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Utility of Lumbar Puncture for First Simple Febrile Seizure Among Children 6 to 18 Months of Age

Amir A. Kimia, MD, Andrew J. Capraro, MD, David Hummel, MSc, Patrick Johnston, MMath, Marvin B. Harper, MD

Division of Emergency Medicine, Department of Medicine, Children's Hospital Boston, Boston, Massachusetts

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What's Known on This Subject

The AAP recommended considering LP for 6- to 18-month-old patients presenting with FSFS. There is some evidence that rates of bacterial meningitis are low in these patients and that LP rates are declining among ED physicians.

What This Study Adds

We present data on a large cohort of 6- to 18-month-old patients presenting with FSFS and rates of LP and of bacterial meningitis. We also present data regarding pediatric ED rates of LP performance.

ABSTRACT

OBJECTIVES. American Academy of Pediatrics consensus statement recommendations are to consider strongly for infants 6 to 12 months of age with a first simple febrile seizure and to consider for children 12 to 18 months of age with a first simple febrile seizure lumbar puncture for cerebrospinal fluid analysis. Our aims were to determine compliance with these recommendations and to assess the rate of bacterial meningitis detected among these children.

METHODS. A retrospective cohort review was performed for patients 6 to 18 months of age who were evaluated for first simple febrile seizure in a pediatric emergency department between October 1995 and October 2006.

RESULTS. First simple febrile seizure accounted for 1% of all emergency department visits for children of this age, with 704 cases among 71 234 eligible visits during the study period. Twenty-seven percent ($n = 188$) of first simple febrile seizure visits were for infants 6 to 12 months of age, and 73% ($n = 516$) were for infants 12 to 18 months of age. Lumbar puncture was performed for 38% of the children ($n = 271$). Samples were available for 70% of children 6 to 12 months of age (131 of 188 children) and 25% of children 12 to 18 months of age (129 of 516 children). Rates of lumbar puncture decreased significantly over time in both age groups. The cerebrospinal fluid white blood cell count was elevated in 10 cases (3.8%). No pathogen was identified in cerebrospinal fluid cultures. Ten cultures (3.8%) yielded a contaminant. No patient was diagnosed as having bacterial meningitis.

CONCLUSIONS. The risk of bacterial meningitis presenting as first simple febrile seizure at ages 6 to 18 months is very low. Current American Academy of Pediatrics recommendations should be reconsidered. *Pediatrics* 2009;123:6–12

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Key Words

febrile seizure, bacterial meningitis, lumbar puncture, consensus statement

Abbreviations

LP—lumbar puncture
AAP—American Academy of Pediatrics
CSF—cerebrospinal fluid
CI—confidence interval
ED—emergency department
FSFS—first simple febrile seizure
WBC—white blood cell

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Address correspondence to Amir A. Kimia, MD, Division of Emergency Medicine, Children's Hospital Boston, 300 Longwood Ave, Boston, MA 02115. E-mail: amir.kimia@childrens.harvard.edu

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IN MAY 1996, the American Academy of Pediatrics (AAP) issued practice parameters regarding the neurodiagnostic evaluation of children with a first simple febrile seizure (FSFS) who present within 12 hours after the seizure.¹ FSFS was defined as a first episode of seizure accompanied by fever, manifested as a primary generalized seizure lasting ≤ 15 minutes and not recurring within 24 hours. The term febrile seizure is not intended for use among children with evident central nervous system infections or underlying seizure disorders.²

The AAP practice parameters recommended that lumbar puncture (LP) be strongly considered for patients < 12 months of age and be considered for patients 12 to 18 months of age, in an effort to diagnose bacterial meningitis among children with FSFS as their sole clinical manifestation of infection. These recommendations were based on the knowledge that seizure is a common presenting symptom of bacterial meningitis,^{3,4} clinical skills and experience vary widely among examiners, and clinical assessment of children at this age for subtle signs can be difficult. However, the issue of whether a well-appearing child presenting with an FSFS is at increased risk for bacterial meningitis has remained controversial,⁵⁻⁷ because of a lack of quantitative data and the inclusion of data from the pre-*Haemophilus influenzae* type B vaccine era.⁸

