 years), were less likely to be ≥5-years seizure-free (32.3% vs. 65.8%), and were more likely to be taking ≥1 AED at the 9-year interview (63.1% vs. 28.3%) ($p's < 0.001$). By definition, all children with uncomplicated epilepsy had a normal neurological exam and IQ ≥80; in contrast, 53% of children with complicated epilepsy had a normal neurological exam and 11% had an IQ ≥80. Injuries were self-reported in 21.6% ($n=108$) of the children with epilepsy group.

Injuries in children with epilepsy and sibling controls

Nearly half of the study group (49.1%; $n=246$) reported they had experienced at least one injury during their lifetime at the 9-year reassessment (Table IV). The most common injuries reported were fracture (25.2%; $n=126$) and head injury (24.4%; $n=122$), followed by other (10.2%; $n=51$), dental (8.4%; $n=42$) and burn/scald (8.0%; $n=40$) injuries. A comparable proportion of children with uncomplicated epilepsy and matched sibling controls ($n=210$ case-control pairs) experienced any injury (overall and by type) with the exception that more children with uncomplicated epilepsy had any head injury compared with controls (30% vs. 19.5%; $p < 0.02$). In an unmatched analysis comparing all children with uncomplicated epilepsy ($n=368$) to all sibling controls ($n=284$), comparable proportions of cases and siblings experienced any injuries (overall and by type; results not shown).

Because injuries were recorded retrospectively as any lifetime injury and thus, timing of injury in reference to epilepsy onset, AEDs, age and remission status was not known, we compared injury reports in children with epilepsy with age of epilepsy onset <5 years (n=229) to those with age of onset ≥5 years (n=272) to determine if more children with epilepsy with an earlier age of onset had injuries; there was no difference in the proportion of injuries overall and by type between these two groups (results not shown). We found no differences in the proportion of children with epilepsy ≥5 years seizure-free at 9-year follow-up (n=216) versus not (n=285) reporting injuries overall or by type (results not shown). In our sensitivity analysis for possible differences in self- versus parent-proxy reporting, we also compared injury reports among those that self-reported (n=108) and those that were parent-proxy reported (n=393) and found that a higher proportion of children who self-reported injuries had an overall injury (59.3% vs. 46.3%; $p<0.02$), fracture (44.4% vs. 19.9%; $p<0.001$) and other injury (21.3% vs. 7.1%; $p<0.001$) but not burn/scald (11.1% vs. 7.1%; $p=0.18$), dental (8.3% vs. 8.4%; $p=0.98$) or head injury (25.0% vs. 24.2%; $p=0.86$).

Seizure-related injuries

Of 246 cases reporting any injury, 42 (17.1%) attributed having an injury to a seizure (Figure 2). The most common injury types attributable to seizures were dental (22.0%) and head (19.8%) injuries; burn/scald (5.0%), fracture (7.3%), and other (12.8%) seizure-related injuries were less common.

Severity of injuries in children with epilepsy and sibling controls – medical treatments

In the 246 children with epilepsy who experienced any injury, 22 (8.9%) required hospitalization or surgery, 8 (3.3%) required any hospitalization, and 15 (6.1%) required any surgery (Table V). Hospitalization was most common in children with head injury (4.1%; n=5), but surgery was most common in those with other injury types (11.8%; n=6). There were no differences in types of treatment needed by overall or by injury type for children with complicated (n=133) versus uncomplicated (n=368) epilepsy, or for children with uncomplicated epilepsy compared with matched sibling controls (n=210 pairs).

Complicated versus uncomplicated epilepsy

A similar proportion of children with uncomplicated (n=368) and complicated (n=133) epilepsy had ever had an injury (50.0% vs. 46.6%; $p=0.54$; Table IV). Although a higher proportion of children with uncomplicated epilepsy versus children with complicated epilepsy had ever had a fracture (28.3% vs. 16.5%; $p<0.007$; Table IV), a higher proportion of those with complicated epilepsy had fracture injuries due to seizures compared with children with uncomplicated epilepsy (23.8 vs. 3.9%; $p<0.007$; Figure 2). Overall, a higher proportion of children with complicated compared with uncomplicated epilepsy with injuries had ever experienced an injury due to a seizure (27.4% vs. 13.6%; $p<0.01$; Figure 2).

