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A prospective, population-based epidemiologic study of status epilepticus in Richmond, Virginia

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Article abstract—This report presents the initial analysis of a prospective, population-based study of status epilepticus (SE) in the city of Richmond, Virginia. The incidence of SE was 41 patients per year per 100,000 population. The frequency of total SE episodes was 50 per year per 100,000 population. The mortality rate for the population was 22%, 3% for children and 26% for adults. Evaluation of the seizure types for adult and pediatric patients demonstrated that both partial and generalized SE occur with a high frequency in these populations. Based on the incidence of SE actually determined in Richmond, Virginia, we project 126,000 to 195,000 SE events with 22,200 to 42,000 deaths per year in the United States. The majority of SE patients had no history of epilepsy. These results indicate that SE is a common neurologic emergency.

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Status epilepticus (SE) is a major medical and neurologic emergency,[1-3] and the current medical management of SE has been extensively reviewed.[4-8] Despite advances in treatment of this condition, SE is still associated with a significant morbidity and mortality.[9-11] The study of SE is problematic, since SE occurs not only in people with epilepsy, but also in the context of acute, symptomatic, systemic, or neurologic insults.[3,10]

Several studies of SE have provided information concerning some of the important clinical features of this condition[2-23] and developed insights into predictive indicators of outcome.[9] Epidemiologic data from retrospective analysis[10] and preliminary prospective data[15] have also provided an estimate of the natural presentation of SE in a population setting. However, as emphasized by Hauser,[10] there are no published population-based studies of SE, and the hospital-based and tertiary clinic series, from which most of our information is derived, provide biased information that may not be relevant to the overall medical community. Thus, it is important to develop a large, prospective, population-based study of SE to investigate this condition in a representative, well-characterized community setting.

This investigation presents the first analysis of a prospective, population-based study of SE in Richmond, Virginia. The Medical College of Virginia/Virginia Commonwealth University Comprehensive Epilepsy Institute has developed a validated population-based prospective study of SE from 1989 to 1991. The results provide information concerning the frequency, incidence, recurrence, etiologies, seizure types, mortality, and other clinical variables of SE in this population.

Methods. *Definitions.* Status epilepticus. SE was strictly defined using the definition of the International Classification of Epileptic Seizures as any seizure lasting for 30 minutes or longer or intermittent seizures lasting for greater than 30 minutes from which the patient did not regain consciousness.[24] Patients that seized up to 29 minutes and were controlled with anticonvulsants were excluded by this definition of SE. In addition, if the seizure episode or event could not be documented as a 30-minute seizure or intermittent seizures without regaining con-

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sciousness for 30 minutes, the patient could not be diagnosed as having SE. Nonconvulsive SE (electrographic) was defined as continuous EEG seizure activity lasting for 30 minutes or longer without significant clinical seizure activity. Periodic lateralized epileptiform discharges (PLEDs) alone were not considered as seizure discharges.

Age. Included in this study were all patients aged 31 days or older. The pediatric population (children) included all patients from 31 days up to 16 years, and adults were patients 16 years of age or older. Neonates less than 1 month in age were excluded from this study. The elderly population was defined as patients aged 60 years and older, and young adults represented patients from 16 to 59 years.

Mortality. Mortality was defined as death in association with SE, occurring from the initiation of SE to 30 days following the termination of SE. All patients were followed for a minimum of 30 days after the control of SE or to the time of death. Survival was defined as alive at 30 days after SE was controlled.

Recurrence rate. The recurrence rate was defined as another episode of SE occurring within a 2-year follow-up time period after the initial SE event. All patients in the study were followed for a 2-year time period in the database. Recurrent SE events within a single hospitalization were also included in this evaluation.

History of epilepsy. History of epilepsy was defined as two or more seizure episodes in a lifetime.