Although seizure is a common symptom among patients presenting with bacterial meningitis, it is quite uncommon for a simple, brief, nonfocal seizure to be the sole manifestation of bacterial meningitis.⁹ With the introduction of a 7-valent, pneumococcal conjugate vaccine (Prevnar [Wyeth Lederle Vaccines, Pearl River, NY]) in 2000, the

incidence of bacterial meningitis has decreased significantly, which further affects the probability of this condition in young patients with simple febrile seizures.¹⁰⁻¹²

Although there are quantitative data regarding the LP yield among patients presenting with FSFS,^{9,13,14} no data from a large cohort of patients that specifically address patients 6 to 18 months of age (the focus of the AAP practice recommendations) have been presented. We found no reports on LP performance rates among pediatric emergency medicine physicians' managing this age group. Hampers et al¹⁵ reported decreases in rates of LP performance in these patients, to <10%, in community hospitals.

Our primary objective in this study was to evaluate the rate of bacterial meningitis among otherwise-healthy infants 6 to 18 months of age who presented to a pediatric emergency department (ED) with FSFS. Our secondary objective was to determine the rate of compliance with the AAP recommendations for LP and practice trends among pediatric emergency medicine physicians regarding LP for those children.

METHODS

Study Design

This was a retrospective cohort review of consecutive patients admitted to an urban, tertiary-care, pediatric ED. The ED serves ~50 000 children per year. The study was approved by the institutional review board.

Study Setting and Population

All patients who presented to the ED between October 1995 and October 2006 with electronically available physician notes (produced with EMStation [Cerner, Kansas City, MO]) were evaluated for inclusion in this study. During the study period, all physician notes were documented electronically except during 4- to 12-hour system downtimes, which occurred approximately quarterly. All clinically well-appearing children 6 to 18 months of age with FSFS who presented to the ED within 12 hours after the seizure were included. Our definition of FSFS matched the definition used by the AAP committee in the 1996 recommendations; FSFS was defined as a first episode of seizure accompanied by fever, manifested as a primary generalized seizure lasting ≤ 15 minutes and not recurring within 24 hours, without evident central nervous system infection or underlying seizure disorder. Exclusion criteria included previous seizures, underlying illness (eg, syndromes associated with seizures, ventriculoperitoneal shunt, or chronic medication use), trauma, and clinical suspicion of meningitis (eg, bulging fontanel, petechiae, and ill appearance, defined on the basis of irritability, toxic appearance, or lethargy).

Study Protocol

Case identification was conducted by using a custom-developed, computer-assisted, screening tool, which was applied to the physician notes for a sample of potentially eligible children. The screening tool was validated through a manual audit of all sampled records. Once the

tool was validated successfully, it was applied to all eligible physician notes during the study period; the records of children screened into the study with the screening tool were reviewed manually.

Text Screening Tool

We created a text screening tool that uses regular expressions for text matching (ActivePerl 5.8.8.820; [ActiveState Software Inc, Vancouver, British Columbia, Canada]). Regular expression matching provides a more-comprehensive search than key word search and is inclusive of various misspelled and mistyped words in the chart (Fig 1).

The module matched a list of expressions in the text. First, a regular expression was applied to every word in every chart. This produced a list of words for the reviewer. The list included abbreviations, as well as misspelled and mistyped versions of the index word (Fig 1A). A comprehensive list, including the misspelled, mistyped, and abbreviated words, was then applied to the text (Fig 1B). In the next step, a regular expression addressing negation form was applied to the cases identified (eg, deleting cases with "no seizures" or "chills/seizures denied"), which further narrowed the search. Finally, a precreated list of exclusion criteria was matched against the text, which resulted in a negative score that was applied to the charts. The final step decreased the output number of charts to its final value before human auditing (Fig 1C).