Because a higher proportion of children with complicated epilepsy (n=124 or 93%) had parent-proxy injury reports compared with children with uncomplicated epilepsy (n=269 or 73%) we performed a sensitivity analysis comparing only those with parent-proxy report and found that there were no differences in the proportion of injuries overall and by type (results not shown). There were no differences reported in injury treatment (results not shown). In the subset with only parent-proxy reports, we did find that compared with children with uncomplicated epilepsy, children with complicated epilepsy had a higher proportion of injuries due to seizures overall (26.3% vs. 5.2%; $p<0.02$) and of fracture injuries due to seizures (26.3% vs. 12.8%; $p<0.03$); there were no differences by other types of injury due to seizures.

DISCUSSION

In this community-based study of childhood-onset epilepsy at 9-year follow-up, we found that a similar proportion of children with uncomplicated epilepsy had injuries requiring medical attention compared with matched sibling controls, with the sole exception that more children with uncomplicated epilepsy reported head injuries compared with matched sibling controls. Nearly one-half of all children with epilepsy had experienced having at least one injury requiring medical attention during their lifetime, with fractures and head injuries being the most frequent. In children with epilepsy reporting injuries, less than 10% required a serious medical intervention as defined by hospitalization or surgery. Seizure-related injuries were reported in 42 (8%) of the cohort overall, with dental and head injuries the most common types of injuries that were attributed to seizures. Although seizure-related injuries were more common in the complicated compared with uncomplicated epilepsy group, a comparable proportion of each group reported injuries.

We found that similar proportions of children with epilepsy with typical cognition and of neurologically normal sibling controls reported at least one injury. Although other studies have also demonstrated that children with epilepsy have similar injury rates as compared with best friend or sibling controls without epilepsy, such studies were limited by small sample sizes, low response rates or non-population based samples.^{7,12} Congruent with our findings, prior studies have reported that persons with epilepsy have higher rates of head injury compared with controls.^{5,18} In contrast, however, several population-based studies have found that overall injury rates for children with epilepsy are higher compared with controls.^{10,13,15,18} children with epilepsy had a higher mean number of overall accidental injuries per 100 person-years at risk compared with those with juvenile rheumatoid arthritis (24.6 vs. 18.7; $p < 0.04$); children with epilepsy in that study were restricted to those with absence epilepsy diagnosed between 1977–1985.¹⁸ Although other population-based studies have found that children with epilepsy have higher rates of submersion injuries and fractures compared with controls, such studies were restricted to retrospective evaluation of only one injury type.^{10,15} The RESt-1 study, a large prospective clinic-based case-control study of adults and children including 951 cases and 909 matched controls in eight European countries found that the cumulative probability of accidents was higher in prevalent cases compared with controls at 24 months (27% vs. 17%) after enrollment although injuries were generally of minor severity.⁵ To our knowledge, no prior studies have compared injuries in a large community-based sample of children with epilepsy with typical cognition with age-matched neurologically normal sibling controls, who share a similar home environment.

Although we found that nearly one-half of all children with epilepsy experienced at least one lifetime injury, only a small proportion of these injuries were severe, as defined by the need for surgery or hospitalization; further, treatment was comparable between children with uncomplicated epilepsy and sibling controls. Many studies have found that the majority of injuries experienced by persons with epilepsy are generally mild.^{1,4,5,14,17,19,26,27} In a consecutive clinic-based series of 198 children with epilepsy seen over a 12-month period, 12.6% had a seizure-related injury prior to the diagnosis of epilepsy, only four of whom required medical attention.⁴ Although persons with epilepsy more frequently had accidents requiring hospitalization compared with controls in the RESt-1 study, overall rates of hospitalization were still low (3% vs. 1%).⁵ In contrast, in the population-based Canadian Community Health Survey of adolescents and adults, persons with epilepsy had higher rates of injury related hospitalizations compared with the general population despite having a similar 12-month weighted prevalence of injuries.¹⁶

Consistent with prior studies of seizure-related injuries in persons with epilepsy, we found that the majority of children experiencing injuries did not attribute the injury to a

seizure.^{4,5,7,14,16,17} In a population-based study of seizure-related injuries amongst adults and adolescents with epilepsy, the cumulative risk of seizure-related injury at 10 years was 14.6% (CI 9.5–19.3).¹⁴ Further, less than 5% of injuries over 12 months were attributable to seizures in a prospective study of injuries in children with epilepsy.⁷ In contrast, studies that have documented higher seizure-related injury rates have generally included persons with epilepsy with more severe, or refractory disease.^{8,27,28}