Etiologies. Etiologies of SE were defined as the acute, remote symptomatic and idiopathic causes of SE. Previous medical conditions that were not the acute cause of SE were not included in acute symptomatic etiologies and were categorized as remote symptomatic. Occasionally, SE was associated with more than one concurrent etiology. Acute symptomatic etiologies were defined as SE in association with an underlying etiology within 7 days of the acute onset of that etiology. Remote symptomatic etiologies included patients with SE without an acute precipitating cause, but with a history of insults to the CNS temporally remote to the first unprovoked SE episode. This category was defined using the classification of Hauser.[3,10] The following acute etiologic categories were associated with SE in this study:

A. Acute symptomatic etiologies. (1) Anoxia: acute deprivation of oxygen to the CNS from documented respiratory or cardiorespiratory arrest lasting greater than 5 minutes. (2) Hypoxia: respiratory insufficiency documented by cyanosis and decreased oxygen saturation or decreased oxygen levels by blood gases prior to SE, or both. (3) Cerebrovascular disease (CVA): cerebrovascular disease, including vascular occlusion, embolism, or hemorrhagic infarct. This category did not include intracerebral hemorrhage associated with hypertension or other causes. (4) Hemorrhage (HEM): intracerebral or subarachnoid hemorrhage. (5) Tumor: primary or metastatic CNS tumors. (6) Infection (Infec)/Fever: systemic infection not involving the CNS with temperature elevation. (7) Central nervous system infections (CNS Infec): infections of the CNS, including meningitis, abscess, and fungal, bacterial, viral, or other causes. (8) Metabolic (Metab): systemic dysfunction manifested by metabolic disturbances, such as electrolyte imbalance, hypoglycemia, uremia, or other metabolic disorders. (9) Low anticonvulsant drugs (LAED): a documented low AED level in a patient with epilepsy that was confirmed by nontherapeutic anticonvulsant blood levels at the time of presentation with SE. (10) Drug overdose (Drug OD): an acute drug overdose. (11) Alcohol related (ETOH): alcohol withdrawal or alcohol intoxication. (12) Head trauma: injury requiring medical treatment or hospitalization with or without loss of consciousness.

B. Remote symptomatic (Remote) etiologies: No acute precipitating etiology, but with a previous history of CNS insult, such as a CVA, CNS infection, congenital (congenital malformations, hydrocephalus, arteriovenous malformations, and genetic diseases), trauma, hemorrhage, or tumor.

C. Idiopathic etiology. SE in association with no identifiable acute or remote cause for the initiation of the seizures.

Seizure types. Seizure types in SE were defined as partial or generalized SE based on the International Classification of Seizure Types and types of SE as defined by the International League Against Epilepsy, as reviewed by Gastaut[24] and Hauser.[3,10] Partial SE was divided into simple partial (SP), complex partial (CP), or partial with secondary generalization (PSG). Simple partial SE referred to episodes where the patient maintained alertness and the ability to interact appropriately with the environment during partial seizure activity that lasted for 30 minutes or longer. Complex partial SE included patients with partial seizures with confusion and with amnesia for the ictus. Partial seizures with secondary generalization were classified as SE that initiated with partial onset and a subsequent secondary generalization, according to the criteria of the International League Against Epilepsy. Electrographic partial SE was included in the electrographic (ELECT) category and was defined as SE that occurred in patients who were unconscious and manifested a single electrographic focal discharge lasting 30 minutes or longer without overt clinical seizure activity such as arm twitching or leg twitching. PLEDS alone were not considered as ictal discharges. Generalized SE was subdivided into generalized tonic-clonic (GTC), generalized absence (ABS), myoclonic (MYOCL), and generalized nonconvulsive SE that was included in the ELECT category. Nonconvulsive SE seizures were defined as 30 minutes or longer of continuous EEG seizure activity based on standard EEG criteria for seizure discharge while the patient was comatose and was without significant clinical activity. These SE seizure types were classified using the International League Against Epilepsy definitions, as reviewed by Gastaut.[24]