Text Screening Tool Validation

The screening tool was validated against a human-audited sample. All 6578 charts for 6- to 18-month-old children seen in 2004 were manually reviewed, as our standard, and results were used to assess the sensitivity of the screening tool to identify eligible children.

Manual Screening of Screening Tool Output

Charts identified with the screening tool were reviewed by 1 of the authors (Dr Kimia), and exclusion criteria were applied. Data collected included age, gender, seizure characteristics, temperature at triage, examination findings, and results of cerebrospinal fluid (CSF) studies. If a trainee was involved in patient care, then the notes of both the trainee and the attending physician were reviewed. In cases of discrepancies between trainee documentation and attending physician documentation, we considered the notes of the attending physician to be authoritative. For every case included in the study, hospital records were reviewed to screen for a second ED visit or hospital admission within 1 week after the index visit.

Definitions

Compliance with AAP recommendations was defined as any attempt to perform LP, regardless of success or deferral because of parental refusal. CSF pleocytosis was defined as CSF white blood cell (WBC) counts of >7 cells per mm^3 . CSF WBC counts for blood-contaminated CSF were determined by using the following correction: cor-

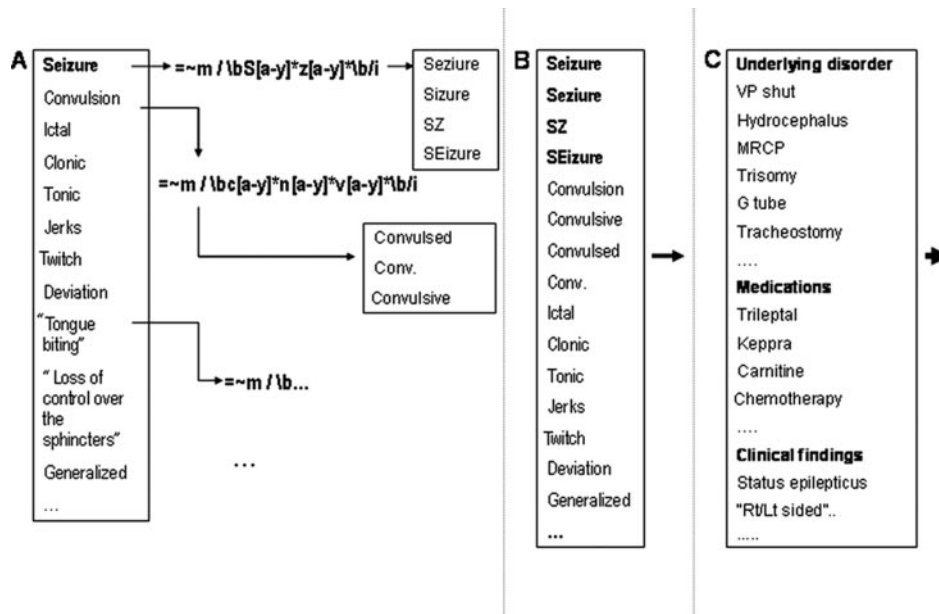


FIGURE 1

Use of text search module to detect cases of FSFS. A, Initial word list. B, Use of regular expressions to add misspelled words. C, Application of a list of exclusion criteria-related words to improve the specificity of the screen. VP indicates ventriculoperitoneal; MRCP, mental retardation/cerebral palsy; G tube, gastrostomy tube; Rt, right; Lt, left.

rected CSF WBC count = CSF WBC count - (CSF red blood cell count/500). Bacterial meningitis was defined on the basis of (1) growth from any CSF specimen obtained within 1 week after the ED visit for seizure, (2) CSF pleocytosis with growth of a pathogen from any blood sample obtained within 1 week after the ED visit for seizure, or (3) a pathogen identified on a Gram-stain of CSF. Latex agglutination tests are not used routinely in our facility for diagnosis of bacterial meningitis.¹⁶

Data Analyses

Proportions and confidence intervals (CIs) were calculated for pleocytosis and meningitis rates by using Bayesian credible intervals based on Jeffreys' prior. Linear regression models were used for LP performance rates over time (SAS 9.1 [SAS, Cary, NC]).