We found that comparable proportions of children with complicated compared with uncomplicated epilepsy experienced injuries overall suggesting that epilepsy-related risk factors may not be associated with overall injury risk. Although some studies have similarly found a lack of association between epilepsy-related factors,^{7,12,18} others have not.²⁹ In one study, duration of epilepsy prior to diagnosis, age of onset, and cognitive function did not correlate with overall injury rates amongst children with absence epilepsy,¹⁸ although in the RESt-1 study an increased risk of accidents was associated with generalized epilepsy, active seizures and at least monthly seizures.²⁹ We did observe, however, that more children with complicated epilepsy had seizure-related injuries compared with those with uncomplicated epilepsy, suggesting that children with epilepsy who have impaired cognition, or an abnormal neurological exam are more likely to experience seizure-related injuries, findings that are consistent with other literature.^{1,8,27} Other studies have additionally demonstrated that younger age of onset, seizure-type, tonic-clonic seizures, seizure frequency, AED burden, and seizure severity are risk factors for seizure-related injury.^{4,6,14,17,26,27} Although children with complicated epilepsy in our cohort had a younger age of onset, were less likely to be 5-years seizure-free and were more likely to be taking 1 AED at the 9-year reassessment compared with children with uncomplicated epilepsy, we are unable to make conclusions regarding whether or not such factors increase the risk of seizure-related injuries because the exact timing of seizure-related injuries in reference to these factors is unknown. For similar reasons we are also unable to draw conclusions regarding potential associations between injury type and seizure types or AEDs. Our observation that there was no difference in injury occurrence between children with epilepsy with age of epilepsy onset before or after 5 years, however, suggests that early age on onset is not associated with lifetime cumulative injury occurrence in our cohort.

Our study has several additional limitations. Because injury data were collected retrospectively, the injuries “remembered” may be skewed toward those that are more severe or memorable, although such a bias would likely be present equally for cases and controls and be applicable to all injury types. Additionally, from the wording of the injury assessment question it is not known whether or not more than one type of injury represented more than one accident or, alternatively whether one accident resulted in more than one injury type. Furthermore, injury reports were not cross-validated with medical records given limited data collection resources. We did not collect data regarding where the injury took place (ex. home, work, school) and therefore, we are not able to comment on risk of injury in relation to specific locations.^{1,4,30} We did not measure safety behaviors or precautions and thus, we are unable to make any conclusions regarding their potential impact nor whether or not precautions were differentially implemented in cases compared with sibling controls. Additionally, we acknowledge that even though differences in self- versus parent-proxy reports may, at least partially, explain some of the differences in injury reports between children with complicated epilepsy and children with uncomplicated epilepsy, the observation that a greater proportion of children with complicated epilepsy had overall and fracture injuries attributable to seizures persisted in sensitivity analysis excluding self-reporting children. When comparing self-report versus parent-proxy reported injuries in children with epilepsy, however, self-report alone was not indiscriminately equated with more frequent injury reports. Lastly, the generalizability of our findings may be limited because our sample population was relatively homogeneous (>80% Caucasian; > 43%

college educated parents), although representative of the state of Connecticut in the early 1990s.

With the exception of head injuries, a similar proportion of adolescents with uncomplicated childhood-onset epilepsy in this community-based cohort experienced lifetime injuries as did matched sibling controls with few injuries requiring serious medical intervention. Further research is needed to assess the degree to which current safety precautions are being employed and their effectiveness. Although recognizing that excessive limitations may have potentially long-term consequences including social isolation, lack of independence and inactivity, it is unclear whether our not our results definitively suggest that clinicians should encourage more activities in children with epilepsy. Our finding that more children with complicated epilepsy reported injuries attributable to seizures compared with those with uncomplicated epilepsy suggests that children with impaired cognition, or an abnormal neurological exam are at higher risk for having seizure-related injuries. Further, such results imply that safety recommendations could be based on an individual child's neurological and epilepsy profile. Additional research, however, is needed to provide more detailed risk stratification for injury based on the child's epilepsy profile and to develop practical educational tools regarding safety implementation for clinicians and families with epilepsy.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funded by the National Institutes of Health (NINDS R37-NS31146 [PI: Berg]). All authors funded by NINDS (R37-NS31146). The study sponsor did not have a role in study design, collection, analysis, interpretation of data, writing of the report, or decision to submit the manuscript.