Classification of seizure types was based on a review of all medical records and direct discussion of each case where indicated with attending physicians, nurses, or with the SE Research Team (SERT). In many cases, reviewing the initial admission history and presentation of the patient to the emergency room or on the hospital floor did not clearly identify the details of the seizure presentation. The accuracy of the seizure history was greatly improved by a member of the SERT being able to review the case within 24 hours of diagnosis and interviewing family, physicians, nurses, and emergency personnel within that time period. Prospective data collection facilitated our ability to document partial onset with secondarily generalized seizures. Without this type of input, over one-half of the partial onset of P2G cases would be missed.

Race. White was defined as Caucasians. Nonwhite represented all non-Caucasians and included primarily African Americans.

Population-based prospective database. To study the epidemiology of SE, we utilized a large population-based, prospectively collected database of SE cases presenting in the Richmond Metropolitan Area from July 1, 1989, to June 30, 1991. SE cases were identified during the course of this study in the Medical College of Virginia Hospitals and the McGuire Veterans Administration, university hospitals and all community hospitals in the Greater Richmond Metropolitan Area (GRMA). Patients living in the city of Richmond who developed SE while in a neighboring suburb and presented to a community hospital that was not in the city limits of Richmond would be identified in the study by reviewing SE cases from all hospitals in the GRMA. The university hospitals are the major hospitals in the city limits and accounted for 75% of the patients presenting with SE in Richmond. The remaining 25% of the patients living in the city limits presented in community hospitals in and around the city.

Case identification. SE cases were prospectively identified by the SERT that evaluated all cases presenting to the study on a daily basis. The case histories and charts of potential SE patients were reviewed by the SERT in order to determine whether each identified case met the rigorous definition of SE described above. SERT members were on-call 24 hours a day, 7 days a week in order to be able to respond to each case of SE in a prospective, timely manner to be able to collect accurate data on the clinical presentation of SE. At both the university and community hospitals, SE cases were identified by neurologists and nurses reporting to the SERT. This form of case identification was identical in all hospitals and accounted for the majority of records. At the Medical College of Virginia Hospital, additional ascertainment of cases could be utilized. Cases were also identified by ER personnel reporting to the SERT and by daily rounds on the Neurology Morning Report Service, in the emergency room and in all ICUs. In reviewing each case reported to SERT, approximately 80% of the SE cases met the definition of SE. The remaining cases had to be excluded because sufficient history or documentation could not be obtained to meet the definition of SE.

Data collection. Following the identification and documentation of each SE case, the medical records were carefully reviewed during the hospitalization period or immediately following discharge of each SE patient. This type of rapid and timely prospective review provided a more accurate assessment of the data on each patient than could be obtained by retrospective analysis. In comparing prospective to retrospective data collection, it was evident that routine chart record-keeping was not of sufficient detail for accurate descriptions of the clinical aspects of SE. Accurate descriptions of seizure type, duration of SE, and times of drug administration were very poorly documented in the clinical chart. However, by being able to directly question the physicians, nurses, and family members of each patient, the SERT could obtain a more accurate and detailed clinical history of each SE event. This information was entered into a data entry system for each patient and included the following information: detailed seizure history, electrophysiologic data, demographic data, previous medical or neurologic history, immediate precipitating etiology of SE, outcome, laboratory studies, and hospital course. To evaluate the duration of SE and time to recovery or death, a time line for each SE event was established. These time lines and medication histories were carefully evaluated and reviewed by the SERT not only to validate the definition of SE, but also to verify the accuracy of the clinical and demographic data.