RESULTS

Text Screening Tool Validation

All 2004 ED charts for patients 6 to 18 months of age were screened manually, and 54 cases of FSFS in otherwise-healthy children (54 of 6578 charts) were identified. The screening tool was then applied independently to the same data set, and 324 eligible cases, including all 54 cases, were identified (sensitivity: 1; specificity: 0.957).

Case Identification

During the study period, there were 564 544 ED visits, of which 71 234 were for children 6 to 18 months of age. The text screening tool identified 4328 potentially eligible patients. These charts were then reviewed manually, and 704 cases of otherwise-healthy children presenting with FSFS were identified (Table 1 summarizes patient

demographic features). A minority of these children were in the younger age group; 27% ($n = 188$) were <12 months of age, and 74% ($n = 516$) were 12 to 18 months of age. Forty-six percent were female (Table 1).

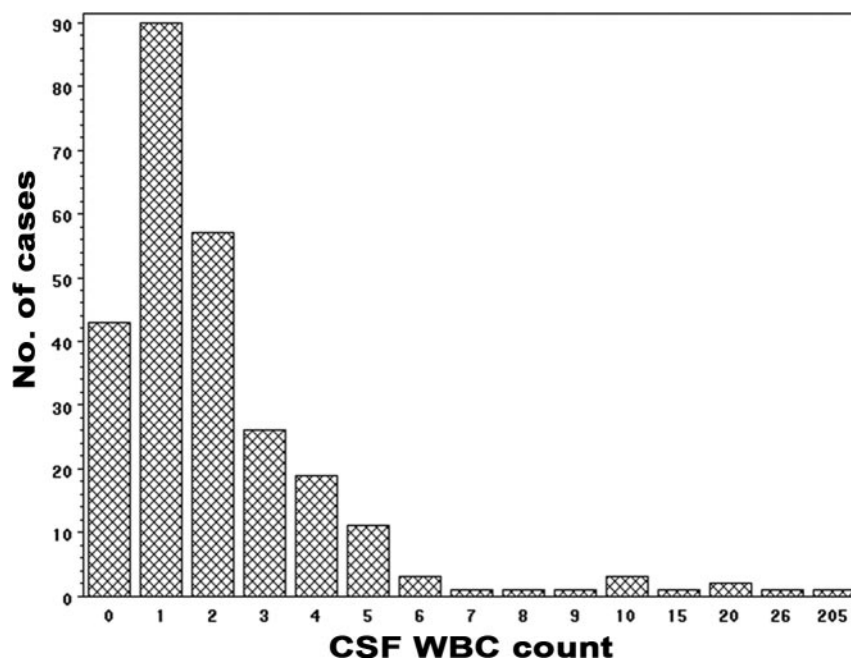
Data regarding immunization were available for 80% of our patients. Of patients with recorded data, 98% were listed as up to date, 1% missed 1 vaccine dose, and 1% missed ≥ 2 vaccine doses.

Fifty-eight patients (8%) were admitted to the hospi-

TABLE 1 Patient Demographic Features, 1995–2006

ED visits	
<i>N</i>	564 544
Age, median (interquartile range), y	5.2 (1.6–11.9)
Patients 6–18 mo of age, <i>n</i>	78 022
Female, %	46.4
Cases identified with screening tool	4328
FSFS population	
<i>N</i>	704
Age, median (interquartile range), mo	14 (11–16)
Female, %	45.7
Excluded cases	
<i>N</i>	3624
Age, median (interquartile range), mo	12.1 (9–15)
Female, %	50.5
Module failed to detect negation form or history, <i>n</i> (%)	1462 (40.3)
Underlying disorder or disease, <i>n</i> (%)	848 (23.4)
Not a seizure (eg, chills or breath-holding), <i>n</i> (%)	380 (10.4)
Seizure disorder with breakthrough seizures, <i>n</i> (%)	304 (8.4)
New onset of nonfebrile seizure, <i>n</i> (%)	264 (7.3)
Complex febrile seizure, <i>n</i> (%)	177 (4.9)
Simple febrile seizure, recurrent, <i>n</i> (%)	112 (3.2)
Seizure in setting of trauma, <i>n</i> (%)	433 (0.9)
Simple febrile seizure > 12 h before ED visit, <i>n</i> (%)	25 (0.7)
Ill appearance or clinical suspicion, <i>n</i> (%)	19 (0.5)