We would like to thank France Nguyen, MPH, PhD (Department of Neurology, University of California-Los Angeles), for her assistance with data analysis of injury free text responses.

Abbreviation

AEDs anti-epileptic drugs

References

1. Wirrell EC. Epilepsy-related injuries. *Epilepsia*. 2006; 47 (Suppl 1):79–86. [PubMed: 17044832]
2. Zachry WM 3rd, Doan QD, Smith BJ, Clewell JD, Griffith JM. Direct medical costs for patients seeking emergency care for losses of epilepsy control in a U.S. managed care setting. *Epilepsy Behav*. 2009; 16:268–73. [PubMed: 19747882]
3. Beghi E. Injuries in patients with epilepsy. *Lancet Neurology*. 2005; 4:71–2. [PubMed: 15664535]
4. Appleton RE. Seizure-related injuries in children with newly diagnosed and untreated epilepsy. *Epilepsia*. 2002; 43:764–7. [PubMed: 12102681]
5. Beghi E, Cornaggia C. Morbidity and accidents in patients with epilepsy: results of a European cohort study. *Epilepsia*. 2002; 43:1076–83. [PubMed: 12199734]
6. Bellon M, Walker C, Peterson C. Seizure-related injuries and hospitalizations: Self-report data from the 2010 Australian Epilepsy Longitudinal Survey. *Epilepsy Behav*. 2013; 26:7–10. [PubMed: 23201608]
7. Are children with epilepsy at higher risk for injury? A prospective study of injury rates in children with epilepsy compared to their nearest-aged sibling. *Epilepsia*. 2010; 0(Suppl 0):3.241.