Validation of the database. A labor-intensive, complete review of SE presentations was performed to more critically evaluate the completeness of case ascertainment and to validate the database. This review evaluated all hospital ICD-9 codes for seizures, 911 reports for seizures in the ER, presentation of SE on hospital rounds, all EEG laboratory reports, and ICU and ER records and personnel. This review provided a high degree of accuracy in documenting essentially all SE cases. This type of detailed review was carried out for 1 month for each year of the study at the MCV Hospitals and at two of the large community hospitals during the course of the study. Comparing the cases identified by this procedure and those prospectively identified during the data collection of this study, we determined that the prospective identification of SE patients at the MCV Hospitals was validated at approximately 90% of all cases. In the community hospitals, it was found that the identification of SE patients was approximately 33%.

During the initial design of this study, evaluation of the community hospitals through consultation with hospital personnel, neurologists, and ER physicians, it was thought that essentially all SE cases received neurologic consultation. Thus, we utilized neurologists and neurology nurses as the referral sources in these hospitals. However, it was evident during the study that over one-half of the SE cases presenting in the community hospitals were not brought to the attention of adult or pediatric neurologists. These cases were being managed by internists, ICU specialists, or ER personnel. Since a significant number of SE cases were not seen by neurologists in these hospitals, the total number of patients identified in the community hospitals did not reach the high level of identification in a prospective manner that was performed at the MCV Hospital and represent an underestimate of the actual presentation of SE. Under-identification of SE cases was partially corrected by using the estimate of underrepresentation described for MCV and community hospitals using the ascertainment rate of 90% for MCV and 33% for community hospitals to estimate the actual incidence of SE in the population. Compensating for the underreporting of SE identification, an estimate of the actual SE incidence was determined (table 1).

Epidemiologic determinations. The incidence determinations of SE were defined as the number of individuals that had SE per year per 100,000 residents living in the city of Richmond, Virginia. The denominator of the incidence calculation was the population of the city of Richmond (1990 US Census Bureau data) minus infants less than 1 month of age (286 babies) and was determined to be 202,774. The numerator of the incidence calculation was the number of patients occurring per year, as collected over a 2-year period. Recurrent SE was not included in this determination. Total frequency of SE events in the population represented the number of SE occurrences per year as the numerator. The frequency of recurrent SE was expressed as the number of patients with recurrent SE in the

Table 1 *SE frequency in Richmond and projection for United States*

	Actual	Estimated*
Richmond		
Incidence of SE/100,000	41	61
Episodes of SE/100,000	50	78
Mortality/100,000	9	17
United States		
Cases of SE/year	102,000	152,000
SE events/year	126,000	195,000
Deaths/year	22,200	42,000

* The estimated values were calculated using the validation corrections for the MCV and community hospitals (Methods).

population per year per 100,000. The frequency of recurrent SE episodes was expressed as the number of recurrent SE events per 100,000.

Results. *Demographics.* There were 166 patients with an initial episode of SE and a total of 204 SE events identified from July 1, 1989, to June 30, 1991, and validated to reside in the Richmond city limits by documenting their addresses on an updated map. There were 83 cases of SE for the first and second years of the study, and there were 97 episodes of SE in the first year and 107 episodes in the second year. The SE population was 55% male and 45% female. The population in Richmond was 58% male and 42% female and 43% white and 57% nonwhite. The population at MCV Hospital averaged 45% white and 55% black, and in the community hospitals the black population averaged 43%. The proportions of white and nonwhite patients that presented with SE were 20% white and 80% nonwhite.

Incidence of SE in Richmond, Virginia. The incidence of SE for Richmond, Virginia, is presented in table 1. The documented incidence of SE in this community was 41 per 100,000 individuals per year. This incidence calculation did not include repeat episodes of SE and counted each patient that had one or more episodes of SE as a single individual in the determination. Including repeat episodes of SE, the total number of SE events in this population occurred with a frequency of 50 per 100,000 individuals per year (table 1). Correcting the total SE events and incidence numbers for MCV and community hospitals to the 100% value, using validation data (Methods), we obtained the estimated values for incidence and frequency of total episodes presented in table 1.