FIGURE 2
CSF pleocytosis in FSFS cases.



tal. Reasons for admission were clearly documented for 42 (72%); 10 were admitted for treatment of a focal infection (pyelonephritis and pneumonia were the leading diagnoses), 9 for hydration, 6 because of a prolonged postictal state, 4 because of CSF pleocytosis, 4 because of concerns regarding prolonged seizure (although <15 minutes), 4 because the parents performed cardiopulmonary resuscitation on the patient, 3 because of failed LP or parental refusal and desired patient observation, 1 because of fever height, and 1 because of the physician's concerns regarding notable peripheral leukocytosis.

Sixty-eight patients (10%) were given ≥ 1 dose of antibiotic before their ED visit. Of those patients, 44 (65%) were given antibiotics for a current illness, 5 (7%) were receiving prophylactic antibiotic therapy (to prevent otitis media or urinary tract infections), and 19 (28%) were given a single dose of antibiotics on the day of the seizure (by the primary care provider or at an outside hospital), before evaluation in our ED. A LP was attempted in 38% of cases ($n = 271$); CSF was obtained successfully in 260 cases, 4 attempts failed, and 7 attempts were deferred because of parental refusal.

CSF Results

CSF pleocytosis was found in 10 of 260 cases (3.8% [95% CI: 1.9%–6.9%]). The median CSF WBC count was 1 cell per mm^3 (interquartile range: 1–3 cell per mm^3) (Fig 2). The CSF pleocytosis correction formula was applied in a total of 4 cases, and 2 of those cases still demonstrated CSF pleocytosis.

Bacterial Meningitis

No pathogen was identified in CSF cultures (0 of 260 [97.5% CI: 0%–1.4%]). Ten cultures (3.8%) yielded a contaminant (5 non-*Staphylococcus aureus* staphylococci, 2 *Streptococcus viridans*, 2 *Micrococcus* sp, and 1 *Enterococcus*

faecalis). None of the 10 patients with CSF pleocytosis had isolation of bacteria from blood cultures. None of the 704 patients with FSFS returned to the hospital with a diagnosis of bacterial meningitis (97.5% CI: 0%–0.005%).

Compliance With AAP Recommendations

LP performance rates decreased significantly after 12 months of age (Fig 3). During the study period, LP performance rates were 70% (131 of 188 infants) for infants <12 months of age (Fig 4A) and 25% (129 of 516 infants) for infants 12 to 18 months of age (Fig 4B). Rates of LP performance decreased over time in both age groups ($P < .001$) (Fig 4).

DISCUSSION

The AAP recommendations published in 1996 regarding the evaluation of young children with FSFS take into account the possible role of a simple febrile seizure as a clinical predictor of bacterial meningitis, as well as clinicians' limited ability to identify clinical signs of meningitis at this challenging age.¹ When assessing a patient for potential bacterial meningitis, the clinician must take into consideration the probability of this illness, on the basis of demographic features and clinical assessment findings. Although bacterial meningitis remains an important cause of morbidity and death, the introduction of highly effective bacterial conjugate vaccines has significantly reduced the probability of bacterial meningitis among febrile children.^{8,10,12}

The association between seizures (of any type, including prolonged, focal, or recurrent) and meningitis is well established.⁴ Recently, Nigrovic et al^{17,18} validated and published a clinical prediction rule stratifying risks for bacterial meningitis among children with CSF pleocytosis; seizure was the only clinical predictor, which suggests its importance. In contrast, Green et al⁹ reported