8. Buffo TH, Guerreiro MM, Tai P, Montenegro MA. Seizure related accidents and injuries in childhood. *Arq Neuropsiquiatr*. 2008; 66:458–61. [PubMed: 18813699]
9. Deekollu D, Besag FM, Aylett SE. Seizure-related injuries in a group of young people with epilepsy wearing protective helmets: incidence, types and circumstances. *Seizure*. 2005; 14:347–53. [PubMed: 15896983]
10. Diekema DS, Quan L, Holt VL. Epilepsy as a risk factor for submersion injury in children. *Pediatrics*. 1993; 91:612–6. [PubMed: 8441568]
11. Kemp AM, Sibert JR. Epilepsy in children and the risk of drowning. *Archives of Disease in Childhood*. 1993; 68:684–5. [PubMed: 8323342]
12. Kirsch R, Wirrell E. Do cognitively normal children with epilepsy have a higher rate of injury than their nonepileptic peers? *J Child Neurol*. 2001; 16:100–4. [PubMed: 11292213]
13. Kwon CS, Liu M, Quan H, et al. The incidence of injuries in persons with and without epilepsy--a population-based study. *Epilepsia*. 2010; 51:2247–53. [PubMed: 20726876]
14. Lawn ND, Bamlet WR, Radhakrishnan K, O'Brien PC, So EL. Injuries due to seizures in persons with epilepsy: a population-based study. *Neurology*. 2004; 63:1565–70. [PubMed: 15534237]
15. Souverein PC, Webb DJ, Petri H, Weil J, Van Staa TP, Egberts T. Incidence of fractures among epilepsy patients: a population-based retrospective cohort study in the General Practice Research Database. *Epilepsia*. 2005; 46:304–10. [PubMed: 15679512]
16. Tellez-Zenteno JF, Hunter G, Wiebe S. Injuries in people with self-reported epilepsy: a population-based study. *Epilepsia*. 2008; 49:954–61. [PubMed: 18177355]
17. Ting YW, Kwong KL. Seizure-related injuries in newly diagnosed childhood epilepsy. *Pediatr Neurol*. 2010; 42:417–21. [PubMed: 20472194]
18. Wirrell EC, Camfield PR, Camfield CS, Dooley JM, Gordon KE. Accidental injury is a serious risk in children with typical absence epilepsy. *Arch Neurol*. 1996; 53:929–32. [PubMed: 8815859]
19. Ziegler AL, Reinberg O, Deonna T. Epilepsy and accidents: what is the risk in children? *Arch Pediatr*. 1994; 1:801–5. [PubMed: 7842122]
20. *Epilepsy Across the Spectrum: Promoting Health and Understanding*. Washington, D.C: Institute of Medicine of the National Academies. The National Academies Press; 2012.
21. Camfield CS, Camfield PR, Gordon K, Wirrell E, Dooley JM. Incidence of epilepsy in childhood and adolescence: a population-based study in Nova Scotia from 1977 to 1985. *Epilepsia*. 1996; 37:19–23. [PubMed: 8603618]
22. Camfield CS, Camfield PR, Veugelers PJ. Death in children with epilepsy: a population-based study. *Lancet*. 2002; 359:1891–5. [PubMed: 12057550]
23. Berg AT, Langfitt JT, Testa FM, et al. Global cognitive function in children with epilepsy: a community-based study. *Epilepsia*. 2008; 49:608–14. [PubMed: 18070088]
24. Berg AT, Shinnar S, Levy SR, Testa FM. Newly diagnosed epilepsy in children: presentation at diagnosis. *Epilepsia*. 1999; 40:445–52. [PubMed: 10219270]
25. Berg AT, Berkovic SF, Brodie MJ, et al. Revised terminology and concepts for organization of seizures and epilepsies: report of the ILAE Commission on Classification and Terminology, 2005–2009. *Epilepsia*. 2010; 51:676–85. [PubMed: 20196795]
26. Asadi-Pooya AA, Nikseresht A, Yaghoubi E, Nei M. Physical injuries in patients with epilepsy and their associated risk factors. *Seizure*. 2012; 21:165–8. [PubMed: 22130005]
27. Friedman DE, Tobias RS, Akman CI, Smith EO, Levin HS. Recurrent seizure-related injuries in people with epilepsy at a tertiary epilepsy center: a 2-year longitudinal study. *Epilepsy Behav*. 2010; 19:400–4. [PubMed: 20851687]
28. Friedman DE, Gilliam FG. Seizure-related injuries are underreported in pharmacoresistant localization-related epilepsy. *Epilepsia*. 2010; 51:43–7. [PubMed: 19519796]
29. van den Broek M, Beghi E. Accidents in patients with epilepsy: types, circumstances, and complications: a European cohort study. *Epilepsia*. 2004; 45:667–72. [PubMed: 15144432]
30. Neufeld MY, Vishne T, Chistik V, Korczyn AD. Life-long history of injuries related to seizures. *Epilepsy Res*. 1999; 34:123–7. [PubMed: 10210026]

Appendix

B.V. serves on scientific advisory boards for the Sports Concussion Institute, American Heart Association, and the NIH; serves on the editorial board of *Neurorehabilitation and Neural Repair*; is a Section Editor for *Stroke*; receives research support from the NIH (NIA – RC4AG038804 and 1U54 NS081764), the US Veterans Administration Health Services Research and Development Service (NRI-11-126 and VA QUERI PRP), the American Heart Association (AHA/PRT 0875133N), and the Food and Drug Administration (R01 FD003923); is a consultant to EMD Serono Canada and to Imperial Clinical Research Services, Inc; and has received travel support from the National Parkinson Foundation and CHDI. Ms. Vassar receives support from NINDS-1U54 NS081764 and NCATS-UL1TR000124. A.B. has received travel funding and honoraria from Eisai, the British Pediatric Neurological Association, and the Epilepsy Research Center (Melbourne); travel funding from UCB, the American Epilepsy Society, and the International League Against Epilepsy, and BIAL; awards from the American Epilepsy Society and British Pediatric Neurological Association; consulting fees from Dow Agro Science; serves on the Editorial Boards of *Epileptic Disorders*, *Epilepsy & Behavior* and *Neurology*; and is past Chair of the ILAE's Commission on Classification and Terminology, and Steward for the NINDS Benchmarks in Epilepsy Research. The other authors declare no conflicts of interest.

Figure 2.

Seizure-related injuries in children with epilepsy. Proportion of injured cases with seizure-related injury (overall and by type). Children with uncomplicated epilepsy were compared with children with complicated epilepsy. Chi-square calculated with significance of $p \leq 0.05$.