Age-specific incidence and episodes of SE. The age distribution of the frequency of total SE events per year and the incidence of SE is presented in figure 1. Both the frequency of SE events and incidence per 100,000 individuals per year showed a bimodal distribution with the highest values during the first year of life and during the decades above 60 years of age. The incidence and frequency of SE events for the total study, pediatric, adult, young adult, and the elderly age groups, are presented in figure 2. The elderly had the highest frequency and incidence of SE events and, thus, represent the age group with the highest risk for developing SE in the population, with

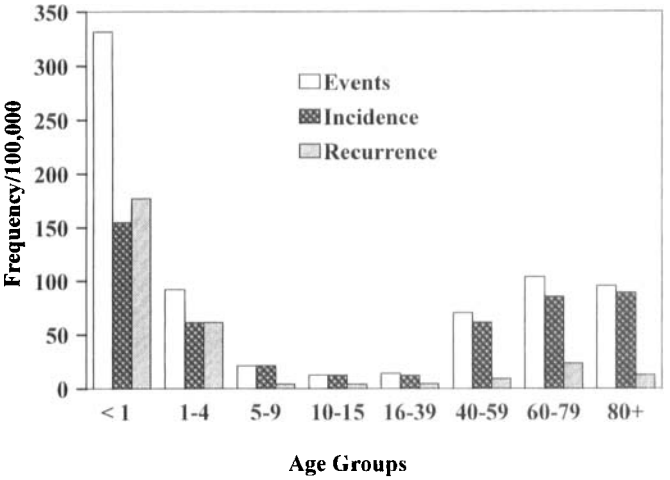

Figure 1. Age-specific distribution of the frequency of SE events, the incidence of SE, and the frequency of SE recurrence per year per 100,000 in Richmond, Virginia. The population in each age group was determined from the National Census Bureau data on the demographics of Richmond, 1990. SE events included all episodes of SE per 100,000 per year. The incidence of SE represents the number of patients that developed SE per 100,000 in Richmond and did not include recurrent episodes of SE.

an incidence of 86 per 100,000 per year. Infants less than 1 year of age represent a subgroup of the pediatric population with the highest incidence and frequency of SE (figure 1).

Age-specific recurrence of SE. The percent of SE patients who had a recurrence of SE in the Richmond population was 13.3%. Forty-three percent of the patients less than 4 years of age had a repeat episode of SE. The age distribution of recurrence frequency of SE is shown in figure 1. Recurrences of SE were most common in the very young and increased slightly in the elderly (figures 1 and 2). Twenty-two patients had repeat episodes of SE within 2

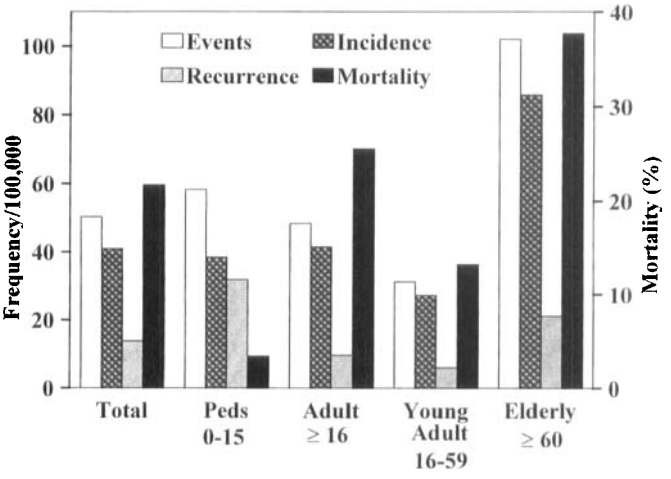

Figure 2. Frequency of SE events, incidence, SE recurrence frequency, and SE mortality in Richmond for the total, pediatric (Peds), adult, young adult (young), and elderly populations. The data for events, incidence, and recurrence present the frequency per 100,000 per year. Mortality data express the percent mortality for each age group.