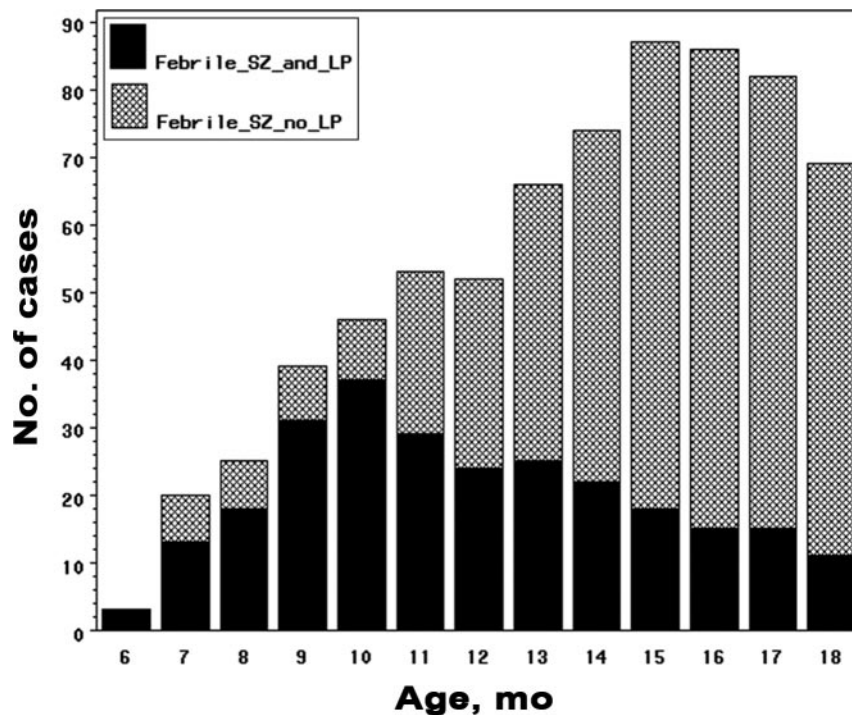


FIGURE 3
LP performance rates according to patient age. SZ indicates seizure.

that, in a large series of patients with bacterial meningitis, 23% had seizures but 91% (105 of 115 patients) were either obtunded or comatose when evaluated by a physician for the seizure and the remaining 9% (10 of 115 patients) with normal levels of consciousness had obvious clinical signs of meningitis (focal seizures, recurrent seizures, petechial rash, or nuchal rigidity).

This is the first study that attempts to quantify the risk for bacterial meningitis among children with FSFS in the age groups in the AAP recommendations. Other studies, not directed to this specific age group, have been conducted. Trainor et al¹³ reported the risk for bacterial infection in children 6 to 60 months of age presenting to multiple centers in the Chicago area with an FSFS, and they found no cases of bacterial meningitis among the 135 patients for whom CSF cultures were obtained. Teach and Geil¹⁴ published their experience with 243 febrile children 3 months to 6 years of age with seizures, 89% of which were simple febrile seizures and 11% complex febrile seizures. No patients had bacterial meningitis. Hampers et al¹⁹ evaluated practice variations in the management of simple febrile seizures among different EDs; among 455 patients 6 to 60 months of age, LPs were performed for 30% and no cases of bacterial meningitis were identified. Studies from developing countries reported higher rates of bacterial meningitis,^{3,20} but the differences in bacterial strains, vaccination status, and utilization of resources make these reports difficult to apply to our setting, just as it is difficult to apply our data to their setting.

In 2002, Carroll and Brookfield⁷ published a systematic review of the evidence, looking at what they defined as 15 “first world” articles regarding the incidence of purulent meningitis after a febrile seizure. That review,

based on articles published between 1977 and 1999 (before Prevnar), reported an extrapolated maximal incidence estimate of 0.44% (95% CI: 0%–0.88%) for unsuspected purulent meningitis after a febrile seizure in our age group. The authors commented that this rate of 1 case per 200 is probably an overestimation, on the basis of study design.