Table 3

Sociodemographic and clinical characteristics of children with epilepsy and sibling controls

	Complicated vs. Uncomplicated			CWUE (case) vs. matched sibling control		
	All CWUE (n = 501)	CWUE (n=368)	CWCE [†] (n=133)	p-value [*]	CWUE (n=210)	p-value [*]
	N (%)	N (%)	N (%)		N (%)	N (%)
Female	249 (49.7)	189 (51.4)	60 (45.1)	0.22	101 (48.1)	121 (57.6)
Age at 9-year reassessment, yrs, mean (SD)	15.3 (4.2)	16.0 (4.1)	13.6 (4.2)	<0.001	15.5 (3.9)	16.0 (5.6)
Race [‡]						
Caucasian	421 (84.0)	322 (87.5)	99 (74.4)	0.002	189 (90.0)	189 (90.0)
African American	43 (8.6)	26 (7.1)	17 (12.8)		12 (5.7)	12 (5.7)
Other (Hispanic, Asian, Other)	37 (7.4)	20 (5.4)	17 (12.8)		9 (4.3)	9 (4.3)
Parent college education or higher	220 (43.9)	172 (46.7)	48 (36.1)	0.03	104 (49.5)	104 (49.5)
Currently in school at 9-year reassessment [¶]	443 (88.4)	317 (86.1)	126 (94.7)	0.008	186 (88.6)	176 (83.8)
Age of epilepsy onset, yrs, mean (SD)	5.8 (4.0)	6.4 (3.9)	4.3 (3.7)	<0.001	6.3 (3.8)	-
Self-reported injuries	108 (21.6)	99 (26.9)	9 (6.8)	<0.001	52 (24.8)	62 (29.5)
Seizure-free 5 years at 9-year reassessment	285 (56.9)	242 (65.8)	43 (32.3)	<0.001	138 (65.7)	-
Taking 1 AED(s) at 9-year reassessment	188 (37.5)	104 (28.3)	84 (63.1)	<0.001	62 (29.5)	-
Taking 2 AED(s) at 9-year reassessment	65 (13.0)	21 (5.7)	44 (33.1)	<0.001	15 (7.1)	-
Full Scale IQ 80	383 (76.5)	368 (100)	15 (11.3)	-	210 (100)	-
Normal neurological exam	439 (87.6)	368 (100)	71 (53.4)	-	210 (100)	-
Cause of epilepsy						
Genetic/unknown (i.e. idiopathic and cryptogenic)	394 (78.6)	342 (92.9)	52 (39.1)	<0.001	195 (92.9)	-
Remote symptomatic epilepsy	107 (21.4)	26 (7.1)	81 (60.9)		15 (7.1)	-
Epilepsy syndrome						
Benign focal epilepsies of childhood ^{**}	60 (12.0)	57 (15.5)	3 (2.3)	<0.001	30 (14.3)	-
Nonsyndromic epilepsies – structural/metabolic ^{¶¶}	85 (17.0)	25 (6.8)	60 (45.1)		15 (7.1)	-
Nonsyndromic epilepsies - unknown cause [§]	176 (35.1)	152 (41.3)	24 (18.1)		89 (42.4)	-
Genetic generalized epilepsies	112 (22.4)	100 (27.2)	12 (9.0)		55 (26.2)	-
Syndromic epilepsies - generalized & focal features ^{††}	41 (8.2)	10 (2.7)	31 (23.3)		6 (2.9)	-
Unclassified	27 (5.4)	24 (6.5)	3 (2.3)		15 (7.1)	-

* T-test, Chi-square or McNemar's test (for paired comparisons) calculated with significance of p 0.05

Children with uncomplicated epilepsy (CWUE) cases include CWE with IQ 80 and a normal neurological exam.

[†] Children with complicated epilepsy (CWCE) cases include CWE with IQ < 80 or an abnormal neurological exam.

[‡] Race/ethnicity data was collected at time of enrollment from parents using categories defined by the investigator at study initiation in 1993.

[¶] Includes children currently attending regular public/private school (high school), home school program (high school), a special school for the learning disabled, college, technical or vocational school, or post-graduate training after college.