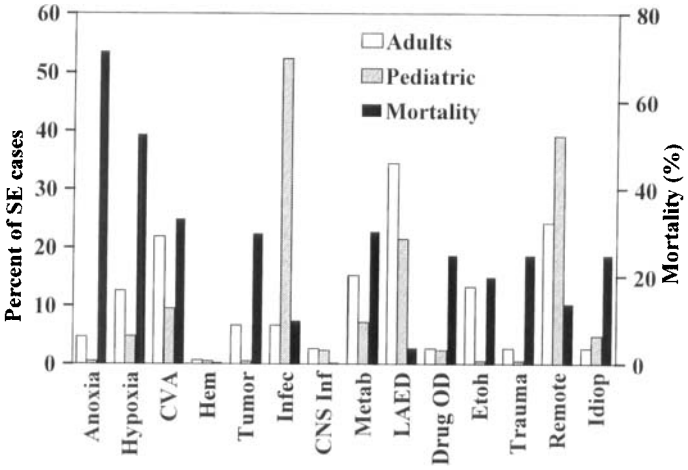

Figure 3. Etiologies of SE for adult and pediatric patients and mortality for adult etiologies. Some patients had more than one etiology. Etiologies included Anoxia, Hypoxia, CVA (cerebral vascular accidents), Hem (hemorrhage), Tumor, Infec (systemic infections with fever), CNS Inf (infections of the central nervous system), Metab (metabolic), LAED (low antiepileptic drug levels), Drug OD (drug overdose), ETOH (alcohol related), Trauma, Remote, and Idiop (idiopathic). Data are expressed as the percent of cases with each etiology. Mortality data represent the percent mortality for each etiology for the adult population.

***Table 2** SE seizure types in Richmond*

	Pediatric	Adult	Total
Final seizure type			
Generalized	71	74	74
Partial	29	26	26
Onset seizure type			
Generalized	36	31	32
Partial	64	69	68
Partial SE			
Simple	29	22	23
Complex	0	4	3
Partial 2° generalized	36	43	42
Generalized			
GTC	36	27	29
Absence	0	1	1
Myoclonic	0	3	2
Electrographic	0	1	1

Data are expressed as percent of SE cases with each seizure type.[24] Final seizure type represented the major seizure type during SE. Onset seizure type included partial 2° (secondarily) generalized as partial onset.

years of their first SE event, and the maximum number of repeat episodes for a single individual was five.

Mortality of SE. The overall mortality of SE in the entire population was 22%. The mortalities for pediatric patients was 3% and the mortality of adults was 26%. The mortality for each age group is presented in figure 2. The highest mortality was seen in the elderly (38%). The pediatric age group had the lowest mortality (3%). Young adults had a mortality of 13%.

Table 1 presents the projected mortality for the United States, assuming that Richmond is a representative urban population. Approximately 22,200 to 42,000 deaths per year would be expected in the United States in association with SE.

Etiologies of SE. The etiologies of SE for the pediatric and adult patients in this series are presented in figure 3. The major etiology in children was infections with fever, accounting for 52% of the cases. Remote symptomatic (39%) and LAED (21%) also accounted for a significant number of cases in children. All other etiologies represented less than 10% of the cases. Three major etiologies were observed in adults: LAED (34%), Remote (24%), and CVA (22%). Hypoxia (13%), metabolic (15%) and ETOH (13%) each represented between 10% and 20% of the cases. The remote symptomatic group consisted of a total of 55 SE events composed of the following etiologies: CVA (45), hemorrhage (6), and tumor (4). Combining the cerebral vascular accidents and hemorrhage events with the remote etiologies related to CVA and hemorrhages, almost 50% of the adult cases of SE were caused by acute or remote cerebrovascular disease.

The mortalities for each etiology for adult cases are presented in figure 3. Anoxia (71%) and hypoxia (53%) were associated with a very high mortality. LAED (4%) had a very low mortality. Thus, the distribution of etiologies in a patient series will greatly affect the mortality of the population. Children had a low mortality, and only one death was observed in the pediatric population.