Discussion of the usefulness of the AAP practice parameters continued with a recent case report in *Pediatrics* of a 12-month-old girl with FSFS who had a brief focal seizure and 48 hours later was found to have pneumococcal meningitis.²¹ Whether the patient already had seeding of the meninges and meningitis at the time of the FSFS is not known, but it is possible. It is unlikely that the occurrence of FSFS would be protective against bacterial meningitis; therefore, FSFS might occur occasionally with occult bacteremia or bacterial meningitis, as with any other febrile illness. There is currently no evidence that FSFS represents any increase in risk for meningitis, compared with children in the same age group with fever but without FSFS.

Our series represents the largest sample of children with FSFS in the 6- to 18-month age group, for which concern regarding meningitis is greatest. We identified no cases of bacterial meningitis in our study group. During this same time period, within the sample of 70 530 children 6 to 18 months of age without FSFS who were seen in our ED, there were 8 cases of bacterial meningitis.

Addressing adherence to these qualitative recommendations (“consider” and “strongly consider”) with quantified data is a challenging task. The rate at which LPs were performed among children in our study was higher than reported previously. Hampers et al¹⁵ evaluated

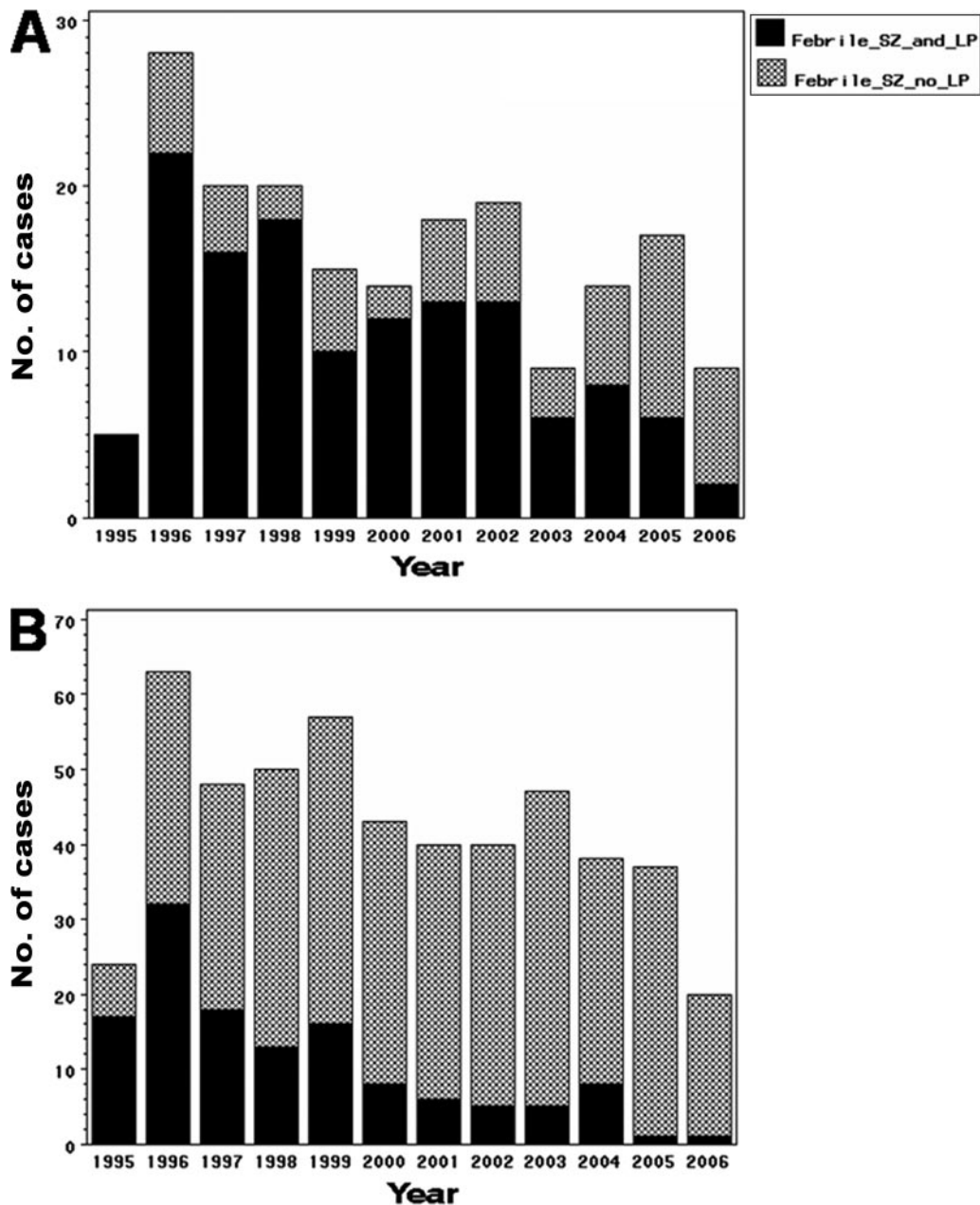


FIGURE 4
Decreases in LP performance rates over time. A, Infants <12 months of age. B, Infants 12 to 18 months of age. SZ indicates seizure.

practices with regard to the AAP guidelines among community ED physicians in 2002–2003 and showed an overall LP performance rate of 8.2% for children <18 months of age. Our overall rate was 38%, and that for the corresponding year (2002–2003) was 29%. Possible explanations may include a conservative clinical approach, the setting of a pediatric tertiary care center, or clinicians being more aware of the AAP FSFS recommendations. Nonetheless, the rates of LP performance at our institution are decreasing, particularly in the 12- to 18-month age group.

Of interest is the decrease in the overall number of FSFS cases seen over the years of our study. Elucidation

of whether this represents a true decrease in the incidence of simple febrile seizures, clinicians being less inclined to diagnose borderline cases, or a decrease in rates of referral to our center for evaluation is beyond the scope of this study.