^{**} Includes benign childhood epilepsy with centrotemporal spikes (BECTs) and benign occipital epilepsies of childhood;

^{¶¶} formerly symptomatic focal;

[§] formerly cryptogenic focal;

formerly idiopathic generalized;

^{††} Includes children with syndromes such as West, Lennox Gastaut and Dravet

Table 4
Report of lifetime injuries (any) at 9-year reassessment: children with epilepsy (cases) and sibling controls

Injury type and subtype, N (%)	All CWE (n=501)		Complicated vs. Uncomplicated		CWUE (case) vs. matched sibling (control)	
	CWUE [†] (n=368)	CWCE [‡] (n=133)	p-value*	CWUE [†] (n=210)	Controls (n=210)	p-value*
Burn/scald (any)	40 (8.0)	26 (7.1)	0.26	18 (8.6)	9 (4.3)	0.09
Head injury (any)	122 (24.4)	87 (23.6)	0.56	63 (30.0)	41 (19.5)	0.02
Concussion	14 (2.8)	13 (3.5)	1 (0.8)	11 (5.2)	9 (4.3)	0.82
Laceration face/scalp	86 (17.2)	60 (16.3)	26 (19.6)	43 (20.5)	28 (13.3)	0.04
Fall and hit head	24 (4.8)	14 (3.8)	10 (7.5)	11 (5.2)	4 (1.9)	0.12
Skull fracture	1 (0.2)	0 (0)	1 (0.8)	0 (0)	1 (0.5)	-
Other (ex. unspecified head injury)	7 (1.4)	5 (1.4)	2 (1.5)	2 (1.0)	2 (1.0)	0.99
Dental injury (any)	42 (8.4)	29 (7.9)	0.47	19 (9.1)	11 (5.2)	0.20
Loss teeth	10 (2.0)	7 (1.9)	3 (2.3)	4 (1.9)	7 (3.3)	0.55
Chipped teeth	9 (1.8)	8 (2.2)	1 (0.8)	5 (2.4)	1 (0.5)	0.22
Fracture jaw	2 (0.4)	2 (0.5)	0 (0.0)	1 (0.5)	0 (0)	-
Other (ex. unspecified tooth injury)	22 (4.4)	12 (3.3)	10 (7.5)	9 (4.3)	3 (1.4)	0.15
Fracture (any)	126 (25.2)	104 (28.3)	0.007	64 (30.5)	61 (29.1)	0.82
Large bone (ex. leg or arm)	31 (6.2)	28 (7.6)	3 (2.3)	18 (8.6)	18 (8.6)	0.99
Medium bone (ex. wrist, hand, ankle or foot)	40 (8.0)	30 (8.2)	10 (7.5)	17 (8.1)	26 (12.4)	0.20
Small bone (ex. fingers or toes)	23 (4.6)	23 (6.3)	0 (0.0)	16 (7.6)	10 (4.8)	0.29
Other (ex. nose, growth plate, unspecified)	42 (8.4)	32 (8.7)	10 (7.5)	19 (9.1)	17 (8.1)	0.85
Other injury (any)	51 (10.2)	40 (10.9)	0.51	20 (9.5)	18 (8.6)	0.87
Laceration or abrasion (not head/face)	20 (4.0)	12 (3.3)	8 (6.0)	8 (3.8)	4 (1.9)	0.34
Dislocation	5 (1.0)	4 (1.1)	1 (0.8)	2 (1.0)	5 (2.4)	0.45
Sprain/strain	6 (1.2)	6 (1.6)	0 (0.0)	2 (1.0)	2 (1.0)	0.99
Other (ex. bite, bruise, eye injury unspecified)	20 (4.0)	18 (4.9)	2 (1.5)	8 (3.8)	7 (3.3)	0.99

Injury type and subtype, N (%)	All CWE (n=501)	Complicated vs. Uncomplicated				CWUE (case) vs. matched sibling (control)	
		CWUE [¶] (n=368)		CWCE [§] (n=133)		CWUE [¶] (n=210)	
			p-value *		p-value *		p-value *
OVERALL (any injury)	246 (49.1)	184 (50.0)	62 (46.6)	0.54	119 (56.7)	105 (50.0)	0.17

[¶]Children with uncomplicated epilepsy (CWUE) cases include CWE with IQ 80 and a normal neurological exam.

[§]Children with complicated epilepsy (CWCE) cases include CWE with IQ < 80 or an abnormal neurological exam.