Race and SE. The incidence of SE for whites was 20 per 100,000. Nonwhites had an incidence of 57 per 100,000. The frequencies of total episodes of SE for whites was 23 per 100,000 and for nonwhites, 71 per 100,000. Nonwhite patients had a higher incidence of SE across the age distribution of the population. The overall mortality for whites was 31% and for nonwhites, 17%.

Seizure types. Table 2 presents the major seizure types in the Richmond study. PSG SE was more completely documented in this study by prospective data collection (Methods). PSG was classified as a partial seizure type that begins with a partial seizure and progresses to generalized seizure activity. Characterizing SE by the final seizure type, 74% of SE was generalized and 26% partial (table 2). A similar distribution was observed for pediatric and adult cases. However, partial seizure discharges were the initiating seizure type of SE in 64% of the pediatric and 69% of adult patients (table 2). The majority of SE cases were initiated across the age spectrum by partial seizure discharge.

Partial seizures were subdivided into simple partial, complex partial, and PSG (table 2). Simple partial SE was more common than complex partial SE in both children and adults. Generalized SE was further divided into generalized tonic-clonic, absence, myoclonic, and electrographic. Generalized tonic-clonic SE was the major type of generalized SE. Generalized absence SE was uncommon in both adults and children in this population. Myoclonic SE was predominantly observed in adult patients. Electrographic SE was observed in adults and seen less frequently in children.

The age-specific distribution of partial, PSG, and generalized SE was evaluated. Generalized SE was the main

seizure type in the first year of life, but was not the predominant type over the adult age groups. PSG was the major seizure type in the elderly and was also seen with a high frequency across all age groups in the population. Partial SE was consistently observed in all age groups.

History of epilepsy. The majority of SE patients in this study did not have a previous epilepsy history. Fifty-eight percent of the patients that presented with SE had no previous history of epilepsy, demonstrating that nonepileptic individuals are also at considerable risk to develop SE. The percentage of patients with a history of epilepsy for each age group was 38% in the pediatric population, 42% in adults, 54% in young adults, and 30% in the elderly. Seventy percent of the elderly SE patients had no previous history of epilepsy.

Discussion. The results of this study indicate that the minimum incidence of SE in Richmond, Virginia, was 41 per 100,000 patients per year. SE events occurred with a frequency of 50 per 100,000 episodes per year. The highest incidence of SE occurred in the first year of life. The second highest incidence of SE occurred in the elderly population, representing the largest group of patients at risk for developing SE. Since many of these patients, especially the elderly, did not have a previous history of epilepsy, SE represents a major medical and neurologic emergency for individuals with and without epilepsy.

The incidence values and SE events per year obtained for Richmond represent an underestimate of the true occurrence of SE. Because of the rigid definition of SE followed in this study, it was not possible to include cases that were probably SE but could not be documented with certainty by the medical history. In addition, a large number of SE patients were rapidly treated with anticonvulsants by physicians or paramedics en route to the hospital or on inpatient services. If the continuous seizures were controlled in the time period between 10 and 30 minutes, these potential SE cases could not be included in the study. This represented patients who would have probably not stopped seizing until they arrived at the hospital if they were not treated. In addition, the validation of our database indicated that there was a significant underestimate of the number of cases in community hospitals. All of these factors contribute to an underestimation of the "true" incidence of SE in the Richmond population.

To project the Richmond epidemiologic data for the United States, we used the US population based on the 1990 census data of 249,924,000 individuals and determined the number of SE cases and the total SE events for both actual and corrected values (table 1). Based on this estimate, 102,000 to 152,000 individuals and 126,000 to 195,000 SE events would be predicted in the United States per year. This projection assumes that Richmond is a representative urban community. This value is only an estimate, since it was not corrected for race, age, or other variables.

The nonwhite population had a significantly higher incidence of SE than the white population, especially in the very young and the elderly. If one assumes that this difference between white and nonwhite patients was solely due to race, then the projected estimates of SE episodes and cases for the United States should be corrected for racial distribution. Thus, the overall incidence in the United States would be somewhat lower, since the United States has a lower percentage of nonwhites than Richmond. However, it is premature to assume that this difference is solely due to race. In addition to race, socioeconomic, cultural, and environmental differences may also contribute to the higher incidence of SE in nonwhites in Richmond. Studies are currently under way at the MCV/VCU Comprehensive Epilepsy Institute to further evaluate these differences.

Obtaining a population-based, prospective analysis of SE in an identified community provides a more representative determination of the mortality and clinical presentation of SE. The results of this epidemiologic study confirm our earlier retrospective analysis,[9] indicating that the mortality of SE in the general population exceeds 20%. This report represents the first population-based study in which children and adults were both evaluated prospectively in the same database. The results confirm previous studies, indicating that children have a much lower mortality than adults in association with SE.[22,23] The elderly represent the segment of the population with the highest mortality. Using the Richmond database and extrapolating to the United States, between 22,200 and 42,000 deaths per year could be associated with SE in the United States. This represents a significant public health risk and indicates that further investigation into the causes of death associated with SE should be initiated.

Cerebrovascular disease in adults was a major etiology of SE and was the major "at risk" condition for developing SE. Combining acute and remote symptomatic cerebrovascular disease, almost one-half of the adult SE cases were caused by cerebrovascular disease. The relationship between ischemic brain injury and SE has not been well established. The role of increased intracellular calcium, gliosis, and acute ischemic injury in modulating the balance between excitability and neuronal inhibition in the development of SE represents an important area for further study.

Withdrawal of anticonvulsant medications and alcohol were large etiologic categories in adults that manifested a lower mortality, as also observed in previous studies.[1-4,8-10,13,15,16] Infections with fever were the major cause of SE in children, as described previously.[15,22,23] Anoxia, hypoxia, and specific other etiologies were associated with a significant mortality. The relationship between the underlying etiology and mortality in SE is an important area that requires further investigation. The mortality from cerebrovascular accidents at the Medical College of Virginia is less than 12%. However, patients with cerebrovascular accidents in association with SE had

a mortality of 32%. This result suggests that the underlying etiology alone is not the only factor contributing to the increased mortality associated with these conditions and SE. Interaction of an injured brain with repeated prolonged seizure activity may present a unique risk for mortality. Understanding this complex relationship may offer an important therapeutic window to lower the mortality associated with these conditions in combination with SE.[9]

Although the majority of patients with SE have generalized tonic-clonic seizures, this study indicates that partial seizures also represent a major type of SE in adults and children. In fact, partial seizures could be documented to initiate greater than 50% of all SE cases. The prospective data collection in this study provided a more accurate description of the initial seizure type at the onset of SE. A significant number of cases that began with partial seizures that secondarily generalized could be diagnosed by prospective data collection. However, PSG SE is still significantly underdiagnosed, because it is not possible to obtain witnessed information at the initiation of all SE cases. Thus, the results indicate that partial seizures are the main initiating seizure type of SE in adults. Other seizure types also occurred in this population setting. Generalized absence SE was rare in the general population. Myoclonic SE occurred in adults, and the mortality was almost 100%. Simple and complex partial SE were commonly observed. Partial SE was also associated with a significant mortality.

The majority of adults and children with SE in this study did not have a previous history of epilepsy. Although a significant number of patients (42%) had a history of epilepsy, SE was shown to occur in association with other diseases in the population at large. The elderly have the largest percentage of SE patients without a previous history of epilepsy (70%). Thus, patients who had no previous history of epilepsy were also at risk to develop SE. The acute etiologies alone had a lower mortality than cases of SE associated with the underlying etiologies. These results underscore the importance of understanding the complex causes of mortality in SE and of using this knowledge to develop new treatment strategies.

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