Caution is advised in the generalization of our results to patients with complex febrile seizures, ill-appearing patients, or patients who have an underlying illness. Sound clinical judgment should always prevail, and clinicians should err on the side of caution (including performing a LP) when evaluating any febrile child for whom the presence of bacterial meningitis is being considered.

Not all patients underwent LP. Although no patient

returned to the hospital with a diagnosis of bacterial meningitis, these patients may have gone to other facilities for their care.

Sixty-eight patients were pretreated with antibiotics before their ED assessment. Of those patients, 36 (53%) underwent LP, with only 1 patient having CSF pleocytosis (9 WBCs per mm³, with 80% monocytes/lymphocytes). No pretreated child subsequently received an antibiotic course that would be recommended for meningitis.

The reported rate of vaccination for our population, when available, was >90% (up to date on all vaccines), which reflects the high compliance reported for all vaccines in Massachusetts²¹ and *Haemophilus influenzae* type B and Prevnar vaccination rates for children in our state. This may limit applicability to patient populations with lower immunization rates.

The ability to generalize results from an academic pediatric ED to other EDs may be questioned. However, data indicate that LP performance rates for FSFS in general EDs are already significantly lower^{15,19} than that seen in our ED. This fact, combined with the finding that it is very rare for bacterial meningitis to present as FSFS, make the AAP practice parameters recommending that clinicians strongly consider or consider LP for very young children with FSFS to have limited utility. We think that the evidence to recommend LP for FSFS does not exist and that the recommendations should be changed to state simply that meningitis should be considered in the differential diagnosis for any febrile child and LP should be performed if there are clinical signs or symptoms of concern.

CONCLUSIONS

The risk of bacterial meningitis presenting as FSFS among children 6 to 18 months of age is very low. The rate of performing LPs in FSFS cases is low and decreasing. Current AAP recommendations regarding LP for FSFS in this age group should be reconsidered.

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