The proportion of children with a given injury type and subtype was calculated in all CWE (n=501), CWUE (n=368), CWCC (n=133) and in the subsample of CWUE with matched sibling pairs (n=210) and then compared between groups. Overall injury rates were calculated as the proportion of children in a given sample with at least one reported injury type. Injury types and subtypes are not mutually exclusive (and therefore, % subtypes within a given type do not necessarily add up to % type).

^{*} Chi-square tests, Fisher's Exact test two-sided probabilities or McNemar's test (for paired comparisons) were calculated with significance of p 0.05

Type of treatment for injuries in CWE and sibling controls

J Pediatr. Author manuscript; available in PMC 2014 December 01.

Injury type, N(%)	All CWE (n=501)	Uncomplicated vs. Complicated		p-value*	CWUE vs. matched sibling control		p-value*
		CWUE [¶] (n=368)	CWCE [§] (n=133)		CWUE [¶] (n=210)	Controls (n=210)	
Non-surgical procedure (ex. cast)	42 (33.3) (25.2)	33 (31.7)	9 (40.9)	0.46	21 (32.8)	22 (36.1)	0.70
Surgery (ex. resetting, rods)	3 (2.4)	3 (2.9)	0 (0)	0.56	2 (3.1)	3 (4.9)	0.67
Hospitalization	2 (1.6)	1 (1.0)	1 (4.6)	0.32	1 (1.6)	0 (0)	-
Other**	39 (31.0)	31 (29.8)	8 (36.4)	0.61	22 (34.4)	16 (26.2)	0.32
Unspecified [‡]	48 (38.1)	44 (42.3)	4 (18.2)	0.05	23 (35.9)	23 (37.7)	0.84
No treatment [‡]	0 (0)	0 (0)	0 (0)	-	1 (0.5)	0 (0)	-
Other injury (any)	51 (10.2)	40 (10.9)	11 (8.3)	0.51	20 (9.5)	18 (8.6)	0.87
Non-surgical procedure (ex. stitches/staples)	16 (31.4)	10 (25.0)	6 (54.6)	0.08	6 (30.0)	1 (5.6)	0.09
Surgery (ex. eye surgery)	6 (11.8)	5 (12.5)	1 (9.1)	0.99	2 (10.0)	4 (22.2)	0.39
Hospitalization	0 (0)	0 (0)	0 (0)	-	1 (5.6)	0 (0)	-
Other**	11 (21.6)	10 (25.0)	1 (9.1)	0.42	4 (20.2)	8 (44.4)	0.11
Unspecified [‡]	18 (35.3)	15 (37.5)	3 (27.3)	0.73	8 (40.0)	4 (22.2)	0.31
No treatment [‡]	1 (2.0)	1 (2.5)	0 (0)	-	0 (0)	0 (0)	-
OVERALL treatment for any injury (any)	246	184 (50.0)	62 (46.6)	0.54	119 (56.7)	105 (50.0)	0.17
Any surgery or hospitalization	22 (8.9) (49.1)	16 (8.7)	6 (9.7)	0.80	11 (9.2)	9 (8.6)	0.86
Any hospitalization	8 (3.3)	6 (3.3)	2 (3.2)	0.99	4 (3.4)	2 (1.9)	0.69
Any surgery	15 (6.1)	11 (6.0)	4 (6.5)	0.99	7 (5.9)	7 (6.7)	0.81

The proportion of children receiving different treatment types by injury type was calculated as the number of children receiving a given treatment type for a given injury type divided by the total number of children who reported any of that injury type. N (%) for each injury type represents the proportion of children with any injury of that type (as per Table 2). Treatment categories were not mutually exclusive with each injury type. By definition, "No treatment" responses were not included in the calculation of any overall treatment for any injury.

Because there were a different number of injuries between CWUE and sibling pairs (n=210) the analysis was not matched.

* Chi-square tests and Fisher's exact test two-sided probabilities were calculated with significance of p 0.05.

[¶]Children with uncomplicated epilepsy (CWUE) cases include CWE with IQ 80 and a normal neurological exam.

[§]Children with complicated epilepsy (CWCE) cases include CWE with IQ < 80 or an abnormal neurological exam.

** Other includes outpatient visits (emergency room, primary care, or medical visit not further specified, but not hospitalization), diagnostic tests, physical therapy or treatment with medications

[‡]Unspecified = no explicit characterization or description of treatment for a given injury type

No treatment = explicitly stated that “no treatment” was required for a given injury type

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript